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Financial Hardship and Age-Related Decrements in Kidney Function Among Black and White Adults in the Midlife in the United States Study

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Objective: This analysis examined if financial hardship was associated with age-related decrements in kidney function using a material-psychosocial-behavioral framework. We also tested if this association was mediated by comorbidity of cardiometabolic risk factors (obesity, elevated blood pressure, and insulin resistance).
Methods: Data from 1361 non-Hispanic Black and White adults (ages 26–94 years; non-Hispanic Black = 258) were obtained from the Wave 3 and Refresher phases of the Midlife in the United States project. Kidney function was based on serum creatinine–based estimated glomerular filtration rate (eGFR; Chronic Kidney Disease Epidemiology Collaboration formula without race adjustment). Financial hardship was evaluated in three domains: material (income to poverty line ratio, health insurance coverage, and public/government financial assistance), psychological (perceived financial status, control over financial status, and perceived financial strains), and behavioral responses (financial adjustment/coping such as sold possessions and cutting back on spending).
Results: More severe financial hardship (overall score and in each domain) was associated with age-related decrements in eGFR, even after adjusting for sociodemographic, education, and health-related covariates. The association between financial hardship and age-related decrements in eGFR was conditional on sex but not race. Finally, cardiometabolic risk factors mediated the association between financial hardship and age-related decrements in eGFR.
Conclusions: These findings affirm the negative effects of financial hardship on age-related decrements in renal clearance. In addition to incorporating traditionally used indicators of SES, such as education and income, future research on social hallmarks of aging should also consider the role of financial hardship on the aging process and age-related diseases.

Key words: accelerated aging, financial hardship, geroscience, renal aging, social hallmarks of aging

Abbreviations: **BP** = blood pressure, **CKD** = chronic kidney disease, **CKD-EPI** = Chronic Kidney Disease Epidemiology Collaboration, **CV** = coefficient of variation, **eGFR** = estimated glomerular filtration rate, **MIDUS** = Midlife in the United States, **NH** = non-Hispanic, **SES** = socioeconomic status

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INTRODUCTION

Geroscience is an interdisciplinary field based on the idea that altering the biological aging process can delay or prevent age-related diseases and extend the period of healthy aging and longevity (1,2). Research in geroscience, mostly involving animal studies, has made significant progress in identifying many biological mediators of aging that contribute to age-related diseases (e.g., genomic instability, telomere attrition, epigenetic alterations), collectively considered as the *hallmarks of aging* (3,4). More recently, the field of geroscience has recognized the importance of integrating the perspectives from social and behavioral research, especially focusing on understanding the role of social and economic factors in the aging process (1,5,6). Crimmins (5) introduced the term *social hallmarks of aging*, referring to social and psychological factors contributing to aging and age-related diseases, including low socioeconomic status (SES), minority status, adverse life events, adverse psychological states, and adverse behaviors. A growing body of work has documented the link between social hallmarks of aging and various biological markers of aging and age-related diseases. The current analysis contributed to this area of research by testing whether financial hardship—an indicator of household economic well-being—is an important social contributor to age-related health outcome, specifically accelerated decline of renal clearance. In addition, we examined racial and sex differences in the association between financial hardship and age-related decrements in renal clearance between non-Hispanic (NH) Black and White adults and between female and male individuals.

Chronic Kidney Disease Is a Pressing Public Health Issue

One of the most common age-related diseases is chronic kidney disease (CKD), which affects more than one in seven adults in the United States (7). CKD refers to various disorders

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associated with damage to kidney structure and the progressive decline in kidney function (8). Although kidney size and function decline progressively across adulthood as part of the normal aging process, accelerated renal aging is characterized by the loss of nephrons and other structural changes within the kidney and a reduction in the clearance rate of proteins and metabolites from the bloodstream (9). Longitudinal studies have documented that a faster decline in kidney function is a robust predictor of progression to CKD (10), atherosclerotic cardiovascular disease (11), and mortality (12).

Furthermore, the burden of CKD is higher among those from lower SES, female individuals, and racial minority backgrounds (7). Findings from cross-sectional and longitudinal studies have shown that lower education and income are associated with a faster decline in kidney function across adulthood (13,14) and a higher risk of CKD (15,16). The risk of CKD due to lower SES was especially higher among Black relative to White Americans (17). However, research on SES and racial disparities in CKD and accelerated renal aging rarely goes beyond traditional indicators of SES (i.e., education and household income). In this article, we consider whether financial hardship is an important socioeconomic indicator that captures household economic well-being and can complement the use of traditional measures of SES to characterize SES disparities in accelerated renal aging. Furthermore, little is known about whether the association between financial hardship and accelerated renal aging differs across racial groups and between female and male individuals.

The Material-Psychological-Behavioral Framework of Financial Hardship

Despite advancements in medical technology and efforts to reduce risk factors, SES remains a fundamental cause of health inequities due to its persistent link to various health conditions (18,19). SES encompasses one's class, wealth, power, and prestige that can be used to avoid health risks and minimize the detrimental impact of pathophysiology if an illness does develop (19,20). Although education and income have been widely used as traditional measures of SES, they do not necessarily fully capture the overall socioeconomic context that affects health and influences risk factors for diseases. Identifying other indicators that can complement education and income to capture socioeconomic conditions can be informative for attaining a better understanding of mechanisms contributing to inequities in health (21).

Financial hardship is a sensitive socioeconomic indicator that captures insufficient economic household resources (22). Multiple terms have been used to describe financial hardship in health inequity research, including financial strain, financial distress, financial stress, financial difficulties, financial challenges, and financial toxicity (23). Various financial hardship terms indicate no agreed-upon definition or measure of this fundamental construct in health inequity research. However, recent articles on socioeconomic and racial inequities in cancer have recommended using the material-psychological-behavioral framework of financial hardship (24,25). According to this framework (Figure 1A), financial hardship can be characterized by three interrelated domains: material, psychological, and behavioral (24,25). The material domain captures the lack of or insufficient access to material resources. The psychological domain focuses on the psychological responses due to the lack of material resources, including financial worries, stress, and the lack of financial satisfaction and control. Finally, the behavioral domain considers coping behaviors to deal with insufficient material resources and their psychological responses. Using the material-psychological-behavioral framework of financial hardship can provide a more comprehensive rendering of the experience of dealing with inadequate economic or material resources that contribute to inequities in health.

Racial and Gender/Sex Differences in Financial Hardship

There is established evidence that the experience of financial hardship is more pervasive among adults from racial/ethnic minority backgrounds relative to NH White. In analysis using data from the Health and Retirement Study, Black adults reported significantly more financial hardship than White adults (26). In a different analysis involving US adults with diabetes, NH Black adults showed a higher likelihood of financial hardship (27). Black adults were also more likely to experience financial hardship due to major life events, such as a global pandemic (28) and cancer treatment diagnosis (29). Furthermore, there is robust evidence that there is a disproportionate burden of financial hardship among female relative to male individuals. For example, female adults with diabetes were more likely to experience financial hardship (27). Similarly, an analysis among cancer survivors in the United States showed that female survivors, relative to male survivors, had higher annual medical expenditures and were more likely to have to change their employment because of cancer (30). Thus, it is critical to consider the intersectional impact of financial hardship, race, and sex when investigating health inequities.

Financial Hardship and Accelerated Renal Aging

Financial hardship is a concept that has been introduced previously in the field of nephrology. However, previous research mainly focused on the financial impact of treatment of kidney disease, including dialysis (31,32), transplantation (33,34), and kidney cancer (35), or CKD in general (36). In nationally representative US adults aged 18 to 64 years with CKD, Acquah and colleagues (36) found that almost half experienced financial hardship from medical bills, mostly because of the lack of health insurance coverage. Furthermore, a study among kidney failure patients in Hong Kong determined that financial hardship was associated with decreased quality of life (31).

However, there is a lack of research examining the association between financial hardship and kidney functioning across adulthood and how the experience of financial hardship may increase the likelihood of progression toward a worsening age-related CKD. A longitudinal study by Corwin and colleagues (27) found that among US adults with diabetes, the experience of chronic financial hardship was associated with an increased probability of developing diabetic kidney disease. However, the study did not analyze all financial hardship domains (i.e., material, psychological, and behavioral). In addition, they did not test if the association between financial hardship and the risk of diabetic kidney disease was conditional on sex or race. More empirical studies are needed to elucidate the link between financial hardship and the aging process of renal clearance to better explain how socioeconomic inequality leads

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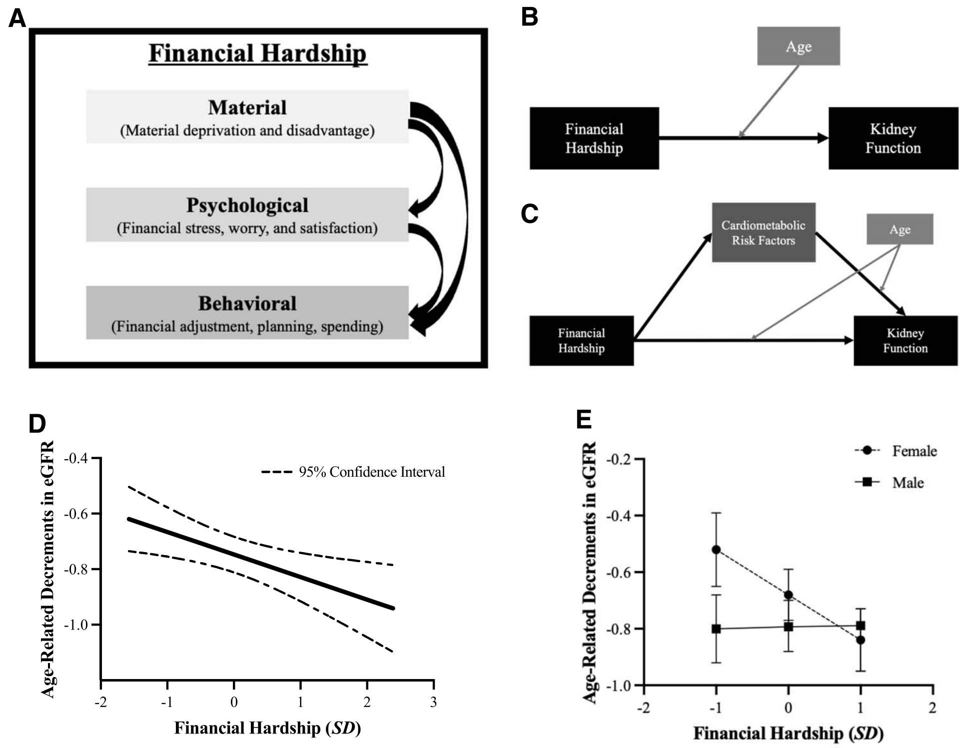

FIGURE 1. A, The material-psychological-behavioral framework of financial hardship. According to this framework, financial hardship can be described as three interrelated domains associated with material deprivation (material domain), psychological stress associated with material deprivation (psychological domain), and the behavioral aspect to cope with material deprivation (behavioral domain). B, The primary goal of the current analysis was to examine the association between the material-psychological-behavioral framework of financial hardship and age-related decrements in kidney function. C, We also tested if this association was conditional on race and sex. Furthermore, we examined if the association between financial hardship and age-related decrements in kidney function was mediated by cardiometabolic risk factors. Finally, we explored if this mediational pathway was conditional on race and sex. D, Graphic representation of the association between financial hardship and age-related decrements in eGFR. Higher financial hardship was associated with steeper age-related decrements in eGFR. E, The association between financial hardship and age-related decrements in eGFR was conditional on sex. Among women, but not men, higher financial hardship was significantly association with steeper age-related decrements in eGFR. eGFR = estimated glomerular filtration rate; SD = standard deviation.

to inequities in CKD. Given that financial hardship and CKD disproportionately impact female individuals and individuals from racial minority backgrounds, additional research is needed to explain the intersection between financial hardship, race, and sex on kidney functioning across adulthood.

Similarly important is understanding the biological pathways through which financial hardship may be linked to age-related decrements in kidney function and whether the pathways differ by race and sex. Previous studies have demonstrated the important roles of cardiometabolic risk factors, including obesity, elevated blood pressure (BP), and insulin resistance. Comorbidity among these cardiometabolic risk factors has been shown to mediate the association between lower SES and risk of CKD (15) and steeper age-related decrements in estimated glomerular filtration rate (eGFR) (14). Furthermore, the mediational role of comorbid cardiometabolic risk factors seems to differ based on race (14) but not sex (15). To our knowledge, no studies have investigated the mediating role of cardiometabolic risk factors on the association between financial hardship and kidney function across adulthood.

Current Study

In summary, this analysis examined the associations between financial hardship in middle-aged and older adults and age-related decrements in kidney function. Specifically, the goals were to a) examine the association between financial hardship and age-related decrements in kidney function, b) investigate if the association between financial hardship and age-related decrements in kidney function was conditional on race and sex, c) determine if the association between financial hardship and age-related decrements in kidney function was mediated by comorbidity of cardiometabolic risk factors (obesity, elevated BP, and insulin resistance), and d) explore if the mediational pathway from financial hardship to age-related decrements in kidney function through comorbidity of cardiometabolic risk factors was conditional on race and sex. We hypothesized that more financial hardship would be associated with faster age-related decrements in kidney function and that comorbidity of cardiometabolic risk factors would mediate this association.

METHODS

Data and Participants

The current analysis used publicly available data from the Midlife in the United States (MIDUS) project (https://www.icpsr.umich.edu/web/ICPSR/series/203), a longitudinal study of biopsychosocial factors associated with age-related changes

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in health and well-being across the adult life course (37). A comprehensive description of the MIDUS protocol and procedures has been provided elsewhere (38). Information relevant to the current analysis is detailed hereinafter. The first wave of the MIDUS study (MIDUS 1) was conducted in 1995 to 1996, when 7108 adults (ages 25–74 years) from the continental United States completed the baseline survey. Follow-ups were conducted every 10 years (MIDUS 2: 2004–2005; MIDUS 3: 2013–2014). In addition, to broaden the age range of the MIDUS study participants, a new national sample was recruited between 2011 and 2014 to participate in the MIDUS Refresher study (MIDUS R) (39). Some questions regarding financial hardship (especially for the behavioral domain) were only included in the assessment for the MIDUS R and MIDUS 3. Thus, the current analysis focuses on data from the MIDUS R and MIDUS 3 phases.

Analytic Sample

MIDUS R included 3577 adults (ages 25–74 years) from the continental United States who were representative of the original MIDUS 1 sample regarding their sociodemographic characteristics. However, to increase the racial diversity of MIDUS R participants, an oversample of mostly Black adults (N = 508; ages = 25–64 years) was recruited from Milwaukee County, Wisconsin, and all completed the MIDUS R survey. A subsample of participants in the MIDUS R national sample and Milwaukee oversample also participated in the MIDUS R Biomarker project (2012–2016; n = 863). For the MIDUS R Biomarker project, blood and urine specimens were collected, which enabled the determination of serum creatinine (it has been used in the current analyses of kidney function) and additional measures related to hypertension, glucose regulation, and lipid metabolism (40).

MIDUS 3 included 3294 adults (ages 40–94 years) who had previously completed the MIDUS 1 and 2 surveys (mortality-adjusted retention rate = 77%). The MIDUS 3 also included the Milwaukee oversample (N = 389; ages = 44–94 years), who previously completed the MIDUS 2 Milwaukee survey (mortality-adjusted retention rate = 78%). Like MIDUS R, a subsample of participants in the MIDUS 3 national sample and Milwaukee oversample also partook in the MIDUS 3 Biomarker project (2017–2021; n = 747). We included data from the MIDUS R Biomarker and MIDUS 3 Biomarker projects for the current analysis. Out of the potential pool of 1610 participants, we included data from 1361 adults who self-identified as NH Black (n = 258) or NH White (n = 1103) and have available serum creatinine data. Detailed biomarker assessment protocol is provided in Section 1 of the Supplemental Digital Content, http://links.lww.com/PSYMED/A980.

Measures

Financial Hardship

Measures of financial hardship were divided into three domains: material, psychological, and behavioral. These items provide a congruent picture of the material-psychological-behavioral framework of financial hardship (25). Three items were included as part of the material domain of financial hardship: a) income to poverty ratio (adjusted for household size; 2 = ≤300%; 1 = 300–<600%; 0 = ≥600%), b) health insurance coverage (1 = no, 0 = yes), and c) received public/government financial assistance (1 = yes, 0 = no). We included four items for the psychological domain of financial hardship: a) perceived current financial situation (2 = worse, 1 = average, 0 = best), b) perceived control over current financial situation (2 = worse, 1 = average, 0 = best), c) perceived availability of money to meet needs (2 = not enough, 1 = enough, 0 = more than enough), and d) perceived difficulty level paying monthly bills (2 = very difficult/somewhat difficult, 1 = not very difficult, 0 = not at all difficult). Finally, four items for the behavioral domain of financial hardship were taken from the National Survey of Unemployed Adults conducted by the Heidrich Center for Workforce Development: a) missed a credit card payment (1 = yes, 0 = no), b) missed other debt payment (e.g., car or student loans; 1 = yes, 0 = no), c) sold possessions to make ends meet (1 = yes, 0 = no), and d) cut back on spending (1 = yes, 0 = no). The total score of financial hardship and the score for each domain of financial hardship were considered in the analyses. The score for each domain of financial hardship was calculated by adding all the items. Thus, higher scores reflect higher material (min–max = 0–4), psychological (min–max = 0–8), and behavioral aspects of financial hardship (min–max = 0–4). Finally, the total scores of financial hardships were calculated by adding scores from the three domains (min–max = 0–16), in which higher scores reflect higher levels of overall financial hardship (Cronbach α = .81).

Kidney Function

Kidney function was based on the eGFR (ml/min/1.73 m^2), calculated from serum creatinine using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula without adjustment for race (41,42). The original CKD-EPI formula takes age, sex, and race into consideration when calculating eGFR (41). Because race is a social and not biological construct, adding race adjustment into the eGFR formula reduces and confounds race's influence within and between populations (42). This effect may contribute to an underdiagnosis of kidney disease in some races, inadvertently perpetuating health disparities (42). Therefore, a race adjustment has been omitted from the recent formulations of CKD-EPI computations (42). Serum creatinine for all participants, regardless of the site for sample collection, was determined on the same Roche Cobas Analyzer at UnityPoint Health-Meriter Lab (Madison, Wisconsin). The assay range was 0.06 to 30.5 mg/dl, with an interassay coefficient of variation (CV) of 2.08%.

Comorbidity of Cardiometabolic Risk Factors

We included obesity (body mass index ≥30 kg/m^2 = 1, otherwise coded as 0), elevated BP (systolic and diastolic BP ≥140/90 mm Hg or self-report of hypertension diagnosis by a physician = 1, otherwise coded as 0), and insulin resistance (HbA_{1c} ≥6.5% or fasting blood glucose ≥126 mg/dl or self-reported diagnosis of type 2 diabetes by a physician = 1, otherwise coded as 0) as cardiometabolic risk factors, elevated BP, and insulin resistance. Fasting blood glucose was determined using an enzymatic colorimetric method (interassay and intra-assay CV of 1%) performed at the ARUP Lab, Salt Lake City, Utah, whereas HbA_{1c} was measured using immunochemiluminescent technology (interassay CV of 1.08%–3.4%

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and intra-assay CV of 2.2%–2.3%) at the UnityPoint Health-Meriter Lab. In the analysis, we used the total number of conditions (min–max = 0–3) to reflect the comorbidity of cardiometabolic risk factors.

Covariates

Covariates included in the analysis included sex (0 = female, 1 = male), race (0 = NH White, 1 = NH Black), education level (0 = no bachelor's degree, 1 = bachelor's degree or higher), marital status (1 = married, 0 = others), smoking status (0 = currently not smoking, 1 = currently smoking), and prescription medication (0 = not taking, 1 = taking prescription medication).

Analytic Strategy

The analytic plan was divided into two parts. The first modeling examined the association between financial hardship and age-related decrements in eGFR. In addition, to test if this association was conditional on race and sex, we examined the moderating roles of race and sex on the association between financial hardship and age-related decrements in eGFR. The second part of the analysis evaluated whether the comorbidity of cardiometabolic risk factors mediates the association between financial hardship and age-related decrements in eGFR. Furthermore, we tested whether the mediational role of comorbid cardiometabolic risk factors was based on race and sex. We used the PROCESS macro version 4.2 (43) to test our moderation and moderated mediation models.

The Association Between Financial Hardship and Age-Related Decrements in eGFR

The association between financial hardship and age-related decrements in kidney function was tested by regressing eGFR on age, financial hardship, and their interaction term (Figure 1B). We fit the unadjusted and adjusted models. The total score of financial hardship and also the scores for each domain of financial hardship were used. Age and financial hardship scores were mean-centered. Significant interactions ($p < .05$) were interrogated using the Johnson-Neyman method (44). Furthermore, to examine whether the association between financial hardship and age-related decrements in kidney function was conditional on race, we tested three-way interactions among age, financial hardship, and race on eGFR. Similarly, we tested three-way interactions among age, financial hardship, and sex on eGFR to examine if sex moderates the link between financial hardship and age-related decrements in kidney function. The unstandardized regression estimates (b) and their 95% confidence interval (CI) are reported.

Financial Hardship, Cardiometabolic Risk Factors, and Age-Related Decrements in eGFR

Regression-based moderated mediation analysis examined whether cardiometabolic risk factors mediated the association between financial hardship and age-related decrements in eGFR. The moderated mediation model is presented in Figure 1C. For parsimony and to limit the number of hypotheses tested, we used only the total score of financial hardship in the moderated mediation analysis. As depicted in the model, eGFR was regressed on age, financial hardship, and cardiometabolic risk factors. In addition, we examined if age also moderated the prediction of eGFR by financial hardship and cardiometabolic risk factors. Age and financial hardship scores were mean-centered. Significant interactions ($p < .05$) were interrogated using the Johnson-Neyman method (44), specifically testing age-related decrements in kidney function at three different points: younger (age = −1 standard deviation [SD]), middle (age = mean age), and older (age = +1 SD). The statistical significance of these indirect effects was tested using bootstrapping procedures using 10,000 bootstrapped samples. The analysis controlled for sociodemographic and health-related covariates. Finally, to explore if the mediation by cardiometabolic risk factors was conditional on race and sex, they are added as an additional moderator in separate moderated moderated-mediation models. Detailed information regarding the regression-based moderated mediation and moderated moderated-mediation analyses is provided in Section 2 of the Supplemental Digital Content, http://links.lww.com/PSYMED/A980.

RESULTS

Descriptive Information

Descriptive information about the sociodemographic characteristics and health of the participants is provided in Table 1, and bivariate correlations among all the variables are provided in Section 3 of the Supplemental Digital Content, http://links.lww.com/PSYMED/A980. Their mean (SD) age was 59.1 (12.8) years (range = 26–94 years), with more than 80% being 50 years or older. There were slightly more women, around 80% identified as NH White, and a larger proportion was married. Almost half of the participants reported having at least a bachelor's degree. The prevalence of current cigarette use (11.2%), obesity (44.5%), hypertension (53.6%), and insulin resistance (19.4%) were similar to the overall levels for middle-aged and older adults in the United States. Relative to those who self-identified as NH White, NH Black participants were significantly younger, more likely to be female, and less likely to be married. Furthermore, fewer Black participants had bachelor's degrees. Relative to the White subgroup, Black participants reported higher financial hardship based on the total score or the scores for each domain. Black participants were also more likely to smoke, be overweight, have elevated BP, and have fasting glucose and HbA_{1c} values indicative of type 2 diabetes. However, the mean eGFR was not different between Black and White participants. Relative to male participants, female participants were younger, less likely to be married, more likely to be NH Black, and less likely to have a bachelor's degree. In addition, female participants, relative to male participants, reported higher total scores of financial hardship and had higher scores in each domain of financial hardship. Finally, female and male participants showed similar numbers of cardiometabolic risk factors, but female participants had slightly higher mean eGFR than male participants.

Association Between Financial Hardship and Age-Related Decrements in eGFR

As expected, age was inversely associated with eGFR ($b = -0.73$, SE = 0.03, $p < .001$, $R^2 = 0.30$). The results from regression analysis on the association between financial hardship and

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TABLE 1. Demographic, Socioeconomic, and Health Characteristics of the Participants for All Participants (N = 1361) and Comparisons Based on Race and Sex

			Comparison Based on Race/Ethnicity		Comparison Based on Sex	
	Missing Data	All Adults (N = 1361)	NH Black (n = 258)	NH White (n = 1103)	Female (n = 731)	Male (n = 630)
Age, M (SD), y	—	59.1 (13.5)	54.5 (12.8)	60.2 (13.0)[a]	58.0 (13.2)	60.4 (13.6)[b]
Female, %	—	53.7	65.9	50.9[a]	—	—
Married, %	2	60.1	24.0	68.7[a]	51.2	70.7[b]
Bachelor's degree, %	1	49.2	25.2	54.9[a]	46.7	52.2[b]
NH Black, %	—	19.0	—	—	23.3	14.0[b]
Total score of financial hardship, M (SD)	4	6.4 (4.0)	9.3 (3.7)	5.7 (3.8)[a]	6.9 (4.0)	5.7 (4.0)[b]
Material domain (total score), M (SD)	11	1.3 (1.1)	2.3 (1.0)	1.1 (1.0)[a]	1.5 (1.2)	1.1 (1.0)[b]
Household income to poverty line ratio, %	35					
<300%		32.8	62.8	26.8[a]	40.5	25.7[b]
300–<600%		32.6	26.1	35.2	30.7	36.7
≥600%		32.0	11.1	37.9	28.8	37.5
No health insurance coverage	10	6.6	12.8	5.1[a]	6.7	6.4
Received public/government financial assistance	16	24.2	70.6	13.8[a]	28.0	20.5[b]
Psychological domain (total score), M (SD)	9	3.9 (2.6)	5.3 (2.4)	2.6[a]	4.2 (2.5)	3.5 (2.6)[b]
Current financial situation, %	55					
Worst		29.8	55.6	25.8	34.4	27.3[b]
Average		33.0	30.2	35.3	35.1	33.6
Best		33.1	14.2	38.9	30.5	39.1
Control over financial situation, %	60					
None		27.2	36.8	26.6	30.9	25.6
Neutral		26.4	20.5	29.1	27.3	27.9
In control		42.0	42.7	44.2	41.8	46.4
Availability of money to meet needs, %	10					
Not enough money		25.3	49.6	19.9[a]	29.8	20.5[b]
Just enough money		50.8	42.2	53.3	51.0	51.4
More than enough money		23.1	8.2	26.8	19.1	28.0
Difficulty paying bills, %	9					
Very/somewhat difficult		35.0	59.5	29.5[a]	39.8	29.9[b]
Not very		29.4	19.1	32.1	29.7	28.4
Not at all difficult		35.0	21.4	38.4	30.5	40.6
Behavioral domain (total score), M (SD)	—	1.2 (1.0)	1.7 (1.1)	1.1 (1.0)[a]	1.3 (1.1)	1.0 (1.0)[b]
Missed a credit card payment, %	1	14.9	27.9	11.9[a]	17.5	11.9[b]
Missed other debt payment, %	1	12.5	31.8	8.0[a]	14.5	10.2[b]
Sold possession to make ends meet, %	—	19.2	28.7	17.0[a]	21.1	17.0[b]
Cut back on spending	—	69.1	84.1	65.5[a]	75.2	61.9[b]
Health-related risk factors						
Currently smoking regularly, %	—	11.2	24.4	8.1[a]	11.9	10.3
Taking prescription medication, %	—	77.8	76.0	78.2	78.9	76.5
Obese	—	44.5	61.2	40.6[a]	45.8	43.0
Hypertension	—	53.6	64.0	51.2[a]	49.9	57.9[b]
Insulin resistance	—	19.4	32.2	16.4[a]	17.8	21.3
No. metabolic risk factors	—	1.2 (0.96)	1.57 (0.94)	1.1 (0.95)[a]	1.1 (0.97)	1.2 (0.95)
Kidney function						
eGFR CKD-EPI, no race adj., M (SD), ml/min/1.73 m^2	—	86.3 (17.9)	84.3 (20.9)	86.8 (17.1)	87.2 (17.5)	85.3 (18.3)[b]

NH = non-Hispanic; M (SD) = mean (standard deviation); eGFR = estimated glomerular filtration rate; CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration.

[a] Significantly different between Black and White adults.

[b] Significantly different between female and male participants.

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age-related decrements in eGFR are presented in Table 2A. Age-related decrements in eGFR were steeper among those with more financial hardship ($b = -0.02$, SE = 0.01, $p = .02$). Even after adjusting for sociodemographic and health-related covariates, higher financial hardship was significantly associated with steeper age-related decrements in eGFR ($b = -0.02$, SE = 0.01, $p = .01$; Figure 1D). Furthermore, analyses based on domains of financial hardship showed that each domain was significantly associated with age-related decrements in eGFR. In the fully adjusted models, higher material ($b = -0.08$, SE = 0.03, $p = .01$), psychological ($b = -0.02$, SE = 0.01, $p = .048$), and behavioral domains ($b = -0.07$, SE = 0.03, $p = .02$) were associated with steeper age-related decrements in eGFR. Detailed results from the regression analyses on the association between each domain of financial hardship and age-related decrements in eGFR are presented in Section 4 of the Supplemental Digital Content, http://links.lww.com/PSYMED/A980.

Racial Differences in the Association Between Financial Hardship and Age-Related Decrements in eGFR

The association between financial hardship and age-related decrements in eGFR was not conditional on race. In both the unadjusted (Table 2A; $b = 0.01$, SE = 0.02, $p = .60$) and adjusted models (Table 2A; $b = 0.01$, SE = 0.02, $p = .66$), the three-way interactions among age, financial hardship, and race were not associated with eGFR. Further analysis using the score for each domain of financial hardship also yielded nonsignificant results (see Section 5 of the Supplemental Digital Content, http://links.lww.com/PSYMED/A980).

Sex Differences in the Association Between Financial Hardship and Age-Related Decrements in eGFR

The association between financial hardship and age-related decrements in eGFR was conditional on sex in both unadjusted (Table 2A; $b = 0.03$, SE = 0.02, $p = .03$) and adjusted models (Table 2A; $b = -0.04$, SE = 0.02, $p = .01$). Sex differences in the association between financial hardship and age-related decrements in eGFR are depicted in Figure 1E. Among female participants, more financial hardship was associated with steeper age-related decrements in eGFR. Further analyses based on domains of financial hardship indicated that there were significant sex differences in the association between the psychological domain and age-related decrements in eGFR in both unadjusted ($b = -0.05$, SE = 0.02, $p = .03$) and adjusted models ($b = -0.06$, SE = 0.02, $p = .02$). Furthermore, the association between the behavioral domain and age-related decrements in eGFR was also conditional on sex, but only in the fully adjusted model (unadjusted: $b = -0.10$, SE = 0.06, $p = .09$; adjusted: $b = -0.12$, SE = 0.06, $p = .044$). Among female participants, higher scores in the psychological and behavioral domains of financial hardship were associated with steeper age-related decrements in eGFR. Moderation by age on the association between the material domain and age-related decrements in eGFR was marginally significant (adjusted: $b = -0.10$, SE = 0.06, $p = .073$). Detailed results from regression analyses that tested sex differences on the association between each domain of financial hardship and age-related decrements in eGFR are presented in Section 6 of the Supplemental Digital Content, http://links.lww.com/PSYMED/A980.

Financial Hardship, Cardiometabolic Risk Factors, and Age-Related Decrements in eGFR

Results from moderated mediation analysis showed that the index of moderated mediation was significant ($b = -0.003$, 95% CI = −0.006 to −0.001; Table 2B), providing evidence for a moderated mediation. More financial hardship was significantly associated with more comorbidity in cardiometabolic risk factors ($b = 0.02$, SE = 0.01, $p < .001$). In turn, more cardiometabolic risk factors were associated with steeper age-related decrements in eGFR ($b = -0.13$, SE = 0.03, $p < .001$). Finally, the direct effect of financial hardship on age-related decrements in eGFR remained significant ($b = -0.02$, SE = 0.01, $p = .038$). Exploratory analyses were conducted on whether the moderated mediation was conditional on sex and race. The indexes of moderated moderated mediation for race ($b = -0.003$, 95% CI = −0.006 to −0.001) and sex ($b = -0.003$, 95% CI = −0.006, to −0.001) were nonsignificant. These findings indicated that the moderated mediation pathway from financial hardship to age-related decrements in eGFR through cardiometabolic risk factors was not conditional on race or sex. Detailed results from the moderated moderated-mediation model by sex and race are presented in Section 7 of the Supplemental Digital Content, http://links.lww.com/PSYMED/A980.

DISCUSSION

Despite long-standing interest in how financial hardship compounds the effects of socioeconomic standing in creating health disparities (45,46), its contributions to key social processes that impact biological aging are still unclear. In this analysis, we used the material-psychological-behavioral framework of financial hardship and examined its association with age-related decrements in kidney function. Furthermore, we explored if the association was conditional on race and sex. Finally, we tested if the association between financial hardship and age-related decrements in kidney function was mediated by comorbidity of cardiometabolic risk factors (obesity, elevated BP, and insulin resistance) and explored if the mediational pathway was conditional on race and sex.

Higher financial hardship was associated with steeper age-related decrements in eGFR, a proxy indicator of renal clearance based on serum creatinine levels (calculated using the CKD-EPI formula without race adjustment). Further analysis showed that higher scores in each domain of financial hardship were consistently associated with steeper age-related decrement in eGFR. The association between financial hardship and age-related decrements in eGFR was not conditional on race but differed between female and male participants. Higher financial hardship was associated with steeper age-related decrements in eGFR among female but not male adults. Finally, our results support the hypothesis that the comorbidity of cardiometabolic risk factors partially mediated the association between financial hardship and age-related decrements in eGFR. However, this moderated mediation pathway was not conditional on race and sex.

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TABLE 2. Results From Regression and Moderated Mediation Analyses

A. Regression Analyses on the Association Among Financial Hardship, Race, Sex, and Age-Related Decrements in eGFR

	Unadjusted		**Adjusted**[a]	
	***B* (SE)**	**95% CI**	***B* (SE)**	**95% CI**
A1: Financial hardship and age-related decrements in eGFR				
Intercept	**86.14 (0.42)*** **	**[85.32 to 86.95]**	**88.18 (1.35) *** **	**[85.54 to 90.83]**
Age (centered)	**−0.75 (0.03)*** **	**[−0.81 to −0.69]**	**−0.75 (0.03)*** **	**[−0.81 to −0.68]**
Financial hardship (centered)	**−0.27 (0.10)** **	**[−0.47 to −0.07]**	−0.09 (0.11)	[−0.31 to 0.14]
Age by financial hardship	**−0.02 (0.01)* **	**[−0.03 to −0.01]**	**−0.02 (0.01)** **	**[−0.04 to −0.01]**
	R^2 = 0.31		R^2 = 0.33	
	F (3,1353) = 204.80***		*F* (10,1343) = 67.40***	
A2: Financial hardship, race, and age-related decrements in eGFR				
Intercept	**87.32 (0.46)*** **	**[86.42 to 88.21]**	**88.10 (1.35) *** **	**[85.92 to 92.09]**
Age (centered)	**−0.75 (0.03)*** **	**[−0.82 to −0.69]**	**−0.73 (0.04)*** **	**[−0.81 to −0.66]**
Financial hardship (centered)	−0.13 (0.12)	[−0.36 to 0.11]	−0.14 (0.12)	[−0.40 to 0.09]
Age by financial hardship	**−0.02 (0.01)* **	**[−0.04 to −0.01]**	**−0.02 (0.01)* **	**[−0.04 to −0.01]**
Race (0 = NH White, 1 = NH Black)	**−7.70 (1.27)*** **	**[−10.19 to −5.22]**	**−7.75 (1.33)*** **	**[−10.47 to −5.25]**
Age by race	−0.11 (0.10)	[−0.29 to 0.08]	−0.10 (0.10)	[−0.28 to 0.09]
Financial hardship by race	0.43 (0.29)	[−0.14 to 0.99]	0.39 (0.29)	[−0.18 to 0.97]
Age by financial hardship by race	0.01 (0.02)	[−0.03 to 0.06]	0.01 (0.02)	[−0.04 to 0.05]
	R^2 = 0.33		R^2 = 0.34	
	F (7,1349) = 95.90***		*F* (13,1340) = 52.09***	
A3: Financial hardship, sex, and age-related decrements in eGFR				
Intercept	**86.15 (0.62)*** **	**[84.94 to 87.35]**	**88.05 (1.35)*** **	**[85.40 to 90.70]**
Age (centered)	**−0.81 (0.05)*** **	**[−0.90 to −0.72]**	**−0.79 (0.05)*** **	**[−0.88 to −0.70]**
Financial hardship (centered)	**−0.53 (0.15)* **	**[−0.83 to −0.24]**	**−0.38 (0.16)* **	**[−0.69 to −0.07]**
Age by financial hardship	−0.00 (0.01)	[−0.02 to 0.02]	0.00 (0.01)	[−0.02 to 0.02]
Sex (0 = male, 1 = female)	−0.14 (0.84)	[−1.78 to 1.50]	0.26 (0.84)	[−1.38 to 1.92]
Age by sex	**0.14 (0.06)* **	**[0.02 to 0.27]**	0.11 (0.06)	[−0.01 to 0.24]
Financial hardship by sex	**0.46 (0.21)* **	**[0.05 to 0.87]**	**0.53 (0.21)* **	**[0.12 to 0.93]**
Age by financial hardship by sex	**−0.03 (0.02)* **	**[−0.06 to −0.01]**	**−0.04 (0.02)* **	**[−0.07 to −0.01]**
	R^2 = 0.17		R^2 = 0.34	
	F (7,1346) = 63.29 ***		*F* (13,1340) = 53.57 ***	

B. Results From the Moderated Mediation Analysis Among Financial Hardship, Cardiometabolic Risk Factors, and Age-Related Decrements in eGFR[b]

	Outcome			
	Cardiometabolic Risk Factors		**eGFR**	
	***B* (SE)**	**95% CI**	***B* (SE)**	**95% CI**
Financial hardship ➔ cardiometabolic risk factors ➔ age-related decrements in eGFR				
Intercept	**−0.37 (0.08)*** **	**[−0.53 to −0.22]**	**88.54 (1.31)*** **	**[85.98 to 91.11]**
Financial hardship (centered)	**0.02 (0.01)*** **	**[0.01 to 0.04]**	−0.11 (0.11)	[−0.33 to 0.12]
Cardiometabolic risk factors (centered)			−0.12 (0.45)	[−1.02 to 0.76]
Age (centered)			**−0.76 (0.03)*** **	**[−0.83 to −0.70]**
Financial hardship by age			**−0.02 (0.01)* **	**[−0.03 to −0.01]**
Cardiometabolic risk factors by age			**−0.13 (0.01)*** **	**[−0.19 to −0.06]**
	R^2 = 0.17		R^2 = 0.34	
	F (7,1346) = 63.29***		*F* (11,1342) = 63.29***	

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TABLE 2. *(Continued)*

B. Results From the Moderated Mediation Analysis Among Financial Hardship, Cardiometabolic Risk Factors, and Age-Related Decrements in eGFR[b]

	Outcome			
	Cardiometabolic Risk Factors		eGFR	
	B **(SE)**	**95% CI**	***B*** **(SE)**	**95% CI**
	Index of Moderated Mediation		**95% CI**	
Age	**−0.003 (0.001)**		**[−0.006 to −0.001]**	

Values in bold format represent significant associations.

eGFR = estimated glomerular filtration rate; SE = standard error; CI = confidence interval; NH = non-Hispanic.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

[a] Adjusted for sex (except for A3; 0 male, 1 = female), race/ethnicity (except for A2; 0 = NH White, 1 = NH Black), education (0 = no bachelor's degree, 1 = bachelor's degree), smoking status (0 = not currently smoking, 1 = currently smoking), taking prescription medication (0 = no, 1 = yes), and number of cardiometabolic risk factors.

[b] Adjusted for sex (0 = male, 1 = female), race/ethnicity (0 = NH White, 1 = NH Black), education (0 = no bachelor's degree, 1 = bachelor's degree), smoking status (0 = not currently smoking, 1 = currently smoking), taking prescription medication (0 = no, 1 = yes).

Financial Hardship and Age-Related Decrements in Kidney Function

This analysis corroborated findings from previous research and identify financial hardship as an important and distinct indicator of SES that can complement regularly used indicators such as education and household income. Previous studies have demonstrated that financial hardship was associated with cardiovascular disease (47), glucose regulation (48), and inflammation (49). Research has recently documented the link between more financial hardship and biological indicators of accelerated aging, including telomere length (50) and epigenetic aging (51). Our research demonstrating the significant association between financial hardship and age-related decrements in kidney function adds to the accumulating evidence that financial hardship is an important component of the socioeconomic factors that can affect biological aging.

Health inequity research does not have a clear definition or measure of financial hardship. Various terms have been used to describe financial hardship, including financial strain, financial distress, financial stress, financial difficulties, financial challenges, and financial toxicity (23). In this analysis, we used a novel approach to financial hardship, known as the material-psychological-behavioral framework of financial hardship (24,25). Although this approach has been commonly used in oncology research, it is less used in nephrology or aging-related research. We have demonstrated that worse financial hardship overall and in each specific domain is associated with worse kidney functioning across adulthood.

Racial and Sex Differences on the Association Between Financial Hardship and Age-Related Decrements in Kidney Function

Financial hardship was worse among NH Black relative to NH White participants, both in overall score and in each domain. However, we did not find support for the conclusion that the association between financial hardship and age-related decrements in eGFR differed between NH Black and NH White participants. Previous research has shown that when using household income and education, lower SES was associated with a higher risk of CKD among Black relative to White adults (52,53). However, our previous cross-sectional analysis showed that the interaction between race and parental education was not associated with age-related decrements in eGFR (14). This may indicate that the significant interaction between SES and race tends to be evident when considering clinical stages of CKD, especially when focusing on stages 3 and beyond, but not among healthy individuals. Future studies should examine if more severe financial hardship is associated with a higher burden of CKD among racially minoritized individuals and patient samples in nephrology clinics. In addition to documenting the interaction between financial hardship and race on the risk of CKD in the United States, future studies should also attempt to integrate multilevel analysis in understanding the role of systemic factors, such as systemic racism, at institutional and structural levels (54). Historical policies in the United States have resulted in persistent racial differences in lack of wealth and financial instability that disadvantage racially minoritized individuals, leading to disparities in access to health care, renal aging, and risk of CKD.

Furthermore, our analysis showed that the association between financial hardship and age-related decrements in eGFR was significantly differentiated by sex. Among female participants, more severe financial hardship was associated with steeper age-related decrements in kidney function. Furthermore, worse psychological and behavioral domains of financial hardship among female participants were also associated with steeper age-related decrements in kidney function. Although the disproportionately higher burden of CKD among female individuals has been well documented, little is known regarding the potential social, psychological, and biological factors contributing to these disparities (55). We demonstrated that financial hardship is an important socioeconomic factor that may contribute to sex disparities in aging associated with

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renal clearance. Our findings indicate that the psychological and coping behaviors associated with financial inadequacy were important contexts for how financial hardship is linked to steeper renal clearance among female participants. These results may be rooted in the gendered roles of family or household resource management that tend to be assigned to women individuals who identify as female. Thus, in instances of chronic financial hardship, female individuals tend to be impacted by more severe stress that can lead to worse health outcomes (56).

Financial Hardship, Comorbidity of Cardiometabolic Risk Factors, and Age-Related Decrements in Kidney Function

A previous study by Vart and colleagues (15) showed that comorbidity of cardiometabolic risk factors contributed 32% to the association between lower SES (especially lower education and income) and risk of CKD. Our results corroborated this finding and showed that comorbidity of cardiometabolic risk factors also mediates the link between financial hardship and aging renal clearance, even after controlling for education, sociodemographic factors, and health-related covariates (i.e., smoking and prescription use). The recent increasing rates of obesity, elevated BP, and insulin resistance among younger adults in the United States (57) are a warning sign for the potential impact on accelerated aging of renal clearance and the increased incidence of CKD. Perhaps because obesity is now so common among Americans, we did not find evidence that the mediating role of comorbidity of cardiometabolic risk factors was conditional on race or sex. Previous research also found similar findings regarding the nonsignificant moderation by sex on the mediating role of comorbidity of cardiometabolic risk factors (15). The absence of a sex-specific effect may also be because obesity tends to be higher among female individuals, whereas hypertension and diabetes are more likely be evinced by male individuals (55).

On the other hand, the absence of as significant racial difference in the mediating role for the comorbidity of cardiometabolic risk factors does differ from our own previous findings (14). In a prior analysis, we found that there were racial differences in the mediating role of cardiometabolic risk factors on the association between parental education and age-related decrements in eGFR (14). The difference may be due to multiple reasons. Parental education may indicate a longer accumulation of socioeconomic hardship when compared with current financial hardship. Thus, parental education may be more sensitive for detecting racial differences in cardiometabolic risk factors. Furthermore, we used a different formula for eGFR in this analysis, which is not adjusted for race, which could have also yielded different results. Further research, especially with prospective, longitudinal assessment, is still needed to resolve this inconsistency and to examine the mediating role of cardiometabolic risk factors more systematically on aging renal clearance.

Limitations

It should also be acknowledged that our study does have some limitations. First, this analysis was cross-sectional; thus, age-related differences in eGFR were determined across individuals of different ages as a proxy of how aging affects renal clearance. However, the analysis of kidney functioning spanned both middle and older adulthood with a wide age range. Second, the generalizability of these findings does not apply to the entire US population, given the low representation of other racial groups, including Asian and Native Americans. Participants in the biological arm of the MIDUS project involved Black participants recruited by oversampling one city, Milwaukee, Wisconsin, to facilitate travel to the clinical research unit in Madison, Wisconsin. On the other hand, the wide range of information acquired in the MIDUS study did provide the opportunity to generate a more comprehensive assessment of financial hardship. Future studies should replicate these findings in a larger sample with a more systematic representation of racially minoritized individuals. Finally, our measure of kidney function was limited to a serum creatinine–based measure of eGFR. Although known to be sensitive for characterizing age-related declines in kidney function when renal clearance is poor—less than 60 ml/min/1.73 m^2—the eGFR is not as accurate in healthier, middle-aged, healthier adults. In addition, a primary tissue source of creatinine in circulation is muscle. Individuals who perform manual labor tend to have higher muscle mass (i.e., higher creatinine clearance) and may also have experienced more financial hardship. Unfortunately, we cannot disentangle the potential influence of muscle mass based on labor status in our analysis. In addition, muscle mass may decline more precipitously in disadvantaged, older women, especially with limited leisure activity and exercise opportunities, or with obesity and clinical sarcopenia. Future analysis should also use other measures of renal clearance, which may be less influenced by muscle mass, such as serum cystatin or the ratio of albumin/creatinine to confirm the conclusions about the effects of financial hardship on age-related declines in kidney function.

CONCLUSIONS

Although financial hardship is not a new construct in health disparities research, our analysis is among the first to show that it is an important socioeconomic factor associated with age-related decrements in kidney function. Our analysis considered financial hardship within a novel material-psychosocial-behavioral framework and showed its utility and value in geroscience. Worse financial hardship, based on the total score or scores for each domain, was associated with steeper age-related decrements in kidney function. We found that worse financial hardship was associated with steeper age-related decrements in kidney function among female but not male participants. However, the association between financial hardship and age-related decrements in kidney function was not conditional on race. Finally, our analysis showed that the comorbidity of cardiometabolic risk factors partially mediated the association between financial hardship and age-related decrements in kidney function. Given that age-related changes in renal clearance are critical predictors for progression to the clinical stages of CKD (i.e., stages 4 and 5), these findings have significant translational implications for geroscience. In addition to incorporating traditionally used indicators of SES, such as education and income, future research on social hallmarks that accelerate aging should also consider

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the role of financial hardship on the aging process and age-related diseases.

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