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Sleep and Cardiometabolic Health by Government-Assisted Rental Housing Status among Black and White Men and Women in the United States

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Abstract

Objectives: To investigate Black-White disparities in suboptimal sleep and cardiometabolic health by government-assisted rental housing status

Design: National Health Interview Survey (NHIS) pooled cross-sectional data (2004-2016)

Setting: United States

Participants: Black and White adult participants (n=80,880)

Measurements: Poisson regression with robust variance was used to estimate prevalence ratios (PRs) and 95% confidence intervals for self-reported unrecommended (<6 hours), short (6–7 hours), and long (>9 hours) sleep duration (each separately vs. recommended (7–9 hours)) and sleep difficulties (e.g., trouble falling/staying asleep ≥ 3 days/week) (yes vs. no) among Blacks compared to Whites within rental housing categories (government-assisted vs. unassisted), separately, for men and women. Within sex/housing categories, we applied the same approach to compare cardiometabolic health outcomes (i.e., overweight/obesity, hypertension, diabetes, heart disease, stroke) between Blacks with worse sleep and Whites with recommended sleep. Models were adjusted for age and other potential confounders.

Results: Participants' mean age was 42±18 years, 57% were female, and 30% Black. Blacks in unassisted housing had a higher prevalence of unrecommended and short sleep (PR=1.22 [1.15-1.30] -men, PR=1.14 [1.08-1.21] -women) compared to their White counterparts ($p_{\text{housing} \times \text{race}}=0.001$ -men, $p_{\text{housing} \times \text{race}}=0.008$ -women), but no Black-White differences (PR=0.88 [0.73-1.07] -men, PR=0.98 [0.89-1.09] -women) were observed among government-assisted renters. Generally, Blacks were less likely to report sleep difficulties than Whites. Cardiometabolic

health disparities between Blacks with worse sleep and Whites with recommended sleep were mostly smaller among government-assisted renters, but relationships varied by sex.

Conclusions: There were no racial disparities in sleep duration, and cardiometabolic health disparities were generally attenuated when Blacks and Whites resided in government-assisted rental housing.

Keywords

Public housing; Sleep; Social determinants of health; Health status disparities; Cardiovascular disease; African Americans

INTRODUCTION

Blacks in the United States are more likely than their White counterparts to have established cardiovascular disease (CVD) risk factors [1], and are twice as likely to die from CVD [2]. Suboptimal sleep is a less well-established contributor to racial/ethnic disparities in cardiovascular health [3]. Poor sleep is associated with an increased risk of obesity, hypertension, type 2 diabetes, coronary heart disease, stroke, and premature mortality [4-6]. While one-third of US adults report not getting the recommended amount of sleep suggested for optimal health [7, 8], Black/African-American adults (46%) are more likely to report not obtaining the recommended amount of sleep [7]. Given the apparent detrimental impact of poor sleep on cardiometabolic health and Black-White disparities in sleep health [7, 9, 10], sleep may help explain recalcitrant, poorly understood disparities in cardiometabolic health by race/ethnicity [3].

Housing tenure, the financial arrangement by which housing is occupied, may contribute to racial/ethnic disparities in sleep and cardiometabolic health by determining where individuals live and their direct exposures, but there is limited research regarding these relationships in the epidemiologic literature. One prior study of British adults found that compared to homeowners and private renters, residents in public housing or government-assisted rentals – where they have lower rent because it is partially paid by the local, state, or federal government – had a higher prevalence of frequent sleep problems [11]. There are currently no comparable studies among US adults (to our knowledge), but data from the American Housing Survey (2011 and 2013) suggest that government-assisted renters may live in residences with greater incidences of severe physical problems/breakdowns (i.e., plumbing and sewage disposal breakdowns, heating equipment breakdowns, and leaking water inside units) compared to unassisted renters [12, 13]. Although differences were small, other issues more prevalent among government-assisted renters include inadequate heating and insulation, cold temperatures in the winter, peeling paint, and signs of rodents and cockroaches [13]. These suboptimal environmental features of housing could contribute to noise pollution due to poor insulation, suboptimal indoor temperatures, and poor indoor air quality, which are factors that can negatively affect one's ability to initiate and maintain healthy sleep [14]. Furthermore, social environments may be worse among public housing tenants who reported lower neighborhood ratings compared to unassisted renters [12]. Neighborhood factors (e.g., noise, air pollution, high crime due to poverty) are also more common among low income residences [15]. Such exposures are also increasingly

associated with worse sleep and cardiometabolic health outcomes (e.g., obesity, cardiovascular disease) [3, 16].

Black-white disparities in both sleep and cardiometabolic health have been observed in prior literature, and the historical legacy of racial residential segregation likely contributes to these disparities due to the potential for vastly different physical and social environmental exposures by race whereby Blacks generally experience more inopportune, health damaging exposures [15]. However, Blacks and Whites living in government-assisted housing are likely to live in more similar environments that impact sleep and cardiometabolic health. In fact, previous studies have demonstrated similar housing environments between Black and White residents of assisted housing [17] as well as reduced or non-existent racial disparities in sleep and cardiometabolic health outcomes when low-income Blacks and Whites live in similar or integrated environments [18, 19]. However, these studies did not measure housing tenure as a possible modifier of racial disparities in poor sleep and cardiometabolic health. Given the potential environmental commonalities between Black and White residents of government-assisted rental housing, it is important to consider housing tenure in investigations of racial disparities in sleep and cardiometabolic health. Therefore, the objective of our study was to investigate housing tenure as a potential modifier of associations between race and (1) sleep duration/quality and (2) cardiometabolic health outcomes in a nationally representative sample of US-born Black and White housing renters. We investigated men and women separately because sleep characteristics like insomnia symptoms, relationships between home socioeconomic environments and sleep, and racial disparities in cardiometabolic health outcomes like obesity vary by sex [20-22]. We hypothesized that smaller disparities in sleep and cardiometabolic health would be observed between Blacks and Whites living in government-assisted rental housing compared to Blacks and Whites living in unassisted rental housing.

PARTICIPANTS & METHODS

The National Health Interview Survey (NHIS)

We analyzed a series of cross-sectional data from the NHIS for the survey years 2004-2016. NHIS is an annual household interview survey that employs a multistage sampling design, which permits representative sampling of the non-institutionalized US civilian population. A detailed description of the NHIS is published elsewhere [23]. Briefly, interviewers, trained by the US Census Bureau per National Center for Health Statistics (NCHS) procedures, obtained self-reported sociodemographic characteristics and health information through in-person interviews from a probability sample of households. A random adult and child (if present; not included in this analysis) provided additional health information. Data were collected with computer-assisted personal interviewing. The response rate for adults was 81% (range: 74.2% in 2008-83.8% in 2004). Participants provided written informed consent, and NHIS protocols were approved by the NCHS review board.

Study population

We included participants who were at least 18 years of age, rented their homes, and self-identified their race/ethnicity as non-Hispanic White or non-Hispanic African American/

Black. Participants were excluded if they had missing data for housing tenure, cardiometabolic outcomes (including weight/height), sleep duration (<3%), or if they reported <3 or >22 hours of sleep duration. We also excluded participants born outside of the US because evidence suggests sleep pattern differences exist between foreign-born and native US residents [24]. Our final analytic sample consisted of 80,880 adults.

Measures

Race/ethnicity—Participants were asked what race or races they considered themselves to be and could select one or more of 12 categories. Participants were also asked to report Hispanic or Latino ethnicity. Our analysis was restricted to participants who self-identified as non-Hispanic/Latino and either White or Black/African American (hereafter referred to as White or Black).

Government-assisted rental housing status—Only families who rent their houses or apartments were asked about government-assisted rental housing. Participants were classified as government-assisted renters if they provided an affirmative response (yes vs. no) to the following question: “[Are you/Is anyone in your family] paying lower rent because the Federal, State, or local government is paying part of the cost?”.

Sleep duration and sleep difficulties—NHIS interviewers were instructed to record the number of hours slept on average during a 24-hour period in whole numbers, rounding values 30 minutes or more up to the nearest hour and otherwise rounding down to the nearest hour [23]. Based on the National Sleep Foundation recommendations, we categorized sleep duration as unrecommended (<6 hours), short sleep (6–<7 hours), recommended sleep (7–9 hours), and long sleep (>9 hours) [8, 25]. We combined unrecommended and short sleep into a short sleep category (<7 hours) in analyses regarding cardiometabolic health. In addition to being recommended by the National Sleep Foundation, seven-to-nine hours of sleep was used as the reference category because it is associated with the lowest levels of morbidity and mortality [26, 27]. Sleep difficulties in the past week included reports of trouble falling asleep and trouble staying asleep (both ≥3 days/week vs. <3 days/week), days woke up feeling rested (‘most’ (4–7 days) vs. ‘few/none’ (0–3 days)), and taking sleep medication ≥3 days/week (vs. <3 days/week). While sleep duration data were available for all survey years (2004–2016), sleep difficulties data were available for the years 2013–2016.

Cardiometabolic health outcomes—We investigated several cardiometabolic health outcomes. Participants self-reported health professional’s diagnosis of hypertension, diabetes, heart disease, or stroke (all separate, yes vs. no) by responding to ‘Have you ever been told by a doctor or health professional that you have [the aforementioned conditions]?’. Heart disease included coronary heart disease, angina pectoris, or myocardial infarction. We used self-reported weight and height to calculate body mass index by dividing weight (kilograms, kg) by height (meters-squared, m²) and created categories: overweight (BMI 25.0 kg/m²) and obesity (BMI ≥30.0 kg/m²) versus normal weight (18.5 ≤BMI<25.0 kg/m²) [28].

Covariates—Participants reported their age (years) and we created age categories (18-30, 31-49, 50-64, 65 years). Socioeconomic status variables included annual household income (<\$35,000, \$35,000-<\$75,000, \$75,000); living in poverty (<100% Federal Poverty Level or 100% Federal Poverty Level); receipt of other forms of government assistance (i.e., food stamps (supplemental nutrition assistance program (SNAP)) or welfare) (yes vs. no); educational attainment (< high school, high school graduate, some college, or college); and employment status (unemployed or not in work force vs. employed). Marital status was categorized as married, divorced/separated/widowed, or never married. From the 23-standardized occupational codes available, we combined occupations into three meaningful occupational status categories (professional/management, support services, or laborers). Region of residence consisted of the Northeast, Midwest, South, and West.

Health behaviors beyond sleep duration were smoking status (never, former, current), alcohol consumption (never, former, current), and leisure-time physical activity (never/unable, low, high). Lastly, we categorized self-reported health status as excellent/very good, good, or fair/poor.

Statistical analysis

Thirteen survey years of NHIS data (2004-2016) were merged by the Integrated Health Interview Series [29]. In all analyses, we used sampling weights that account for the complex sampling design, oversampling of subgroups (e.g., racial/ethnic minorities, elderly), and non-response [23]. We calculated standard errors by applying Taylor series linearization. Each statistical test was two-sided and a p-value of 0.05 was used to determine statistical significance. For all analyses, we used STATA 14 statistical software (Stata Corporation, College Station, Texas, USA).

Using the direct standardization method, we calculated age-standardized, weighted percentages of all categorical variables by sex, race, and government-assisted housing status. All percentages were standardized to the age structure of the 2010 census. After the *a priori* stratification of government-assisted housing status and sex, we used Poisson regression models with robust variance estimators to calculate prevalence ratios (PRs) and confidence intervals (CIs) to compare dichotomously-categorized sleep and cardiometabolic health outcomes between Blacks and Whites in the models described below. White participants were the reference group for these comparisons because Whites 1) had the largest sample size for greater statistical stability and 2) are the majority population in the US. We compared sleep duration (unrecommended, short, and long sleep duration (separately) vs. recommended sleep duration) and sleep difficulties between Blacks and Whites and calculated housing tenure-by-race and sex-by-race interaction terms using log likelihood tests for statistical significance. By sex within housing category, we then compared the prevalence of each cardiometabolic health outcome (i.e., hypertension, overweight, obesity, diabetes, heart disease, and stroke) between (1) Blacks with short sleep duration, (2) Blacks with recommended sleep duration, and (3) Blacks with long sleep duration to Whites with recommended sleep duration. We used this approach to determine how racial differences in cardiometabolic health were affected by sleep duration within each housing category and sex. Lastly, we combined sleep duration and difficulty measures to create a poor sleep (short

sleep, long sleep, trouble falling asleep, trouble staying asleep, not feeling rested most days, or sleep medication use) versus non-poor sleep (recommended sleep duration and no sleep difficulties) variable to compare the prevalence of cardiometabolic health outcomes for Black men and women with poor sleep to their White counterparts with non-poor sleep within each housing tenure category. Due to data limitations, poor sleep was inclusive of sleep duration and quality only for the years 2013-2016. All final models were adjusted for *a priori* potential confounders: age category, educational attainment, annual household income, occupational class, general health status, and region of residence.

RESULTS

Study population characteristics

The age-standardized prevalence of sociodemographic characteristics, health behaviors, cardiometabolic health outcomes, and general health status are described by government-assisted housing status among 80,880 White and Black renters (Table 1). Nine percent of men (46% of whom were Black) and 20% of women (54% of whom were Black) were government-assisted renters.

Sociodemographic Characteristics.—Regardless of government-assisted housing status, White men and women were more likely to have completed at least some college. Black male and female government-assisted housing renters mostly resided in the Southern US while their White counterparts were more evenly distributed across the US.

Sleep Duration and Difficulties.—Among government-assisted renters, Black and White men had a similar prevalence of habitual unrecommended (15% White, 14% Black) and short sleep duration (20% White, 19% Black), but White men were more likely to report long sleep duration (13% White, 9% Black). Among unassisted renters, Black men had a higher prevalence of unrecommended (13% vs. 10%) and short sleep duration (25% vs. 22%) than White men. Similarly, Black and White women in government-assisted housing had a similar prevalence of unrecommended and short sleep duration, but White women had a higher prevalence of long sleep. Black women had a higher prevalence of unrecommended (14% vs. 11%) and short sleep (24% vs. 22%) duration compared to their White counterparts in unassisted housing. Regardless of housing status, White adults more often reported trouble staying asleep and sleep medication use compared to Black adults.

Cardiometabolic Health.—The prevalence of most cardiometabolic health outcomes, including obesity, was higher among Blacks compared to Whites, and these racial differences were often greater among unassisted renters compared to government-assisted renters. Conversely, Blacks had a lower prevalence of heart disease than Whites.

Black-White disparities in sleep duration/difficulties by housing tenure

There was no Black-White disparity in unrecommended and short sleep duration among government-assisted renters; however, Blacks in unassisted housing had a higher prevalence of unrecommended and short sleep duration compared to their white counterparts, after adjustment ($PR_{\text{unrecommended sleep}}=1.33$ [95% CI: 1.21-1.46] for men ($p_{\text{tenure} \times \text{race}}=0.002$);

$PR_{\text{unrecommended sleep}}=1.11$ [95% CI: 1.02-1.20] for women ($p_{\text{tenure*race}}=0.360$); $PR_{\text{short sleep}}=1.22$ [95% CI: 1.15-1.30] for men ($p_{\text{tenure*race}}=0.001$); $PR_{\text{short sleep}}=1.14$ [95% CI: 1.08-1.21] for women ($p_{\text{tenure*race}}=0.008$); , Table 2, Supplemental Table 1, Supplemental Figure 1a)). Furthermore, Black men in government-assisted housing were less likely to report long sleep than their White counterparts ($PR=0.74$ [95% CI: 0.55,0.99]), and Black male unassisted renters had a 20% higher prevalence of long sleep compared to their white counterparts ($PR=1.20$ [95% CI: 1.00-1.44], $p_{\text{tenure*race}}=0.004$). Black men and women were less likely to report frequent trouble falling asleep, trouble staying asleep, and taking sleep medication than White men and women regardless of government-assisted housing status. Racial differences in feeling rested significantly varied by housing status only among men (government-assisted renters: $PR=1.23$ [95% CI: 1.07,1.41] and unassisted renters: $PR=1.05$ [95% CI: 1.00,1.10] ($p_{\text{tenure*race}}=0.040$)) (Table 2, Supplemental Table 1, Supplemental Figure 1b).

Racial disparities in cardiometabolic health outcomes by housing tenure

Racial disparities in cardiometabolic health were similar across sleep duration categories and generally stronger among unassisted renters compared to government-assisted renters (Table 3). For both sexes, comparing Blacks with short and recommended sleep to Whites with recommended sleep, Black-White differences in the prevalence of overweight and obesity were consistently greater among unassisted renters compared to government-assisted renters. For instance, among government-assisted housing renters, Black male short sleepers were no more likely to be overweight ($PR=0.98$ [95% CI: 0.88-1.10]) or obese ($PR=0.97$ [95% CI: 0.80-1.18]) compared to White male recommended sleepers; but, among unassisted renters, Black male short sleepers had a 13% ($PR=1.13$ [95% CI: 1.09-1.17]) higher prevalence of overweight and 35% ($PR=1.35$ [95% CI: 1.26-1.44]) higher prevalence of obesity compared to White male recommended sleepers. Black female short and recommended sleepers had a higher prevalence of hypertension, overweight, and obesity regardless of housing tenure; however, racial differences were also greater among unassisted renters compared to government-assisted renters. For instance, Black women with short sleep in government-assisted housing had a 29% ($PR=1.29$ [95% CI: 1.18-1.41]) higher prevalence of hypertension, but those in unassisted housing had a 55% ($PR=1.55$ [95% CI: 1.44-1.67]) higher prevalence of hypertension compared to White counterparts with recommended sleep duration. Racial differences in cardiometabolic health outcomes between Black long sleepers and White recommended sleepers did not vary by housing tenure. Overall, Blacks were less likely to have heart disease than Whites.

When sleep duration and sleep quality were combined to compare Blacks with poor sleep to Whites with non-poor sleep, results described in Table 4 were like those observed in Table 3 (except for hypertension among men). Among men, there were no racial differences in certain cardiometabolic health outcomes (i.e., overweight, obesity, diabetes, heart disease) between Black poor sleepers and White non-poor sleepers in government-assisted housing; however, among unassisted renters, Black men with poor sleep had a higher prevalence of overweight, obesity, and diabetes than White men with non-poor sleep. Racial differences in cardiometabolic health between Black women with poor sleep and White women with non-poor sleep in unassisted housing were greater than racial differences observed among

government-assisted renters. For example, Black women with poor sleep in government-assisted housing had a 36% higher prevalence of obesity (PR=1.36 [95% CI: 1.12-1.66]), but Black women with poor sleep in unassisted housing had a 76% higher prevalence of obesity (PR=1.76 [95% CI: 1.59-1.94]) compared to their White counterparts with non-poor sleep.

DISCUSSION

In a nationally representative study of US-born Black and White adult residents of rental housing, we found important Black-White disparities in sleep and cardiometabolic health outcomes that varied by housing tenure among both men and women. There was no racial disparity in the prevalence of unrecommended and short sleep duration between Blacks and Whites in government-assisted housing, but Blacks in unassisted housing were more likely to report unrecommended, short, and long sleep duration than their White counterparts. However, Whites were generally more likely to self-report sleep difficulties. Among men, we observed Black-White racial disparities in overweight, obesity, and diabetes only among residents of unassisted housing across sleep duration categories. Worse cardiometabolic health was apparent among Black compared to White women regardless of sleep duration and housing tenure. However, the racial disparities in hypertension, overweight, and obesity associated with worse sleep among Black women were greater among residents of unassisted housing.

Our results are consistent with prior research. In Great Britain, residents of public housing reported a higher prevalence of sleep problems compared to private renters [11]. Similarly, in our study, government-assisted housing renters often had worse sleep than their counterparts in unassisted housing. Furthermore, studies of Black-White disparities in poor sleep and cardiometabolic health have consistently shown a higher prevalence of each among Blacks compared to Whites [3, 30]. Prior research also shows – like our study – that although Black-White disparities in short sleep and poor cardiometabolic health persist in the general population, those racial disparities attenuate or even disappear when Blacks and Whites are socioeconomically similar and reside in comparable environments [18, 19]. Specifically, Gamaldo et al. found no racial disparities in short sleep duration among Blacks and White residents of similar urban neighborhoods, and LaVeist et al. found that, compared to NHIS 2003 data, racial disparities in obesity and diabetes disappeared and disparities in hypertension decreased among similarly educated White and Black residents of racially-integrated, low-income communities [19].

Environmental similarities between Blacks and Whites in government-assisted housing and dissimilarities between Black and White unassisted renters could explain the variation in sleep disparities by housing tenure. In the American Housing Survey, compared to unassisted renters, government-assisted renters were more likely to report poor insulation, cold temperatures, and conditions that could result in a suboptimal sleep environment and thus poor sleep [12-14]. Black and White government-assisted renters may live in comparable suboptimal sleep environments. Furthermore, income disparities by race in which Blacks, on average, have lower incomes and consequently, have a greater likelihood of living in worse housing conditions than Whites can result in racial differences in home environments, especially among unassisted renters. Furthermore, the removal of

socioeconomic dissimilarities among government-assisted renters may affect observed racial disparities in sleep. For example, in an analysis NHIS 2004-2015 data, there were no racial differences in short sleep duration between Black and White mobile home/trailer residents who likely lived in similar low income and lower quality housing, but among apartment/house residents, Black men and women had a higher prevalence of short sleep compared to their White counterparts [31]. Outside of the home, worse neighborhood environmental conditions may lead to greater exposure to psychosocial stressors (e.g., social disorder, lack of safety, low social cohesion) that likely contribute to harmful health behaviors, insufficient sleep duration, and poor cardiometabolic health [16, 32-37]. Furthermore, poor sleep can subsequently affect cardiometabolic health by affecting the diurnal patterns of blood pressure and heart rate, insulin sensitivity, and ability to maintain physiological homeostasis [3]. Factors related to housing environment differences, or lack thereof among government-assisted renters, not race, could partially explain the observed variation in racial disparities in sleep and cardiometabolic health by housing tenure. Nonetheless, disparities in cardiometabolic health between Blacks and Whites with recommended sleep duration were only marginally attenuated compared to those observed between Blacks with short sleep and Whites with recommended sleep duration. This finding suggests there are other factors in combination with sleep and housing tenure required for further investigation of Black-White cardiometabolic health disparities.

Our study has several limitations. First, all data were self-reported and there is potential for misclassification/measurement error. Specifically, the rounding up and down of sleep duration to the nearest hour may result in misclassification of individuals into sleep duration categories and affect results. While housing tenure is unlikely to be misreported, participants have been shown to overestimate sleep duration and Whites are more likely to report sleep difficulties despite worse objectively-measured sleep among racial/ethnic minorities [38-40]. Future studies including objective sleep measures are needed. Compared to higher-income adults and Whites, low-income individuals and racial/ethnic minorities may also be more likely to underreport physician diagnoses of cardiometabolic health outcomes due to limited healthcare access and utilization. The results suggesting a lower prevalence of self-reported heart disease among Blacks compared to Whites could be due to differential access to and utilization of healthcare whereby heart disease among Blacks is under-diagnosed and/or underreported. Second, the cross-sectional study design prevented our ability to establish temporality and avoid biases related to endogeneity and reverse causation, which may mask the dynamic nature of housing tenure. Third, detailed residential environment data were not available. For instance, we were unable to distinguish between distinct types of government-assisted housing, locations, and neighborhoods in which renters live. We were also unable to adjust for factors (e.g., neighborhood social cohesion) that may buffer the effects of an otherwise adverse environment on health. Future research using longitudinal designs should consider these physical and social environmental factors along with accessibility of resources, and other environmental exposures surrounding the housing environment. It would also be useful to incorporate biological data like biomarkers to better understand how these environmental factors affect health. Lastly, some results could be due to chance because we tested for multiple associations; however, we sought to capture any possible associations that offer opportunities for future research.

Despite the limitations, this study has several important strengths. Most prior epidemiologic studies have focused on the neighborhood rather than housing tenure as a proxy for more immediate exposures, but we investigated the understudied associations between this exposure, sleep, and cardiometabolic health. We used recently available data to capture contemporary racial disparities and broadened the findings of the aforementioned nationally representative British study [11] to a large, representative sample of US-born Black and White adult rental housing residents in the US; thus, our findings extend the existing literature. Additionally, the NHIS has quality control procedures that increase the validity of the findings. We also had a large population of Black men and women, which allowed for robust stratification by sex and housing tenure. Furthermore, we estimated prevalence ratios, rather than odds ratios which can overestimate prevalence when outcomes are not rare.

This study has several public health implications and future research directions in addition to those previously mentioned. First, the potential economic and health effects of political policies and decisions should be considered. Certain policies (e.g., density zoning [regulations of residential construction density], gerrymandering, and land-use laws) contribute to the supply, price, and distribution of affordable housing [41]. Such policies affect housing and surrounding environments and may result in differential sleeping environments between Blacks and Whites. Second, government-assisted housing (particularly housing vouchers), social determinants of health that may contribute to racial differences in housing environments like residential segregation which remains pervasive in the US [42], and other housing environment exposures are understudied and often not collected by national health surveys. If these measures were available, research could better elucidate their independent and combined relationships with sleep and cardiometabolic health. Third, we largely observed racial disparities among women regardless of housing tenure. Because women are often primary caregivers, there are implications for children's health and well-being, which deserves further attention. Fourth, it is important to repeat our investigation among other racial/ethnic groups such as Hispanics/Latinos and Asians. Lastly, more research related to relationships between mixed-income housing and health behaviors is necessary.

CONCLUSIONS

We found no Black-White disparities in sleep duration and that cardiometabolic health disparities were generally attenuated among residents of government-assisted rental housing compared to unassisted rental housing residents. Black and White residents of government-assisted housing may live in more similar physical and social environments, while higher-income Blacks and Whites are less likely to live in comparable environments. Future longitudinal studies are necessary to examine differences in environmental features that contribute to racial disparities in sleep and cardiometabolic health. Illuminating the various pathways by which these differentially-experienced environmental factors lead to health disparities can provide important insights for intervention development to help prevent disparities in chronic disease.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ABBREVIATIONS

PR	Prevalence ratio
BMI	Body mass index
CI	Confidence interval
NCHS	National Center for Health Statistics
NHIS	National Health Interview Survey

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Table 1.

Age-Standardized Sociodemographic, Health Behavior, and Clinical Characteristics among US White and Black Renters by Sex, Housing Tenure, and Race, National Health Interview Survey, 2004-2016 (N = 80,880) ^a

	Men, n=35,151 (43%)						Women, n=45,729 (57%)					
	Government-assisted Housing (yes) n=3,212 (9%)			Government-assisted Housing (no) n=31,939 (91%)			Government-assisted Housing (yes) n=9,050 (20%)			Government-assisted Housing (no) n=36,679 (80%)		
	White	Black		White	Black		White	Black		White	Black	
	n	%		n	%		n	%		n	%	
Sample size	1,719	54		24,478	77		4,909	54		26,211	71	
Age, mean ±SE (years)	49.0	0.76		37.6	0.20		40.5	0.50		39.0	0.23	
Annual household income												
<\$35,000/year	1,619	94		12,203	48		4,546	95		14,555	55	
\$35,000 - <\$75,000	59	6		7,591	34		191	5		7,343	32	
\$75,000	7	1		3,345	18		9	0		2,760	13	
Living in poverty (yes)	918	58		4,130	14		3,181	69		5,317	18	
Other government assistance (yes)	928	56		2,577	12		3,483	67		4,374	16	
Educational attainment												
< High school	438	25		2,043	12		1,416	33		2,266	11	
High school graduate	683	41		6,922	30		1,902	39		6,898	32	
Some college	445	25		8,674	31		1,421	25		9,805	35	
College	134	9		6,788	26		155	3		7,187	23	
Marital status												
Married	219	21		5,680	36		193	6		6,255	31	
Divorced/separated/widowed	743	36		6,243	32		1,750	44		9,451	44	
Never married	751	43		12,496	32		2,957	50		10,429	25	
Unemployed/not in work force (yes) ^b	1,395	80		6,866	40		3,272	73		9,656	47	
Occupation												
Professional/management	108	6		4,820	20		145	4		3,599	13	
Support Services	373	25		7,196	29		2,459	53		15,774	63	
Laborers	1,045	69		11,312	50		1,626	43		5,425	23	

	Men, n=35,151 (43%)												Women, n=45,729 (57%)											
	Government-assisted Housing (yes) n=3,212 (9%)						Government-assisted Housing (no) n=31,939 (91%)						Government-assisted Housing (yes) n=9,050 (20%)						Government-assisted Housing (no) n=36,679 (80%)					
	White		Black		White		Black		White		Black		White		Black		White		Black		White		Black	
Region of residence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Northeast	508	31	316	23	3,905	18	899	14	1,044	25	910	21	4,130	17	1,345	15								
Midwest	503	29	326	23	6,675	26	1,414	20	1,371	33	1,007	21	7,249	28	1,998	21								
South	331	20	672	44	7,309	31	4,180	55	989	25	2,562	49	8,081	31	6,056	54								
West	377	20	179	11	6,589	24	968	12	737	17	430	9	6,751	24	1,069	10								
Sleep duration																								
Unrecommended (<6 hours)	257	15	218	14	2,355	10	1,046	13	631	15	718	16	2,763	11	1,412	14								
Short (6-<7 hours)	343	20	299	19	5,623	22	1,921	25	944	23	1,108	22	5,752	22	2,700	24								
Recommended (7-9 hours)	916	52	842	58	15,646	63	4,128	56	2,214	53	2,702	54	16,531	61	5,786	54								
Long (>9 hours)	203	13	134	9	854	5	366	7	352	9	381	7	1,165	5	570	7								
Trouble falling asleep (3 days/week)	221	31	141	26	1,979	20	465	20	633	40	489	33	2,888	31	875	26								
Trouble staying asleep (3 days/week)	260	37	149	27	2,270	29	553	24	719	44	513	34	3,405	37	966	31								
Woke up feeling rested most days (4 days/week)	389	56	341	68	5,913	64	1,598	67	762	48	862	53	5,247	54	1,897	61								
Sleep medication (3 days/week)	152	21	57	10	818	11	153	7	383	24	221	16	1,339	17	312	10								
Smoking status																								
Never	527	31	566	39	11,251	39	3,978	48	1,652	38	2,775	54	13,840	48	7,070	64								
Former	507	29	314	20	5,059	28	1,074	21	1,051	23	675	17	4,952	23	1,078	15								
Current	683	40	613	40	8,131	32	2,394	32	1,434	39	1,451	28	7,387	28	2,305	21								
Alcohol consumption																								
Never	284	18	321	22	2,251	10	1,385	19	1,048	25	1,716	36	4,068	19	3,172	33								
Former	579	35	361	24	3,143	20	1,069	20	1,269	31	914	24	3,762	20	1,442	19								
Current	832	48	797	53	18,820	70	4,896	61	1,789	44	2,221	40	18,180	62	5,741	47								
Leisure-time physical activity																								
Never/unable	878	52	748	49	6,602	35	2,775	43	2,224	54	2,829	61	8,148	39	4,729	51								
Low	346	20	316	21	8,023	30	2,248	29	878	22	1,017	20	8,449	30	2,999	27								
High	491	27	427	29	9,754	34	2,406	28	1,032	24	1,051	20	9,557	31	2,714	23								

Men, n=35,151 (43%)												Women, n=45,729 (57%)																																																											
Government-assisted Housing (yes) n=3,212 (9%)						Government-assisted Housing (no) n=31,939 (91%)						Government-assisted Housing (yes) n=9,050 (20%)						Government-assisted Housing (no) n=36,679 (80%)																																																					
White												Black												White												Black																																			
n												%												n												%												n												%											
Cardiometabolic health outcomes																																																																							
Overweight (yes) ^c		1,148	68	963	64	15,215	67	5,157	70	2,744	69	3,613	76	13,324	58	7,516	75																																																						
Obesity (yes) ^d		587	52	453	45	6,035	46	2,442	53	1,633	57	2,303	68	6,868	42	4,493	65																																																						
Hypertension (yes)		810	46	750	49	5,719	36	2,389	43	1,961	45	2,203	56	6,142	35	3,591	50																																																						
Diabetes (yes)		334	20	295	20	1,522	11	771	16	770	19	775	22	1,752	11	1,054	17																																																						
Heart disease (yes)		368	21	214	14	2,297	17	598	12	918	21	636	17	2,580	14	854	13																																																						
Stroke (yes)		148	8	132	9	561	5	265	6	376	8	304	9	784	5	367	6																																																						
Health status																																																																							
Excellent/very good		462	26	460	32	15,587	53	4,081	45	1,231	28	1,740	28	15,999	52	5,316	41																																																						
Good		581	33	475	32	5,948	28	2,062	30	1,378	32	1,572	32	6,636	28	3,109	32																																																						
Fair/poor		674	40	558	37	2,936	19	1,318	24	1,529	40	1,596	41	3,571	20	2,042	27																																																						

SE = standard error

^aPercentages may not sum to 100 due to missing values and rounding.^bUnemployed=jobless and actively seeking work; Not in labor force=jobless and not actively seeking work^cOverweight/obese defined as body mass index (BMI) (weight (kg)/height (m²)) value of ≥ 25 kg/m²^dObese defined as BMI of ≥ 30 kg/m²

Note. All counts are unweighted. All estimates are weighted for the survey's complex sampling design.

Table 2.

Fully-Adjusted Prevalence Ratios for Sleep-Related Health Behaviors by Housing Tenure Status among Black Men and Women compared to their White Counterparts, National Health Interview Survey, 2004-2016 (N=80,880)

	Men (n=35,151) (Reference: White Men)		Women (n=45,729) (Reference: White Women)	
	Government- assisted Housing (Yes)	Government- assisted Housing (No)	Government- assisted Housing (Yes)	Government- assisted Housing (No)
	1,493 Black (vs. 1,719 White)	7,461 Black (vs. 24,478 White)	4,909 Black (vs. 4,141 White)	10,468 Black (vs. 26,211 White)
Sleep duration	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Unrecommended (<6 hours) vs. recommended (7-9 hours)	0.95 (0.75-1.22)	1.33 (1.21-1.46)	1.07 (0.94-1.22)	1.11 (1.02-1.20)
Short (6 - <7 hours) vs. recommended (7-9 hours)	0.88 (0.73-1.07)	1.22 (1.15-1.30)	0.98 (0.89-1.09)	1.14 (1.08-1.21)
Long (>9 hours) vs. recommended (7-9 hours)	0.74 (0.55-0.99)	1.20 (1.00-1.44)	0.95 (0.77-1.18)	1.18 (1.02-1.36)
Trouble falling asleep (3 days/week vs. <3 days/week, past week) ^a	0.74 (0.56-0.98)	0.89 (0.78-1.01)	0.83 (0.72-0.96)	0.84 (0.77-0.93)
Trouble staying asleep (3 days/week vs. <3 days/week, past week) ^a	0.64 (0.49-0.82)	0.86 (0.76-0.97)	0.81 (0.71-0.92)	0.78 (0.72-0.85)
Days woke up feeling rested (most (4-7 days) vs. few/none (0-3 days), past week) ^a	1.23 (1.07-1.41)	1.05 (1.00-1.10)	1.11 (0.99-1.24)	1.15 (1.09-1.22)
Sleep medication use (3 days/week vs. <3 days/week, past week) ^a	0.46 (0.31-0.68)	0.55 (0.44-0.70)	0.75 (0.58-0.97)	0.56 (0.48-0.66)

PR=Prevalence Ratio; CI=Confidence Interval

Adjusted for age (18-30, 31-49, 50-64, 65+), educational attainment (<high school, high school graduate, some college, college), annual household income (<\$35,000, \$35,000 - <\$75,000, \$75,000), occupational class (professional/management, support services, laborers), general health status (excellent, very good, good vs. fair/poor) and region of residence (Northeast, Midwest, South, West).

Note. All estimates are weighted for the survey's complex sampling design.

Boldface indicates statistically significant results at the p=0.05 level.

^a Available survey years: 2013-2016

Fully-Adjusted Prevalence Ratios for Cardiometabolic Health Outcomes by Housing Tenure Status among Black Men and Women with Short, Recommended, and Long Sleep Duration compared to White Men and Women with Recommended Sleep Duration, National Health Interview Survey, 2004-2016 (N=80,880)

Table 3.

	Short Sleep Duration (<7 hours) vs. Recommended Sleep Duration (7-9 hours)		Recommended Sleep Duration (7-9 hours) vs. Recommended Sleep Duration (7-9 hours)		Long Sleep Duration (>9 hours) vs. Recommended Sleep Duration (7-9 hours)	
	Men (n=20,046) (Black men with short sleep vs. White men with recommended sleep)	Women (n=24,683) (Black women with short sleep vs. White women with recommended sleep)	Men (n=21,532) (Black men with recommended sleep vs. White men with recommended sleep)	Women (n=27,233) (Black women with recommended sleep vs. White women with recommended sleep)	Men (n=17,062) (Black men with long sleep vs. White men with recommended sleep)	Women (n=19,696) (Black women with long sleep vs. White women with recommended sleep)
	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (no)	Government-assisted Rental Housing (no)
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Hypertension (yes)	1.13 (0.98-1.30)	1.29 (1.18-1.41)	1.09 (0.95-1.25)	1.18 (1.08-1.28)	1.29 (1.04-1.60)	1.26 (1.09-1.45)
Overweight (yes) ^a	0.98 (0.88-1.10)	1.20 (1.14-1.27)	0.96 (0.87-1.06)	1.18 (1.12-1.25)	0.90 (0.73-1.11)	1.22 (1.12-1.33)
Obesity (yes) ^b	0.97 (0.80-1.18)	1.31 (1.20-1.42)	0.90 (0.76-1.08)	1.29 (1.19-1.40)	0.77 (0.55-1.08)	1.39 (1.24-1.55)
Diabetes (yes)	1.31 (0.96-1.78)	1.21 (1.02-1.43)	1.34 (1.05-1.72)	1.10 (0.92-1.32)	1.47 (0.88-2.46)	1.25 (0.92-1.71)
Heart disease (yes)	0.86 (0.64-1.15)	0.85 (0.73-1.00)	0.64 (0.48-0.85)	0.75 (0.64-0.88)	0.66 (0.36-1.18)	0.86 (0.63-1.16)
Stroke (yes)	NE	1.22 (0.92-1.63)	NE	1.03 (0.78-1.36)	NE	1.36 (0.89-2.06)

PR=Prevalence Ratio; CI=Confidence Interval.

^aOverweight: body mass index (BMI) ≥ 25 kg/m²;

^bObesity: BMI ≥ 30 kg/m².

Note. All estimates are weighted for the survey's complex sampling design and adjusted for age (years) category (18-30, 31-49, 50-64, 65+), educational attainment (<high school, high school graduate, some college, college), annual household income (<\$35,000, \$35,000 - <\$75,000, \$75,000), occupational class (professional/management, support services, laborers), general health status (excellent, very good, good vs. fair/poor) and region of residence (Northeast, Midwest, South, West).

Boldface indicates statistically significant results at the two-sided p=0.05 level.

NE=not estimated (failed to converge)

Table 4.

Fully-adjusted Prevalence Ratios for Cardiometabolic Health Outcomes by Housing Tenure Status among Black Men and Women with Poor Sleep compared to White Men and Women with Non-poor Sleep, National Health Interview Survey, 2013-2016 (N=19,638)

	Men (n=8,326) (Black men with poor sleep vs. White men with recommended sleep)		Women (n=11,312) (Black women with poor sleep vs. White women with recommended sleep)	
	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (no)	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (no)
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Hypertension (yes)	1.48 (1.10-2.00)	1.30 (1.16-1.46)	1.20 (1.00-1.45)	1.52 (1.35-1.71)
Overweight (yes) ^a	0.93 (0.79-1.10)	1.11 (1.06-1.16)	1.21 (1.06-1.37)	1.40 (1.32-1.48)
Obesity (yes) ^b	0.83 (0.62-1.11)	1.29 (1.18-1.42)	1.36 (1.12-1.66)	1.76 (1.59-1.94)
Diabetes (yes)	1.36 (0.86-2.17)	1.41 (1.05-1.89)	1.26 (0.87-1.82)	1.66 (1.26-2.18)
Heart disease (yes)	0.90 (0.54-1.49)	0.95 (0.75-1.21)	NE	1.13 (0.91-1.40)
Stroke (yes)	NE	1.93 (1.21-3.08)	0.71 (0.44-1.14)	1.79 (1.12-2.84)

PR=Prevalence Ratio; CI=Confidence Interval.

^aOverweight: body mass index (BMI) ≥ 25 kg/m²;

^bObesity: BMI ≥ 30 kg/m².

Note. Poor sleep is defined as unrecommended sleep duration (short sleep duration (≤ 7 hours), long sleep duration (≥ 9 hours)) OR poor sleep quality (trouble falling asleep (≥ 3 days/week), trouble staying asleep (≥ 3 days/week), woke up feeling rested no/few days (0-3 days/week), sleep medication use (≥ 3 days/week)) versus non-poor sleep (neither unrecommended sleep duration nor poor sleep quality). Sleep quality available only for survey years 2013-2016.

All estimates are weighted for the survey's complex sampling design and adjusted for age (years) category (18-30, 31-49, 50-64, 65+), educational attainment ($\leq$ high school, high school graduate, some college, college), annual household income ($\leq$ \$35,000, \$35,000 - $\leq$ \$75,000, $\geq$ \$75,000), occupational class (professional/management, support services, laborers), general health status (excellent, very good, good vs. fair/poor) and region of residence (Northeast, Midwest, South, West).

Boldface indicates statistically significant results at the two-sided $p=0.05$ level.

NE=not estimated (failed to converge)