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Everyday and major experiences of racial/ethnic discrimination and sleep health in a multiethnic population of U.S. women: Findings from the Sister Study

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Abstract

Background: Perceived racial/ethnic discrimination and poor sleep occur across all races/ethnicities in the U.S., though both are most common among racial/ethnic minorities. Few studies

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have investigated associations between perceived racial/ethnic discrimination and various sleep dimensions in a multiethnic population.

Methods: We analyzed cross-sectional associations among 40,038 eligible Sister Study participants (enrollment: 2003–2009) who reported ever/never experiencing specific types of everyday (e.g., treated unfairly at a store or restaurant) or major (e.g., unfairly stopped, threatened, or searched by police) discrimination attributed to their race/ethnicity during a follow-up survey in 2008–2012. Participants also reported short sleep duration (<7 hours), sleep debt (≥2-hour difference between longest and shortest sleep duration), frequent napping (≥3 times/week), and insomnia. Poisson regression with robust variance estimation, adjusted for sociodemographic and health characteristics, estimated prevalence ratios (PRs) and 95% confidence intervals (CIs) for the association between each type of racial/ethnic discrimination and each sleep dimension, overall and by race/ethnicity.

Results: Mean age was 55 ± 8.9 years, 89% were NH-white, 8% NH-black, and 3% Hispanic/Latina. NH-black participants were the most likely to report everyday (76% vs. 4% [NH-whites] and 36% [Hispanics/Latinas]) and major racial/ethnic discrimination (52% vs. 2% [NH-whites] and 18% [Hispanics/Latinas]). Participants who experienced both types versus neither were more likely to report short sleep duration (PR=1.17 [95% CI: 1.09–1.25]) and insomnia symptoms (PR=1.10 [1.01–1.20]) but not other poor sleep dimensions.

Conclusions: Racial/ethnic minority women were most likely to experience racial/ethnic discrimination, which was associated with certain poor sleep dimensions among women of all races/ethnicities.

Keywords

Racism; Sleep; Sleep initiation and maintenance disorders; African Americans; Hispanic Americans; Whites; Women

INTRODUCTION

Sleep disturbances are increasingly recognized as a public health concern and have been hypothesized contributors to poor cardiometabolic health outcomes like obesity and hypertension [1, 2]. Despite the recommendation of at least 7-hours of sleep per day [3], one-third of U.S. adults report habitually getting <7-hours of sleep [4]. Racial/ethnic minority groups in the U.S., including African Americans or non-Hispanic (NH)-blacks and specific Hispanic/Latinx heritage groups (e.g., Puerto Ricans), are more likely than NH-whites to report habitual short sleep duration [5]. In prior studies, NH-black adults have also reported worse sleep quality than NH-whites [5]. Adverse environments and experiences resulting from discrimination due to membership in marginalized racial/ethnic minority groups may contribute to sleep disparities [6–8].

Perceived discrimination is a form of psychosocial stress that contributes to poor sleep duration and quality [7, 9–18], and there are several hypothesized mechanisms. For instance, experiencing discrimination – whether actual or perceived – can cause distress, trigger arousal of the hypothalamic pituitary adrenal axis, and activate the sympathetic nervous system, which can lead to an increased stress response and inability to engage in quality,

uninterrupted sleep [7]. Furthermore, studies suggest that expectation/anticipation of impending discrimination or vigilance along with associated arousal also make it difficult to engage in restorative sleep [19]. Research on discrimination as a psychosocial stressor that contributes to poor sleep is particularly relevant among women because of their higher prevalence of sleep problems compared to men [20]. Furthermore, a prior study among NH-black participants reported that the burden of discrimination on subjective sleep duration was greater among women compared to men [16].

Few studies of discrimination and sleep have 1) focused on women, who may be particularly socially and biologically vulnerable, 2) investigated multiple sleep dimensions, 3) distinguished between racial/ethnic discrimination and other forms of discrimination, or 4) included multiethnic populations despite evidence of: all races/ethnicities reporting experiences of racial/ethnic discrimination, observed associations between discrimination and sleep, and multiple calls for more, explicit minority health research [7–12, 14–16, 18, 21–24]. Further, it is important to differentiate between chronic- or everyday- and acute- or major-experiences of racial/ethnic discrimination due to their potential differential effects on the stress response system. Prior studies indicate that chronic stress leads to more severe dysregulation of stress response systems compared to acute stressors [25]. Additionally, differentiating between each type of racial/ethnic discrimination better informs potential interpersonal and institutional/structural targets for interventions designed to improve sleep health. To identify potential intervention targets and address research gaps, we investigated associations between lifetime experiences of everyday (i.e., chronic, routine) and major (i.e., acute structural or systemic) racial/ethnic discrimination and multiple sleep dimensions in a cohort of NH-white, NH-black, and Hispanic/Latina middle-to-older-aged women in the U.S.

METHODS

The Sister Study Cohort

The Sister Study is a prospective cohort study of 50,884 U.S. (including Puerto Rico) women aged 35–74 years at enrollment (2003–2009) who had a sister diagnosed with breast cancer but were free of breast cancer at baseline data collection. Detailed sampling and recruitment strategies are described elsewhere [26]. Briefly, if eligibility criteria were met, women completed self-administered questionnaires, a home visit with biologic specimen collection, and a computer-assisted telephone interview in either English or Spanish. Detailed follow-up questionnaires occurred every two to three years post-enrollment. All participants provided written informed consent. The National Institute of Environmental Health Sciences Institutional Review Board and the Copernicus Group Independent Review Board approved the Sister Study.

Study Population

We used data release 6.0, which included baseline and first-detailed follow-up (2008–2012) data. Eligibility criteria included no missing racial/ethnic discrimination data; self-identification as NH-white alone (hereafter referred to as NH-white), NH-black alone (hereafter referred to as NH-black), or Hispanic/Latina; non-pregnant; no report of long

sleep duration (>9-hours, due to small sample size); and no implausible data or missing data for covariates. Exclusions were applied in a stepwise manner (Supplemental Figure 1). Participants who resided in Puerto Rico (n=629; 99% Hispanic/Latina) were separately analyzed. Therefore, the sample in the main analysis consisted of 40,038 participants. Compared to excluded NH-white, NH-black, and Hispanic/Latina participants, a greater proportion of included participants were NH-white, of higher socioeconomic status (SES; i.e., education and income), and reported slightly better health behavior and clinical characteristics (Supplemental Table 1).

Exposure: Racial/ethnic discrimination

In a self-administered questionnaire during the first detailed follow-up (2–3 years post-baseline), participants reported (yes/no) whether they ever experienced unfair treatment that they attributed to their race or ethnicity. Each 'yes' response was assigned a value of one, and responses were summed to create discrimination scores. Adapted from The Everyday Discrimination Scale [27], everyday racial/ethnic discrimination was the sum of three items: treated unfairly in receiving service at a store or restaurant; treated as less intelligent, worthy or honest than others; and experienced people acting as if they are afraid of you. Similar to prior literature [8], major racial/ethnic discrimination was the sum of three items: treated unfairly in home renting, buying or mortgage lending; treated unfairly in being stopped, searched, or threatened by police; and treated unfairly in job hiring, promotion, or firing. Most participants had a score of zero; therefore, dichotomous categories of everyday and major discrimination were ever versus never (summary score ≥1 vs. 0). We also combined everyday and major racial/ethnic discrimination, and categories included (1) both—ever experienced both everyday and major discrimination; (2) either—ever experienced either everyday or major discrimination; and (3) none—experienced neither everyday nor major discrimination. Participants additionally reported whether each experience occurred within the past five years.

Outcome: Self-reported sleep duration and sleep quality

At baseline, participants self-reported typical sleep duration and quality during the six weeks prior to the interview. The detailed sleep questionnaire is publicly available at https://sisterstudy.niehs.nih.gov/English/enroll-data.htm. Based on the National Sleep Foundation categories, average sleep duration per day was defined as either short (<7-hours) or recommended (7–9-hours) [3]. If women reported consistent weekly sleep patterns (86%), they provided daily bed times and wake up times. From this data, we determined average shortest and longest sleep duration per week. Women with inconsistent weekly sleep patterns (14%) reported their average shortest and longest sleep duration. For all women, we calculated sleep debt as ≥2-hour difference between longest and shortest sleep duration, which is consistent with prior literature [28, 29]. Frequent napping included reports of napping ≥3 days/week versus <3 days/week. Insomnia symptoms included reports of either difficulty initiating sleep (taking >30 minutes to fall asleep on average) or difficulty maintaining sleep (waking up ≥3 times/night ≥3 nights/week versus waking up <3 times/night <3 nights/week) versus neither. Additionally, poor sleep characteristics (i.e., short sleep, sleep debt, frequent napping, difficulty initiating sleep, difficulty maintaining sleep) were assigned values of one (yes) or zero (no) and summed to create a poor sleep score

ranging from zero to five. Approximately 90% of participants had a sleep score of <3. We dichotomized high poor sleep score (yes [sleep score ≥3] vs. no [sleep score ≤2]) to identify participants with the greatest number of sleep problems.

Potential Modifier: Race/ethnicity

Participants self-identified their race/ethnicity. Participants were categorized as NH-white alone, NH-black alone, and Hispanic/Latina (of any race).

Potential Confounders

Potential *a priori* confounders measured at baseline included self-reported (unless otherwise stated) sociodemographic, health behavioral, clinical, and stress-related characteristics, and categories (if applicable) are defined in Table 1. Sociodemographic factors included age category, educational attainment, current employment, current shift work/irregular hours, annual household income, marital status, and U.S. Census region of residence. Health behaviors and characteristics included smoking status, alcohol consumption during the past 12 months, objectively-measured body mass index (BMI) category [30], Healthy Eating Index 2000 score (range:0–100 with higher scores indicating healthier diet) calculated from a modified Block 1998 Food Frequency Questionnaire [31], and log-transformed metabolic equivalent minutes (METs) of leisure-time, transportation-, and work-related physical activity per week [32, 33]. Sleep medication was self-reported use of any medication to help fall or stay asleep. Based on self-reported physician diagnosis or current medication use, clinical characteristics included hypertension, diabetes, and cerebrovascular/cardiovascular disease (i.e., transient ischemic attack, stroke, myocardial infarction, or congestive heart failure), cancer other than non-melanoma skin cancer, and clinical depression. Stress measures included the 4-item Perceived Stress Scale (PSS-4) [34] score and a dichotomous indicator of other discrimination experiences (job and sexual orientation).

Statistical Analyses

We calculated frequencies and proportions for categorical variables and means ± standard deviations for continuous variables. We compared everyday, major, and combined racial/ethnic discrimination frequencies and proportions across sleep characteristics for all participants and stratified by race.

Using adjusted Poisson regression with robust variance, we estimated prevalence ratios (PRs) and 95% confidence intervals (CIs) of individual poor sleep characteristics for participants who reported everyday (yes vs. no), major (yes vs. no), and combined (both or either vs. none) racial/ethnic discrimination, separately. Overall models were adjusted for race/ethnicity. For overall and race/ethnicity-stratified models, sets of covariates were included in a stepwise manner. Model 1 was adjusted for socioeconomic factors: age category, educational attainment, employment status, current shift work/irregular work hours, annual household income, marital status, and region of residence. Model 2 was additionally adjusted for health behaviors and clinical characteristics: smoking status, alcohol consumption, diet, physical activity, sleep medication use, and physician diagnosis of clinical depression. Model 3 was additionally adjusted for other forms of stress: PSS-4 score and other discrimination. Models for sleep debt included adjustment for consistent

weekly sleep patterns (yes, no). To test for differences by race/ethnicity, race/ethnicity*racial/ethnic discrimination interaction terms were added to overall models. Analyses were conducted in SAS version 9.4 for Windows (Cary, North Carolina), and a two-sided p-value of 0.05 was used to determine statistical significance.

Secondary Analyses—We used the previously described modeling approaches to perform eight secondary analyses, which included (1) estimating the associations between the six individual racial/ethnic discrimination measures and each poor sleep characteristic; (2) estimating associations between both everyday and major discrimination with sleep outcomes in the same model; (3) estimating associations among NH-white women of Middle-Eastern descent separately from NH-white women of European descent; (4) estimating prevalence differences using modified Poisson regression models with an identity link function [35]; (5) estimating PRs for participants whose discrimination experiences occurred prior to the past five years versus those participants who reported no discrimination, to isolate discrimination experiences that clearly occurred prior to the sleep assessment; (6) restricting analyses to participants without chronic disease; (7) treating racial/ethnic discrimination as continuous scores; and (8) stratifying by shift work/irregular working hours status, which could modify associations because of racial/ethnic differences in occupational categories [36].

RESULTS

Study Population Characteristics

Among the 40,038 included participants, 89% self-identified as NH-white, 7.7% as NH-black, and 3.0% as Hispanic/Latina (Table 1). Most (83%) were aged 35–64 years. Prevalence of habitual short sleep duration was highest among NH-black participants (54%) followed by Hispanic/Latina (34%) and NH-white (25%) participants. A similar pattern was present for all other sleep characteristics including high poor sleep score (17% among NH-blacks, 12% among Hispanics/Latinas, and 8% among NH-whites). Among NH-black participants, 76% (vs. 4% NH-white and 36% Hispanic/Latinas) reported everyday racial/ethnic discrimination; half (52% vs. 2% NH-white and 18% Hispanic/Latina) reported major discrimination; and half (48% vs. 1% NH-white and 13% Hispanic/Latina) reported both everyday and major racial/ethnic discrimination. Population characteristics (and additional results) in the Puerto Rico sample are described in Supplemental Text and Supplemental Tables 2 and 3.

Racial/Ethnic Discrimination and Multiple Sleep Dimensions

Overall, the prevalence of habitual short sleep duration, insomnia symptoms, and high poor sleep score were generally highest among participants who reported racial/ethnic discrimination (Table 2).

Habitual Short Sleep Duration. After full adjustment (Table 3, Model 3), everyday (PR=1.10 [95% CI: 1.04–1.16]) and major racial/ethnic discrimination (PR=1.12 [1.06–1.19]) were positively associated with higher prevalence of habitual short sleep duration. Compared to participants who reported neither everyday nor major racial/ethnic discrimination,

participants who reported either form of discrimination had 10% higher prevalence (PR=1.10 [1.04–1.17]) and those who reported both forms of discrimination had 17% higher prevalence (PR=1.17 [1.09–1.25]) of habitual short sleep duration. Although race/ethnicity-stratified PRs were greater among Hispanics/Latinas compared to NH-whites, race/ethnicity*discrimination interaction terms were not statistically significant.

Sleep Debt and Frequent Napping. After full-adjustment, neither everyday, major, nor combined racial/ethnic discrimination was associated with either sleep debt or frequent napping and there was no variation between racial/ethnic groups.

Insomnia Symptoms. After full-adjustment, participants who reported both forms of racial/ethnic discrimination had 10% higher prevalence (PR=1.10 [1.01–1.20]) of insomnia symptoms compared to participants who reported no racial/ethnic discrimination. PRs did not vary by race/ethnicity.

High Poor Sleep Score. In fully-adjusted models, there were suggestive positive associations between each form of racial/ethnic discrimination and high poor sleep score (e.g., PReveryday=1.11 [0.99–1.24]), which did not vary by race/ethnicity.

Secondary Analyses

Results of the secondary analyses are presented in Supplemental Tables 4 through 11. Being treated as less intelligent, unfair renting/mortgaging, and unfair treatment by police appear to be salient predictors of short sleep duration. Both everyday and major racial/ethnic discrimination remained positively associated with short sleep duration after mutual adjustment. Results suggested potentially stronger associations between racial/ethnic discrimination and both short sleep and insomnia symptoms among NH-white women with Middle Eastern descent compared to NH-white women of European descent. There was racial/ethnic variation in prevalence differences of short sleep duration associated with everyday discrimination and insomnia symptoms associated with major discrimination. Results comparing participants who reported discrimination occurring prior to the past five years of follow-up versus those with no lifetime discrimination were consistent with the main analysis. Results for continuous racial/ethnic discrimination scores and among participants without chronic disease were also unchanged. Lastly, positive associations between (1) everyday and major discrimination (separately) and short sleep duration as well as (2) major discrimination and insomnia symptoms varied by race/ethnicity among shift workers, with associations most pronounced among Hispanic/Latina shift-workers.

DISCUSSION

In this large cohort of middle-to-older-aged NH-white, NH-black, and Hispanic/Latina women in the U.S., lifetime experience of both everyday and major racial/ethnic discrimination was positively associated with sleep disturbances. There was also a suggestive positive association between experiencing both everyday and major discrimination and a high poor sleep score. Racial/ethnic discrimination was not associated with either sleep debt or napping. Prevalence of lifetime racial/ethnic discrimination was approximately 5-to-19 times higher among NH-black and Hispanic/Latina women compared

to NH-white women. Furthermore, the prevalence of poor sleep dimensions was approximately up to 2 times higher among NH-black and Hispanic/Latina women compared to NH-white women. Although there were no race/ethnicity-by-racial/ethnic discrimination interactions after full adjustment, the higher prevalence of both racial/ethnic discrimination and poor sleep characteristics among non-white participants suggest racial/ethnic differences in exposure to racial/ethnic discrimination may contribute to racial/ethnic disparities in sleep [24, 37].

Findings from this study are biologically plausible. For instance, prior studies have demonstrated that both anticipated and actual perceived racial/ethnic discrimination may contribute to perceived stress, depressive symptoms, parasympathetic nervous system activity during sleep, and ultimately disturbed sleep [19, 38, 39]. Studies of polysomnography-assessed sleep architecture among NH-black and NH-white adults showed that perceived racial/ethnic discrimination is associated with less slow wave sleep or deep sleep and more time spent in lighter sleep [40, 41], which could partially explain observed associations with insomnia symptoms like difficulty staying asleep. Furthermore, NH-blacks were more likely to report discrimination, and perceived racial/ethnic discrimination partially mediated racial/ethnic differences in sleep architecture [40].

Our findings are consistent with most prior literature. The US was the setting for one of two prior studies that included multiple races/ethnicities and considered race/ethnicity as a potential modifier of the racial/ethnic discrimination-sleep relationship [15, 23]. Among a representative sample of adults in Michigan and Wisconsin, the magnitude of the positive association between perceived racism in the healthcare setting and difficulty initiating or maintaining sleep did not vary by race/ethnicity [23], which we also observed. In a cross-sectional survey of NH-black, NH-white, and Hispanic/Latinx adults in the Chicago Community Adult Health Study, like our study, everyday and major racial/ethnic discrimination experiences were positively associated with a composite score of multiple poor sleep dimensions and shorter sleep duration [8]. Also consistent with our study, investigations among U.S. and non-U.S. populations of adults across various ages, locations, and races/ethnicities have generally found that racial/ethnic discrimination is associated with self-reported short sleep duration and insomnia symptoms [8–11, 14–16, 18, 22, 23]. Our results extend these prior findings by focusing on women, investigating race/ethnicity as a potential modifier, and by including a broad set of sleep dimensions such as sleep debt and frequent napping, which may be indicators of poor sleep quality although each was not associated with racial/ethnic discrimination in this study.

Our study has limitations. Because temporality between discrimination and sleep health was not established, we cannot infer causality. However, we captured lifetime experiences and in sensitivity analyses among participants who reported that discrimination occurred prior to the sleep assessment, results were consistent with the overall analysis, reducing likelihood of reverse causation. Nonetheless, prospective studies with repeated measures are necessary. Secondly, eligible participants included versus excluded in analyses were more likely to self-identify as NH-white and to report higher SES as well as better health behaviors; therefore, the results may underestimate associations between discrimination and sleep characteristics. Third, sleep dimensions were self-reported, which could result in misclassification.

Importantly, a validation study of self-reported versus objectively-measured sleep suggested misclassification was non-differential by race/ethnicity [42]. Fourth, residual confounding related to categorization of included variables (e.g., dichotomization) and unobserved potential confounders is possible. Fifth, by attributing discrimination to race/ethnicity, results may overlook within-racial/ethnic group heterogeneity (e.g., age, SES) that affects perceived discrimination experiences [43]. Sixth, results may be due to chance. Lastly, future, more generalizable studies inclusive of other sociodemographic groups (e.g., other races/ethnicities, men, younger age groups) in the U.S. are needed.

Despite the limitations, this study has several important strengths. Specifically, we investigated both multiple forms of racial/ethnic discrimination and multiple sleep dimensions using data collected from a large multiethnic cohort of women, which allowed for testing of specific associations by race/ethnicity while adjusting for many potential confounders. As revealed in our sensitivity analyses, factors such as shift work may modify racial/ethnic differences in associations between racial/ethnic discrimination and sleep; therefore, future research assessing additional potential modifiers is warranted. In addition to this implication for future research, our results suggest public health and clinical implications. Our data support the importance of anti-discriminatory practices and policies in workplaces, businesses, neighborhoods/communities, and social settings to reduce negative health consequences resulting from the poor sleep health of employees, customers, community members, and other stakeholders [7]. Furthermore, sleep health practitioners can better provide culturally-relevant services to clients by screening for patient experiences with acute and chronic discrimination followed by mitigation interventions [44].

This epidemiological study resulted in two observations: both everyday and major discrimination were more commonly experienced by racial/ethnic minorities and each likely contributes to poor sleep duration and quality among women in the U.S. Insufficient sleep is increasingly recognized as a public health problem, and there are persistent racial/ethnic disparities in poor sleep. Ultimately, poor sleep and its health sequelae across all races/ethnicities and particularly among racial/ethnic minorities in the U.S. may benefit from implementing and evaluating multi-level strategies to reduce everyday and major racial/ethnic discrimination.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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The datasets generated during and/or analyzed during the current study are not publicly available due to privacy concerns. However, requests for data, including the data used in this analysis may be made following procedures described on the Sister Study Website

(www.sisterstudy.niehs.nih.gov-under the tab For Researchers).

ABBREVIATIONS

BMI	Body Mass Index
CI	Confidence Interval
NH	Non-Hispanic
METs	Metabolic Equivalents
PD	Prevalence Difference
PR	Prevalence Ratio
SES	Socioeconomic Status

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Highlights (3 to 5 bullet points-max 85 characters including spaces)

- Everyday discrimination was associated with a 10% higher short sleep prevalence.
- Major discrimination was associated with a 12% higher short sleep prevalence.
- Both forms were associated with a 10% higher prevalence of insomnia symptoms.
- Half (Black), 13% (Latina), and 1% (White) reported both forms of discrimination.
- Racial/ethnic discrimination is a likely contributor to sleep health disparities.

Table 1.

Baseline sociodemographic characteristics, health behaviors, chronic diseases, and stress measures, and experiences of discrimination among included participants, Sister Study (2003–2012)

Sample size	Total N= 40,038	NH-White n=35,763 (89%)	NH-Black n=3,088 (7.7%)	Hispanic/Latina n=1,187 (3.0%)
	%, mean ± SD, or median (IQR)			
Sociodemographic Characteristics				
Age categories				
35–64 years	83	82	91	90
65+ years	17	18	9	10
Educational attainment				
≤ High school	15	15	10	21
Some college or technical degree	33	33	34	36
≥ College (Bachelor's or greater)	52	52	56	43
Employment status				
Unemployed	33	34	25	30
Currently employed	67	66	75	70
Current shift work/irregular hours (yes)	15	15	13	14
Annual household income				
<$20,000	4	3	5	10
$20,000 to $49,999	20	20	24	25
$50,000 to $99,999	42	42	44	38
≥$100,000	35	36	27	28
Marital status				
Married/living as married	76	78	53	72
Single/never married	5	4	14	6
Divorced/separated/widowed	19	18	33	22
Region of residence				
Northeast	17	18	9	12
Midwest	28	29	23	9
South	33	30	60	42
West	22	22	8	38
Health behaviors and characteristics				
Smoking status				
Current	8	7	9	6
Former	36	37	26	27
Never	57	56	65	67
Alcohol consumption (past 12 months)				
Heavy (>7 drinks/week)	11	12	4	6
Light/moderate (≤7 drinks/week)	71	71	66	73
Nondrinker (never/former)	18	16	30	21
BMI ± SD, (kg/m^2)	28 ± 6	27 ± 6	31 ± 7	28 ± 6

Sample size	Total N= 40,038	NH-White n=35,763 (89%)	NH-Black n=3,088 (7.7%)	Hispanic/Latina n=1,187 (3.0%)
BMI category				
Underweight/normal (BMI ≤24.9 kg/m^2)	39	41	17	32
Overweight (25 kg/m^2≤ BMI ≤29.9 kg/m^2)	32	31	32	38
Obese (BMI ≥30 kg/m^2)	29	27	51	30
Healthy Eating Index Score, mean ± SD	62 ± 12	63 ± 12	59 ± 11	61 ± 12
Log-METs-hours/week ± SD	4 ± 0.7	4 ± 0.6	4 ± 0.7	4 ± 0.7
Sleep medication use (yes)	24	25	16	22
Habitual sleep duration category				
Short sleep (5-<7 hours)	28	25	54	34
Recommended sleep (7–9 hours)	72	75	46	66
Sleep debt (yes)	25	24	34	30
Napping ≥3 days/week (yes)	10	10	14	12
Insomnia symptoms (yes)	26	25	34	32
Cumulative sleep score, mean ± SD	0.9 ± 1.0	0.9 ± 1.0	1.4 ± 1.1	1.1 ± 1.1
High poor sleep score (yes)	9	8	17	12
Clinical characteristics				
Hypertension	28	27	49	24
Diabetes	5	5	12	9
Cardiovascular disease	3	3	5	3
Cancer	5	6	3	4
Clinical depression				
Yes	20	21	16	21
No	69	68	77	69
Unknown	11	11	7	9
Psychosocial stress				
Perceived stress scale-4, mean ± SD	2.7 ± 2.7	2.6 ± 2.7	3.1 ± 3.0	3.3 ± 2.9
Other discrimination (yes)	26	25	34	20
Racial/ethnic discrimination				
Everyday				
Score, mean ±SD	0.2 ± 0.6	0.0 ± 0.2	1.6 ± 1.1	0.6 ± 0.9
Ever (yes)	10	4	76	36
Major				
Score, mean ± SD	0.1 ± 0.4	0.0 ± 0.2	0.8 ± 0.9	0.2 ± 0.6
Ever (yes)	7	2	52	18
Combined (Major and Everyday)				
Score, mean ± SD	0.3 ± 0.9	0.1 ± 0.3	2.4 ± 1.8	0.8 ± 1.2
Both	5	1	48	13
Either	7	5	31	26
None	88	94	20	60

Data presented as %, median (interquartile range), or mean ± SD. Percentages may not add up to 100 due to rounding.

<4% missingness for children in home, marital status, current smoking, BMI/BMI category, hypertension, diabetes, cardiovascular/cerebrovascular disease, and cancer Abbreviations: NH (non-Hispanic); SD (standard deviation); IQR (interquartile range); BMI (body mass index); METs (metabolic equivalent); PSS (Perceived Stress Scale)

Note: Unemployed includes unemployed, homemaker, student, and retired. Healthy Eating Index scores range from 0–100 with higher scores indicating a healthier diet. Participants who reported long sleep were excluded from analysis due to small sample size (n=459).

All sleep characteristics were self-reported. Sleep debt was defined as an average of ≥2-hour difference vs. <2-hour difference between longest and shortest sleep duration during the week. Insomnia symptoms included: difficulty initiating asleep (taking ≥30 minutes or more to fall asleep on average) or difficultly maintaining asleep (waking up ≥3 times/night ≥3 nights/week vs. <3 times/night <3 nights/week). High sleep score was defined as at least three of the following: short sleep duration, sleep debt, napping ≥3 days/week, difficulty initiating sleep, and difficulty maintaining sleep.

Everyday discrimination includes being treated unfairly in receiving service at a store or restaurant; being treated as though you were less intelligent, worthy, or honest than others; and experiencing people acting as if they are afraid of you due to your race or ethnicity. Major racial/ethnic discrimination includes being treated unfairly in home renting, buying, or mortgage; treated unfairly in being stopped, searched, or threatened by police, or treated unfairly in job hiring, promotion, or firing due to your race or ethnicity. Combined discrimination: Both = everyday and major discrimination; either = either everyday or major discrimination, but not both; and none.

Table 2.

Mean scores of racial/ethnic discrimination measures and proportions of participants reporting racial/ethnic discrimination by sleep duration/quality at baseline, Sister Study (2003–2012)

	Sleep Duration Category		Sleep Debt		Napping ≥ 3 Days/Week		Insomnia Symptoms		High Poor Sleep Score	
	<7 hours	7–9 hours	Yes	No	Yes	No	Yes	No	Yes	No
	% or mean ± standard deviation (SD)									
Everyday										
All										
Score, mean ±SD	0.3 (0.8)	0.1 (0.5)	0.2 (0.7)	0.2 (0.5)	0.2 (0.6)	0.2 (0.6)	0.2 (0.7)	0.2 (0.5)	0.3 (0.8)	0.2 (0.6)
Ever(yes)	45.0	55.0	32.4	67.6	12.5	87.5	32.1	67.9	14.9	85.1
Ever (no)	25.9	74.1	23.8	76.2	9.8	90.2	25.5	74.5	8.1	91.9
NH-White										
Score, mean ±SD	0.1 (0.3)	0.0 (0.2)	0.1 (0.3)	0.0 (0.2)	0.1 (0.3)	0.0 (0.2)	0.1 (0.3)	0.0 (0.2)	0.1 (0.3)	0.0 (0.2)
Ever (yes)	28.6	71.4	28.4	71.6	11.0	89.0	27.6	72.4	10.0	90.0
Ever (no)	25.3	74.7	23.5	76.5	9.6	90.4	25.3	74.7	7.8	92.2
NH-Black										
Score, mean ±SD	1.6 (1.1)	1.5 (1.1)	1.6 (1.1)	1.6 (1.1)	1.5 (1.1)	1.6 (1.1)	1.6 (1.1)	1.5 (1.1)	1.7 (1.1)	1.5 (1.1)
Ever (yes)	55.5	44.5	34.6	65.4	13.5	86.5	35.0	65.0	17.9	82.1
Ever (no)	48.8	51.2	33.2	66.8	14.8	85.2	31.7	68.3	14.8	85.2
Hispanic/Latina										
Score, mean ±SD	0.7 (0.9)	0.5 (0.8)	0.7 (0.9)	0.5 (0.8)	0.5 (0.8)	0.6 (0.9)	0.6 (0.9)	0.6 (0.9)	0.7 (0.9)	0.6 (0.9)
Ever (yes)	40.5	59.5	33.6	66.4	11.8	88.2	31.0	69.0	14.2	85.8
Ever (no)	31.1	68.9	28.6	71.4	12.0	88.0	31.8	68.2	11.4	88.6
Major										
All										
Score, mean ± SD	0.2 (0.5)	0.1 (0.3)	0.1 (0.4)	0.1 (0.4)	0.1 (0.4)	0.1 (0.4)	0.1 (0.4)	0.1 (0.4)	0.2 (0.5)	0.1 (0.4)
Ever (yes)	47.5	52.5	31.8	68.2	12.8	87.2	33.5	66.5	15.8	84.2
Ever (no)	26.5	73.5	24.2	75.8	9.9	90.1	25.7	74.3	8.3	91.7
NH-White										
Score, mean ±SD	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)
Ever (yes)	31.2	68.8	28.2	71.8	12.0	88.0	28.6	71.4	11.3	88.7

	Sleep Duration Category		Sleep Debt		Napping ≥ 3 Days/Week		Insomnia Symptoms		High Poor Sleep Score	
	<7 hours	7–9 hours	Yes	No	Yes	No	Yes	No	Yes	No
Ever (no)	25.3	74.7	23.6	76.4	9.6	90.4	25.3	74.7	7.8	92.2
NH-Black										
Score, mean ±SD	0.9 (0.9)	0.8 (0.9)	0.8 (0.9)	0.8 (0.9)	0.7 (0.9)	0.8 (0.9)	0.9 (0.9)	0.8 (0.9)	0.9 (1.0)	0.8 (0.9)
Ever (yes)	56.4	43.6	33.8	66.2	12.9	87.1	35.6	64.4	18.0	82.0
Ever (no)	51.1	48.9	34.8	65.2	14.8	85.2	32.7	67.3	16.1	83.9
Hispanic/Latina										
Score, mean ±SD	0.3 (0.7)	0.2 (0.5)	0.2(0.60)	0.2(0.60)	0.2(0.60)	0.3 (0.6)	0.2 (0.5)	0.3 (0.7)	0.3 (0.7)	0.2 (0.6)
Ever (yes)	44.2	55.8	30.8	69.2	14.4	85.6	37.0	63.0	15.9	84.1
Ever (no)	32.4	67.6	30.3	69.7	11.4	88.6	30.3	69.7	11.6	88.4
					Combined					
All										
Score, mean ± SD	0.5 (1.2)	0.2 (0.7)	0.4 (1.0)	0.2 (0.8)	0.3 (1.0)	0.3 (0.9)	0.4 (1.0)	0.2 (0.8)	0.5 (1.2)	0.2 (0.8)
Both	52.4	47.6	33.6	66.4	12.7	87.3	35.9	64.1	17.7	82.3
Either	37.8	62.2	30.4	69.6	12.4	87.6	28.6	71.4	12.0	88.0
None	25.7	74.3	23.8	76.2	9.7	90.3	25.5	74.5	8.0	92.0
NH-White										
Score, mean ±SD	0.1 (0.4)	0.1 (0.3)	0.1 (0.4)	0.1 (0.3)	0.1 (0.4)	0.1 (0.3)	0.1 (0.4)	0.1 (0.3)	0.1 (0.4)	0.1 (0.3)
Both	31.1	68.9	31.5	68.5	13.6	86.4	31.9	68.1	14.0	86.0
Either	29.1	70.9	27.4	72.6	10.7	89.3	26.8	73.2	9.5	90.5
None	25.2	74.8	23.5	76.5	9.6	90.4	25.2	74.8	7.8	92.2
NH-Black										
Score, mean ±SD	2.5 (1.8)	2.2 (1.7)	2.4 (1.8)	2.4 (1.8)	2.2 (1.7)	2.4 (1.8)	2.5 (1.8)	2.3 (1.7)	2.5 (1.8)	2.3 (1.7)
Both	56.8	43.2	34.2	65.8	12.7	87.3	36.4	63.6	18.5	81.5
Either	53.0	47.0	34.5	65.5	15.0	85.0	31.6	68.4	16.3	83.7
None	48.3	51.7	34.1	65.9	14.7	85.3	33.0	67.0	15.2	84.8
Hispanic/Latina										
Score, mean ±SD	1.0 (1.4)	0.7 (1.2)	0.9 (1.3)	0.8 (1.2)	0.8 (1.1)	0.8 (1.3)	0.9 (1.3)	0.8 (1.2)	1.0 (1.4)	0.8 (1.2)
Both	44.9	55.1	31.0	69.0	11.4	88.6	37.3	62.7	16.5	83.5
Either	38.5	61.5	34.4	65.6	14.0	86.0	28.7	71.3	13.1	86.9
None	30.3	69.7	28.5	71.5	11.2	88.8	31.5	68.5	11.2	88.8

Note: Row percentages are presented.

Abbreviations: NH (non-Hispanic)

All sleep characteristics were self-reported. Sleep debt was defined as an average of ≥2-hour difference vs. <2-hour difference between longest and shortest sleep duration during the week. Insomnia symptoms included: difficulty initiating asleep (taking ≥30 minutes or more to fall asleep on average) or difficultly maintaining asleep (waking up ≥3 times/night ≥3 nights/week vs. <3 times/night <3 nights/week). High sleep score was defined as at least three of the following: short sleep duration, sleep debt, napping ≥3 days/week, difficulty initiating sleep, and difficulty maintaining sleep.

Everyday discrimination includes being treated unfairly in receiving service at a store or restaurant; being treated as though you were less intelligent, worthy, or honest than others; and experiencing people acting as if they are afraid of you due to race or ethnicity. Major racial/ethnic discrimination includes being treated unfairly in home renting, buying, or mortgage; treated unfairly in being stopped, searched, or threatened by police, or treated unfairly in job hiring, promotion, or firing due to race or ethnicity. Combined discrimination: Both = everyday and major discrimination; either = either everyday or major discrimination, but not both; and none.

Table 3.

Adjusted prevalence ratios and 95% confidence intervals (CIs) for poor sleep characteristics associated with racial/ethnic discrimination among white, black, and Hispanic/Latina women, Sister Study, N=40,038

	Short Sleep Duration (<7 hours vs. 7–9 hours)			Sleep Debt (yes vs. no)			Napping ≥3 Days/Week (yes vs. no)			Insomnia Symptoms (yes vs. no)			High Sleep Score (yes vs. no)		
Racial/ethnic Discrimination	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
							Prevalence Ratio (95% CI)								
Everyday (yes vs. no)															
All	**1.16 (1.10, 1.23)**	**1.16 (1.09, 1.22)**	**1.10 (1.04, 1.16)**	1.06 (1.00, 1.12)	1.04 (0.99, 1.10)	1.02 (0.97, 1.08)	1.10 (0.98, 1.24)	1.06 (0.94, 1.19)	1.02 (0.91, 1.15)	**1.11 (1.04, 1.19)**	**1.08 (1.01, 1.15)**	1.04 (0.97, 1.10)	**1.30 (1.16, 1.46)**	**1.23 (1.10, 1.37)**	1.11 (0.99, 1.24)
NH-White	**1.12 (1.03, 1.22)**	**1.11 (1.02, 1.21)**	1.04 (0.96, 1.14)	1.07 (1.00, 1.15)	1.05 (0.98, 1.13)	1.03 (0.96, 1.11)	**1.19 (1.03, 1.39)**	1.13 (0.97, 1.31)	1.08 (0.93, 1.25)	**1.10 (1.01, 1.20)**	1.06 (0.98, 1.16)	1.01 (0.93, 1.10)	**1.26 (1.08, 1.48)**	1.18 (1.00, 1.38)	1.05 (0.89, 1.23)
NH-Black	**1.18 (1.09, 1.28)**	**1.17 (1.08, 1.27)**	**1.13 (1.04, 1.22)**	1.02 (0.92, 1.13)	1.01 (0.91, 1.12)	1.00 (0.90, 1.11)	0.98 (0.81, 1.20)	0.98 (0.80, 1.19)	0.94 (0.77, 1.14)	**1.18 (1.05, 1.33)**	**1.15 (1.03, 1.29)**	1.11 (0.99, 1.24)	**1.35 (1.12, 1.64)**	**1.30 (1.08, 1.56)**	1.17 (0.97, 1.41)
Hispanic/ Latina	**1.32 (1.13, 1.54)**	**1.31 (1.12, 1.53)**	**1.27 (1.09, 1.48)**	1.09 (0.93, 1.27)	1.07 (0.92, 1.25)	1.06 (0.91, 1.24)	1.02 (0.74, 1.40)	1.00 (0.72, 1.38)	0.98 (0.71, 1.35)	1.02 (0.86, 1.21)	1.00 (0.84, 1.18)	0.97 (0.82, 1.15)	1.32 (0.97, 1.79)	1.27 (0.94, 1.72)	1.18 (0.87, 1.60)
Major (yes vs. no)															
All	**1.19 (1.12, 1.25)**	**1.17 (1.11, 1.24)**	**1.12 (1.06, 1.19)**	1.00 (0.94, 1.06)	0.99 (0.93, 1.05)	0.97 (0.91, 1.03)	1.05 (0.93, 1.20)*MD*	1.02 (0.90, 1.16)	0.98 (0.86, 1.11)	**1.14 (1.07, 1.22)**	**1.09 (1.02, 1.16)**	1.04 (0.98, 1.11)	**1.29 (1.15, 1.45)**	**1.19 (1.06, 1.34)**	1.07 (0.95, 1.20)
NH-White	**1.22 (1.10, 1.35)**	**1.19 (1.08, 1.32)**	**1.12 (1.01, 1.24)**	1.07 (0.98, 1.17)	1.05 (0.96, 1.15)	1.03 (0.94, 1.12)	**1.23 (1.02, 1.47)***MD*	1.16 (0.97, 1.39)	1.10 (0.92, 1.32)	1.11 (1.00, 1.24)	1.04 (0.94, 1.15)	0.99 (0.89, 1.09)	**1.37 (1.14, 1.66)**	**1.22 (1.01, 1.47)**	1.06 (0.88, 1.28)
NH-Black	**1.14 (1.06, 1.21)**	**1.13 (1.06, 1.21)**	**1.09 (1.02, 1.17)**	0.94 (0.87, 1.03)	0.94 (0.86, 1.02)	0.92 (0.84, 1.00)	0.90 (0.76, 1.07)*MD*	0.89 (0.74, 1.05)	0.85 (0.71, 1.02)	**1.15 (1.04, 1.26)**	**1.11 (1.01, 1.22)**	1.08 (0.98, 1.18)	**1.22 (1.05, 1.43)**	1.16 (0.99, 1.35)	1.05 (0.90, 1.23)
Hispanic/ Latina	**1.37 (1.15, 1.64)**	**1.36 (1.15, 1.63)**	**1.30 (1.09, 1.55)**	0.98 (0.82, 1.18)	0.97 (0.81, 1.16)	0.95 (0.79, 1.14)	1.20 (0.83, 1.73)*MD*	1.18 (0.81, 1.71)	1.13 (0.78, 1.64)	**1.23 (1.01, 1.51)**	1.20 (0.98, 1.47)	1.15 (0.94, 1.41)	1.36 (0.95, 1.95)	1.31 (0.91, 1.87)	1.16 (0.81, 1.67)
Combined															
All															
Both vs. None	**1.26 (1.18, 1.35)**	**1.25 (1.17, 1.34)**	**1.17 (1.09, 1.25)**	1.01 (0.94, 1.09)	1.00 (0.93, 1.08)	0.97 (0.90, 1.05)	1.05 (0.89, 1.24)	1.00 (0.85, 1.18)	0.94 (0.80, 1.11)	**1.23 (1.13, 1.34)**	**1.17 (1.08, 1.27)**	**1.10 (1.01, 1.20)**	**1.48 (1.28, 1.71)**	**1.35 (1.17, 1.55)**	1.14 (0.99, 1.33)

	Short Sleep Duration (<7 hours vs. 7–9 hours)			Sleep Debt (yes vs. no)			Napping ≥3 Days/Week (yes vs. no)			Insomnia Symptoms (yes vs. no)			High Sleep Score (yes vs. no)		
Racial/ethnic Discrimination	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Either vs. None	**1.16 (1.09, 1.23)**	**1.15 (1.08, 1.21)**	**1.10 (1.04, 1.17)**	**1.07 (1.02, 1.13)**	1.06 (1.00, 1.12)	1.04 (0.99, 1.10)	**1.17 (1.05, 1.31)**	**1.13 (1.01, 1.26)**	1.09 (0.98, 1.22)	1.04 (0.98, 1.12)	1.01 (0.95, 1.07)	0.97 (0.91, 1.04)	**1.21 (1.08, 1.36)**	**1.14 (1.02, 1.28)**	1.04 (0.93, 1.17)
NH-White															
Both vs. None	1.20 (1.00, 1.44)	1.18 (0.98, 1.41)	1.08 (0.90, 1.30)	1.08 (0.94, 1.24)	1.07 (0.93, 1.23)	1.03 (0.90, 1.19)	**1.40 (1.04, 1.88)**	1.29 (0.95, 1.73)	1.20 (0.89, 1.62)	**1.23 (1.03, 1.46)**	1.15 (0.98, 1.37)	1.07 (0.90, 1.27)	**1.64 (1.22, 2.21)**	**1.45 (1.07, 1.95)**	1.21 (0.89, 1.65)
Either vs. None	**1.15 (1.07, 1.24)**	**1.13 (1.05, 1.22)**	1.08 (1.00, 1.16)	1.07 (1.00, 1.14)	1.05 (0.98, 1.12)	1.03 (0.96, 1.10)	1.15 (1.00, 1.32)	1.10 (0.96, 1.26)	1.05 (0.91, 1.21)	1.07 (0.99, 1.16)	1.02 (0.95, 1.11)	0.98 (0.91, 1.06)	**1.21 (1.04, 1.40)**	1.11 (0.96, 1.29)	1.00 (0.86, 1.16)
NH-Black															
Both vs. None	**1.23 (1.12, 1.35)**	**1.23 (1.12, 1.35)**	**1.17 (1.06, 1.28)**	0.98 (0.87, 1.10)	0.97 (0.86, 1.09)	0.94 (0.84, 1.06)	0.94 (0.75, 1.18)	0.93 (0.74, 1.16)	0.88 (0.70, 1.10)	**1.20 (1.06, 1.37)**	**1.16 (1.02, 1.31)**	1.11 (0.98, 1.26)	**1.41 (1.14, 1.74)**	**1.32 (1.07, 1.63)**	1.16 (0.94, 1.43)
Either vs. None	**1.13 (1.02, 1.25)**	**1.13 (1.02, 1.25)**	1.11 (1.00, 1.22)	1.03 (0.90, 1.17)	1.02 (0.90, 1.16)	1.01 (0.89, 1.15)	1.11 (0.87, 1.40)	1.11 (0.88, 1.40)	1.09 (0.86, 1.38)	1.01 (0.88, 1.17)	1.00 (0.87, 1.15)	0.98 (0.86, 1.13)	1.18 (0.93, 1.49)	1.16 (0.93, 1.46)	1.11 (0.81, 1.43)
Hispanic/ Latina															
Both vs. None	**1.49 (1.22, 1.83)**	**1.48 (1.21, 1.81)**	**1.40 (1.14, 1.71)**	0.98 (0.79, 1.21)	0.96 (0.78, 1.19)	0.94 (0.76, 1.16)	1.02 (0.63, 1.64)	0.99 (0.62, 1.60)	0.95 (0.59, 1.53)	1.23 (0.98, 1.55)	1.20 (0.95, 1.50)	1.14 (0.90, 1.43)	**1.53 (1.02, 2.30)**	1.45 (0.96, 2.20)	1.27 (0.84, 1.93)
Either vs. None	**1.30 (1.09, 1.54)**	**1.29 (1.08, 1.53)**	**1.26 (1.06, 1.50)**	1.19 (1.00, 1.41)	1.17 (0.99, 1.40)	1.16 (0.98, 1.38)	1.26 (0.89, 1.77)	1.23 (0.87, 1.73)	1.21 (0.86, 1.70)	0.93 (0.76, 1.14)	0.92 (0.76, 1.12)	0.90 (0.74, 1.10)	1.21 (0.86, 1.71)	1.17 (0.83, 1.65)	1.10 (0.78, 1.55)

Bolded values indicate statistical significance at a two-sided p-value of 0.05.

Abbreviations: NH (non-Hispanic)

All sleep characteristics were self-reported. Sleep debt was defined as an average of ≥2-hour difference vs. <2-hour difference between longest and shortest sleep duration during the week. Insomnia symptoms included: difficulty initiating asleep (taking ≥30 minutes or more to fall asleep on average) or difficultly maintaining asleep (waking up ≥3 times/night ≥3 nights/week vs. <3 times/night <3 nights/week). High sleep score was defined as at least three of the following: short sleep duration, sleep debt, napping ≥3 days/week, difficulty initiating sleep, and difficulty maintaining sleep.

Everyday discrimination includes being treated unfairly in receiving service at a store or restaurant; being treated as though you were less intelligent, worthy, or honest than others; and experiencing people acting as if they are afraid of you due to race or ethnicity. Major racial/ethnic discrimination includes being treated unfairly in home renting, buying, or mortgage; treated unfairly in being stopped, searched, or threatened by police, or treated unfairly in job hiring, promotion, or firing due to race or ethnicity. Combined discrimination: Both = everyday and major discrimination; either = either everyday or major discrimination, but not both; and none.

Model 1: Adjusted for age category (35–64 years, 65+ years), educational attainment (≤high school, some college/technical degree, ≥college [≥Bachelor's degree]), employment status (employed, not employed), current shift work/irregular work hours (yes, no), annual household income (<$20,000, $20,000 to $49,999, $50,000 to $99,999, ≥$100,000), marital status (married/living as married, single/never married, divorced/separated/widowed), and region of residence (Northeast, Midwest, South, West). Model 2: Model 1 + smoking status (current, former, never), alcohol consumption (heavy, light/

moderate, none), diet (Healthy Eating Index score), physical activity (log-metabolic equivalent hours/week), sleep medication use (yes, no), and physician diagnosis of clinical depression (yes, no). Model 3: Model 2 + other forms of discrimination (sexual orientation, job [yes, no]) and Perceived Stress Scale-4 score. Models for all participants additionally adjusted for race/ethnicity (NH-white, NH-black, Hispanic/Latina). Models for sleep debt additionally adjusted for consistent weekly sleep patterns (yes, no).

MD $_{\text{Prace/ethnicity*major discrimination}}$<0.05