Sleep and cardiometabolic health by government-assisted rental housing status among Black and White men and women in the United States

Symielle A. Gaston, PhD, MPH [a], W. Braxton Jackson II, MPH [b], David R. Williams, PhD [c,d], Chandra L. Jackson, PhD, MS [a,*]

[a] Epidemiology Branch, National Institute of Environmental Health Sciences, National Institutes of Health, Department of Health and Human Services, Research Triangle Park, NC, USA
[b] Social & Scientific Systems, Inc., Research Triangle Park, NC, USA
[c] Department of Social and Behavioral Sciences, Harvard T. H. Chan School of Public Health, Boston, MA, USA
[d] Department of African and African American Studies, Harvard University, Cambridge, MA, USA

ARTICLE INFO

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 (eg, 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 (ie, 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 ($p_{housing*race}$ = 0.001 -men, $p_{housing*race}$ = 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 generally smaller among government-assisted renters, but relationships varied by sex.
Conclusions: There were no racial disparities in short sleep duration, and cardiometabolic health disparities were generally attenuated when Blacks and Whites resided in government-assisted rental housing.

Published by Elsevier Inc. on behalf of National Sleep Foundation.

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] Although poor sleep is a less well-established contributor to racial/ethnic disparities in cardiovascular health,[3] it has been 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 more severe physical problems/breakdowns (e.g., 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 (eg, noise, air pollution, high crime due to poverty) are also more common among low-income residences.[15] Such exposures are increasingly associated with worse sleep and cardiometabolic health outcomes (eg, 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 United States 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, m^2) and created categories: overweight (BMI ≥25.0 kg/m^2) and obesity (BMI ≥30.0 kg/m^2) versus normal weight (18.5 ≤ BMI - < 25.0 kg/m^2).[28]

Covariates

Participants reported their age (in 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 (ie, 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 (eg, 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 United States. 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 (ie, 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 differences in data collection, measurement of poor sleep was possible for participants interviewed during 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 United States while their White counterparts were more evenly distributed across the United States.

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 were no Black-White disparities in unrecommended and short sleep duration among government-assisted renters;

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 = 3212 (9%)				Government-assisted Housing (no) n = 31,939 (91%)				Government-assisted Housing (yes) n = 9050 (20%)				Government-assisted Housing (no) n = 36,679 (80%)			
	White		Black		White		Black		White		Black		White		Black	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Sample size	1719	54	1493	46	24,478	77	7461	23	4141	46	4909	54	26,211	71	10,468	29
Age, mean ± SE (years)	49.0	0.76	42.2	0.71	37.6	0.20	38.1	0.24	51.5	0.76	40.5	0.50	39.0	0.23	38.7	0.24
Annual household income																
<$35,000	1619	94	1358	93	12,203	48	4277	60	3902	96	4546	95	14,555	55	6666	64
$35,000 - <$75,000	59	6	77	7	7591	34	2100	30	116	3	191	5	7343	32	2609	28
≥$75,000	7	1	9	1	3345	18	599	10	29	1	9	0	2760	13	528	8
Living in poverty (yes)	918	58	892	62	4130	14	1559	22	2323	62	3181	69	5317	18	2897	27
Other government assistance (yes)	928	56	875	60	2577	12	1540	23	2416	60	3483	67	4374	16	3485	32
Educational attainment																
<High school	438	25	483	33	2043	12	1124	20	1002	24	1416	33	2266	11	1349	17
High school graduate	683	41	609	41	6922	30	2861	39	1553	38	1902	39	6898	32	3483	36
Some college	445	25	329	21	8674	31	2355	28	1300	32	1421	25	9805	35	3946	34
≥College	134	9	62	4	6788	26	1085	12	268	6	155	3	7187	23	1649	13
Marital status																
Married	219	21	169	18	5680	36	1542	30	328	12	193	6	6255	31	1461	19
Divorced/separated/widowed	743	36	548	33	6243	32	2152	34	2704	61	1750	44	9451	44	3315	43
Never married	751	43	773	49	12,496	32	3743	36	1097	27	2957	50	10,429	25	5646	38
Unemployed/not in work force (yes) [b]	1395	80	1159	75	6866	40	2678	48	3209	75	3272	73	9656	47	3798	49
Occupation																
Professional/management	108	6	47	3	4820	20	730	10	221	6	145	4	3599	13	945	9
Support Services	373	25	304	24	7196	29	1960	24	2093	56	2459	53	15,774	63	6073	60
Laborers	1045	69	927	73	11,312	50	4173	66	1413	38	1626	43	5425	23	2527	30
Region of residence																
Northeast	508	31	316	23	3905	18	899	14	1044	25	910	21	4130	17	1345	15
Midwest	503	29	326	23	6675	26	1414	20	1371	33	1007	21	7249	28	1998	21
South	331	20	672	44	7309	31	4180	55	989	25	2562	49	8081	31	6056	54
West	377	20	179	11	6589	24	968	12	737	17	430	9	6751	24	1069	10
Sleep duration																
Unrecommended (<6 hours)	257	15	218	14	2355	10	1046	13	631	15	718	16	2763	11	1412	14
Short (6–<7 hours)	343	20	299	19	5623	22	1921	25	944	23	1108	22	5752	22	2700	24
Recommended (7–9 hours)	916	52	842	58	15,646	63	4128	56	2214	53	2702	54	16,531	61	5786	54
Long (>9 hours)	203	13	134	9	854	5	366	7	352	9	381	7	1165	5	570	7
Trouble falling asleep (≥3 days/week)	221	31	141	26	1979	20	465	20	633	40	489	33	2888	31	875	26
Trouble staying asleep (≥3 days/week)	260	37	149	27	2270	29	553	24	719	44	513	34	3405	37	966	31
Woke up feeling rested most days (≥4 days/week)	389	56	341	68	5913	64	1598	67	762	48	862	53	5247	54	1897	61
Sleep medication (≥3 days/week)	152	21	57	10	818	11	153	7	383	24	221	16	1339	17	312	10
Smoking status																
Never	527	31	566	39	11,251	39	3978	48	1652	38	2775	54	13,840	48	7070	64
Former	507	29	314	20	5059	28	1074	21	1051	23	675	17	4952	23	1078	15
Current	683	40	613	40	8131	32	2394	32	1434	39	1451	28	7387	28	2305	21
Alcohol consumption																
Never	284	18	321	22	2251	10	1385	19	1048	25	1716	36	4068	19	3172	33
Former	579	35	361	24	3143	20	1069	20	1269	31	914	24	3762	20	1442	19
Current	832	48	797	53	18,820	70	4896	61	1789	44	2221	40	18,180	62	5741	47
Leisure-time physical activity																
Never/unable	878	52	748	49	6602	35	2775	43	2224	54	2829	61	8148	39	4729	51
Low	346	20	316	21	8023	30	2248	29	878	22	1017	20	8449	30	2999	27
High	491	27	427	29	9754	34	2406	28	1032	24	1051	20	9557	31	2714	23
Cardiometabolic health outcomes																
Overweight (yes) [c]	1148	68	963	64	15,215	67	5157	70	2744	69	3613	76	13,324	58	7516	75
Obesity (yes) [d]	587	52	453	45	6035	46	2442	53	1633	57	2303	68	6868	42	4493	65
Hypertension (yes)	810	46	750	49	5719	36	2389	43	1961	45	2203	56	6142	35	3591	50
Diabetes (yes)	334	20	295	20	1522	11	771	16	770	19	775	22	1752	11	1054	17
Heart disease (yes)	368	21	214	14	2297	17	598	12	918	21	636	17	2580	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	4081	45	1231	28	1740	28	15,999	52	5316	41
Good	581	33	475	32	5948	28	2062	30	1378	32	1572	32	6636	28	3109	32
Fair/poor	674	40	558	37	2936	19	1318	24	1529	40	1596	41	3571	20	2042	27

SE = standard error.
Note. All counts are unweighted. All estimates are weighted for the survey's complex sampling design.
[a] Percentages may not sum to 100 due to missing values and rounding.
[b] Unemployed = jobless and actively seeking work; Not in labor force = jobless and not actively seeking work.
[c] Overweight/obese defined as body mass index (BMI) (weight (kg)/height (m^2)) value of ≥25 kg/m^2.
[d] Obese defined as BMI of ≥30 kg/m^2.

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)		Women (n = 45,729)	
	(Reference: White Men)		(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)
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Sleep duration				
Unrecommended (<6 hours)	0.95	**1.33**	1.07	**1.11**
vs recommended (7–9 hours)	(0.75–1.22)	**(1.21–1.46)**	(0.94–1.22)	**(1.02–1.20)**
Short (6–<7 hours)	0.88	**1.22**	0.98	**1.14**
vs recommended (7–9 hours)	(0.73–1.07)	**(1.15–1.30)**	(0.89–1.09)	**(1.08–1.21)**
Long (>9 hours)	**0.74**	**1.20**	0.95	**1.18**
vs recommended (7–9 hours)	**(0.55–0.99)**	**(1.00–1.44)**	(0.77–1.18)	**(1.02–1.36)**
Trouble falling asleep	**0.74**	0.89	**0.83**	**0.84**
(≥3 days/week vs <3 days/week, past week) [a]	**(0.56–0.98)**	(0.78–1.01)	**(0.72–0.96)**	**(0.77–0.93)**
Trouble staying asleep	**0.64**	**0.86**	**0.81**	**0.78**
(≥3 days/week vs <3 days/week, past week) [a]	**(0.49–0.82)**	**(0.76–0.97)**	**(0.71–0.92)**	**(0.72–0.85)**
Days woke up feeling rested	**1.23**	1.05	1.11	**1.15**
(most (4–7 days) vs few/none (0–3 days), past week) [a]	**(1.07–1.41)**	(1.00–1.10)	(0.99–1.24)	**(1.09–1.22)**
Sleep medication use	**0.46**	**0.55**	**0.75**	**0.56**
(≥3 days/week vs <3 days/week, past week) [a]	**(0.31–0.68)**	**(0.44–0.70)**	**(0.58–0.97)**	**(0.48–0.66)**

PR = Prevalence Ratio; CI=Confidence Interval.
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).
Note. All estimates are weighted for the survey's complex sampling design.
Boldface indicates statistically significant results at the P = .05 level.
  [a] Available survey years: 2013–2016.

however, Blacks in unassisted housing had a higher prevalence of unrecommended and short sleep duration compared to their White counterparts, after adjustment ($PR_{unrecommended \ sleep}$ = 1.33 [95% CI: 1.21–1.46] for men ($p_{tenure*race}$ = 0.002); $PR_{unrecommended \ sleep}$ = 1.11 [95% CI: 1.02–1.20] for women ($p_{tenure*race}$ = 0.360); $PR_{short \ sleep}$ = 1.22 [95% CI: 1.15–1.30] for men ($p_{tenure*race}$ = 0.001); $PR_{short \ sleep}$ = 1.14 [95% CI: 1.08–1.21] for women ($p_{tenure*race}$ = 0.008); Table 2, Supplemental Table 1, Supplemental Fig. 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], $p_{tenure*race}$ = 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] ($p_{tenure*race}$ = 0.040)) (Table 2, Supplemental Table 1, Supplemental Fig. 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 report 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 similar to those observed in Table 3 (except for hypertension among men). Among men, there were no racial differences in certain cardiometabolic health outcomes (ie, 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

Table 3

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)

	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)		Women (n = 24,683)		Men (n = 21,532)		Women (n = 27,233)		Men (n = 17,062)		Women (n = 19,696)	
	(Black men with short sleep vs White men with recommended sleep)		(Black women with short sleep vs White women with recommended sleep)		(Black men with recommended sleep vs White men with recommended sleep)		(Black women with recommended sleep vs White women with recommended sleep)		(Black men with long sleep vs White men with recommended sleep)		(Black women with long 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)	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (no)	Government-assisted Rental Housing (yes)	Government-assisted Rental Housing (no)	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)	PR (95% CI)	PR (95% CI)	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)	**1.20 (1.11–1.30)**	**1.29 (1.18–1.41)**	**1.55 (1.44–1.67)**	1.09 (0.95–1.25)	**1.12 (1.03–1.22)**	**1.18 (1.08–1.28)**	**1.46 (1.37–1.56)**	**1.29 (1.04–1.60)**	**1.22 (1.03–1.44)**	**1.25 (1.07–1.47)**	**1.26 (1.09–1.45)**
Overweight (yes)[a]	0.98 (0.88–1.10)	**1.13 (1.09–1.17)**	**1.20 (1.14–1.27)**	**1.33 (1.29–1.38)**	0.96 (0.87–1.06)	**1.09 (1.05–1.12)**	**1.18 (1.12–1.25)**	**1.30 (1.26–1.35)**	0.90 (0.73–1.11)	1.09 (1.00–1.20)	**1.22 (1.12–1.33)**	**1.24 (1.15–1.33)**
Obesity (yes)[b]	0.97 (0.80–1.18)	**1.35 (1.26–1.44)**	**1.31 (1.20–1.42)**	**1.55 (1.48–1.63)**	0.90 (0.76–1.08)	**1.23 (1.15–1.32)**	**1.29 (1.19–1.40)**	**1.49 (1.42–1.57)**	0.77 (0.55–1.08)	1.14 (0.97–1.35)	**1.40 (1.23–1.59)**	**1.39 (1.24–1.55)**
Diabetes (yes)	1.31 (0.96–1.78)	**1.47 (1.23–1.75)**	**1.21 (1.02–1.43)**	**1.24 (1.07–1.44)**	**1.34 (1.05–1.72)**	**1.42 (1.20–1.68)**	1.10 (0.92–1.32)	**1.29 (1.11–1.51)**	1.47 (0.88–2.46)	1.24 (0.88–1.75)	1.19 (0.87–1.64)	1.25 (0.92–1.71)
Heart disease (yes)	0.86 (0.64–1.15)	**0.85 (0.73–1.00)**	**0.78 (0.65–0.93)**	0.97 (0.82–1.14)	**0.64 (0.48–0.85)**	**0.67 (0.57–0.78)**	**0.75 (0.64–0.88)**	**0.83 (0.71–0.96)**	0.66 (0.36–1.18)	0.74 (0.54–1.02)	**0.62 (0.45–0.85)**	0.86 (0.63–1.16)
Stroke (yes)	NE	1.22 (0.92–1.63)	NE	**1.33 (1.04–1.72)**	NE	1.15 (0.86–1.53)	NE	1.03 (0.78–1.36)	NE	1.25 (0.72–2.14)	0.93 (0.60–1.46)	1.36 (0.89–2.06)

PR = Prevalence Ratio; CI=Confidence Interval. [a]Overweight: body mass index (BMI) ≥25 kg/m^2; [b] Obesity: BMI ≥30 kg/m^2.

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 $P = .05$ level.

NE = not estimated (statistical models 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.

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 (<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 = .05 level.

NE = not estimated (failed to converge).

[a] Overweight: body mass index (BMI) ≥25 kg/m^2.
[b] Obesity: BMI ≥30 kg/m^2.

---

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 of 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 (eg, 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

requiring 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 or statistical correction for errors 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 (eg, 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 United States; 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 (eg, 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, social determinants of health that may contribute to racial differences in housing environments like residential segregation which remains pervasive in the United States,[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 more 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.

Conflict of interest statement

The authors have no conflicts of interest to declare.

Acknowledgements

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleh.2018.07.010.

References

1. NCHS. Health, United States, 2016: With Chartbook on Long-term Trends in Health [Hyattsville, MD] ; 2017.
2. CDC. Heart Disease and Stroke. Preventing the Nation's Leading Killers: At a Glance 2016. https://www.cdc.gov/chronicdisease/resources/publications/aag/heart-disease-stroke.htm; 2017, Accessed date: 8 September 2017.
3. Jackson CL, Redline S, Emmons KM. Sleep as a potential fundamental contributor to disparities in cardiovascular health. Annu Rev Public Health. 2015;36:417–440.
4. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. Sleep. 2008;31(5):619–626.
5. Laugsand LE, Vatten LJ, Platou C, Janszky I. Insomnia and the risk of acute myocardial infarction: a population study. Circulation. 2011;124(19):2073–2081.
6. Buxton OM, Marcelli E. Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. Soc Sci Med. 2010;71(5):1027–1036.
7. Liu Y, Wheaton AG, Chapman DP, Cunningham TJ, Lu H, Croft JB. Prevalence of Healthy Sleep Duration among Adults–United States, 2014. MMWR Morb Mortal Wkly Rep. 2016;65(6):137–141.
8. Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, Don Carlos L, et al. National Sleep Foundation's updated sleep duration recommendations: final report. Sleep Health. 2015;1(4):233–243.
9. Hale L, Do DP. Racial differences in self-reports of sleep duration in a population-based study. Sleep. 2007;30(9):1096–1103.
10. Nunes J, Jean-Louis G, Zizi F, et al. Sleep duration among Black and White Americans: results of the National Health Interview Survey. J Natl Med Assoc. 2008;100(3):317–322.
11. Arber S, Bote M, Meadows R. Gender and socio-economic patterning of self-reported sleep problems in Britain. Soc Sci Med. 2009;68(2):281–289.

12. Eggers FJ, Econometrica. Characteristics of HUD-Assisted Renters and Their Units in 2013. Washington, DC: US Department of Housing and Urban Development, Office of Policy Development and Research; 2017.

13. Newman SJ, Holupka SC. The Quality of America's Assisted Housing Stock: Analysis of the 2011 and 2013 American Housing Surveys. Washington, DC: US Department of Housing and Urban Development, Office of Policy Development and Research; 2017.

14. Caddick ZA, Gregory K, Arsintescu L, Flynn-Evans EE. A review of the environmental parameters necessary for an optimal sleep environment. *Build Environ*. 2018; 132:11–20.

15. Williams DR, Collins C. Racial residential segregation: a fundamental cause of racial disparities in health. *Public Health Rep*. 2001;116(5):404–416.

16. Jackson CL. Determinants of racial/ethnic disparities in disordered sleep and obesity. *Sleep Health*. 2017;3(5):401–415.

17. Newman SJ, Holupka CS. Race and Assisted Housing. *Hous Policy Debate*. 2017; 27(5):751–771.

18. Gamaldo AA, McNeely JM, Shah MT, Evans MK, Zonderman AB. Racial differences in self-reports of short sleep duration in an urban-dwelling environment. *J Gerontol Ser B Psychol Sci Soc Sci*. 2015;70(4):568–575.

19. LaVeist T, Pollack K, Thorpe Jr R, Fesahazion R, Gaskin D. Place, not race: disparities dissipate in southwest Baltimore when Blacks and Whites live under similar conditions. *Health Aff (Millwood)*. 2011;30(10):1880–1887.

20. Theorell-Haglöw J, Miller CB, Bartlett DJ, Yee BJ, Openshaw HD, Grunstein RR. Gender differences in obstructive sleep apnoea, insomnia and restless legs syndrome in adults – What do we know? A clinical update. *Sleep Med Rev*. 2018;38:28–38.

21. Wang Y, Beydoun MA. The Obesity Epidemic in the United States—Gender, Age, Socioeconomic, Racial/Ethnic, and Geographic Characteristics: A Systematic Review and Meta-Regression Analysis. *Epidemiol Rev*. 2007;29(1):6–28.

22. Bassett E, Moore S. Neighbourhood disadvantage, network capital and restless sleep: is the association moderated by gender in urban-dwelling adults? *Soc Sci Med*. 2014;108:185–193.

23. NCHS. Survey Description, National Health Interview Survey, 2015. ftp://ftp.cdc. gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc. pdf; 2016.

24. Jackson CL, Hu FB, Redline S, Williams DR, Mattei J, Kawachi I. Racial/ethnic disparities in short sleep duration by occupation: the contribution of immigrant status. *Soc Sci Med*. 2014;118:71–79.

25. Grandner MA, Williams NJ, Knutson KL, Roberts D, Jean-Louis G. Sleep disparity, race/ethnicity, and socioeconomic position. *Sleep Med*. 2016;18:7–18.

26. Alvarez GG, Ayas NT. The impact of daily sleep duration on health: a review of the literature. *Prog Cardiovasc Nurs*. 2004;19(2):56–59.

27. Grandner MA, Hale L, Moore M, Patel NP. Mortality associated with short sleep duration: The evidence, the possible mechanisms, and the future.

28. USPSTF. Screening for obesity in adults: recommendations and rationale. *Am Fam Physician*. 2004;69(8):1973–1976.

29. Blewett LA, et al. IPUMS Health Surveys: National Health Interview Survey, Version 6.2. Available from: http://www.nhis.ipums.org; 2016.

30. Adenekan B, Pandey A, McKenzie SE, Zizi F, Casimir GJ, Jean-Louis G, et al. Sleep in America: role of racial/ethnic differences. *Sleep Med Rev*. 2013;17(4):255–262.

31. Johnson DA, Thorpe RJ, McGrath JA, Jackson WB, Jackson CL. Black-White differences in housing type and sleep duration as well as sleep difficulties in the United States. *Int J Environ Res Public Health*. 2018;15(4).

32. Jackson JS, Knight KM, Rafferty JA. Race and unhealthy behaviors: chronic stress, the HPA axis, and physical and mental health disparities over the life course. *Am J Public Health*. 2010;100(5):933–939.

33. Chambers EC, Pichardo MS, Rosenbaum E. Sleep and the housing and neighborhood environment of urban Latino adults living in low-income housing: the AHOME study. *Behav Sleep Med*. 2016;14(2):169–184.

34. Chen-Edinboro LP, Kaufmann CN, Augustinavicius JL, Mojtabai R, Parisi JM, Wennberg AM, et al. Neighborhood physical disorder, social cohesion, and insomnia: results from participants over age 50 in the Health and Retirement Study. *Int Psychogeriatr*. 2014:1–8.

35. Desantis AS, Diez Roux AV, Moore KE, Baron KG, Mujahid MS, Javier Nieto F, et al. Associations of neighborhood characteristics with sleep timing and quality: the multi-ethnic study of atherosclerosis. *Sleep*. 2013;36(10):1543–1551.

36. Hale L, Hill TD, Friedman EL, Javier Nieto F, Galvão LW, Engelman CD, et al. Perceived neighborhood quality, sleep quality, and health status: evidence from the survey of the health of Wisconsin. *Soc Sci Med*. 2013;79:16–22.

37. Johnson DA, Moore KA, Mujahid MS, Kawachi I, Roux AD, Simonelli G, et al. The neighborhood social environment and objective measures of sleep in the multi-ethnic study of atherosclerosis. *Sleep*. 2017;40(1).

38. Lauderdale DS, Knutson KL, Yan LL, Liu K, Rathouz PJ. Self-reported and measured sleep duration: how similar are they? *Epidemiology*. 2008;19(6): 838–845.

39. Grandner MA, Patel NP, Gehrman PR, Xie D, Sha D, Weaver T, et al. Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Med*. 2010;11(5):470–478.

40. Jackson CL, Patel SR, Jackson WB, Lutsey PL, Redline S. Agreement between self-reported and objectively measured sleep duration among White, Black, Hispanic, and Chinese adults in the United States: multi-ethnic study of atherosclerosis. *Sleep*. 2018.

41. Massey DS, Rothwell J, Domina T. The changing bases of segregation in the United States. *Ann Am Acad Pol Soc Sci*. 2009;626(1). https://doi.org/10.1177/ 0002716209343558.

42. Spader J, Rieger S. Patterns and Trends of Residential Integration in the United States Since 2000; 2017.