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Racial differences in sleep duration intersect with sex, socioeconomic status, and U.S. geographic region: The REGARDS study

Megan E. Petrov, PhD[a,*], **D. Leann Long, PhD**[b], **Michael A. Grandner, PhD**[c], **Leslie A. MacDonald, ScD**[d], **Matthew R. Cribbet, PhD**[e], **Rebecca Robbins, PhD**[f,g], **Jenny M. Cundiff, PhD**[e], **Jennifer R. Molano, MD**[h], **Coles M. Hoffmann, PhD**[a], **Xuewen Wang, PhD**[i], **George Howard, DrPH**[b], **Virginia J. Howard, PhD**[j]

[a]Edson College of Nursing and Health Innovation, Arizona State University, Phoenix, AZ, USA

[b]Department of Biostatistics, School of Public Health, University of Alabama at Birmingham, Birmingham, AL, USA

[c]Department of Psychiatry, University of Arizona, Tucson, AZ, USA

[d]National Institute for Occupational Safety and Health, Cincinnati, OH, USA (see disclaimer below)

[e]Department of Psychology, University of Alabama, Tuscaloosa, AL, USA

[f]Harvard Medical School, Harvard University, Cambridge, MA, USA

[g]Division of Sleep and Circadian Disorders, Brigham & Women's Hospital, Boston, MA, USA

[h]Department of Neurology, University of Cincinnati, Cincinnati, OH, USA

[i]Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA

[j]Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Birmingham, AL, USA

Abstract

Objectives: Short and long sleep duration are associated with poor health outcomes and are most prevalent among racial/ethnic minorities. Few studies have investigated the intersection of other sociodemographic characteristics with race/ethnicity on sleep duration prevalence.

Design: Longitudinal retrospective analysis of continental U.S. cohort, the REasons for Geographic And Racial Differences in Stroke (REGARDS)

[*]Corresponding author at: Edson College of Nursing and Health Innovation, 550 N. 3rd Street, MC:3020, Phoenix, AZ 85004, USA. Tel.: +1-602-496-2297; fax: +1-602-496-0886. Megan.Petrov@asu.edu (M.E. Petrov).

Disclosures

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Supplementary materials

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Participants: Black (n = 7,547) and white (n = 12,341) adults, 56% women, ≥45 years

Measurements: At baseline (2003–07), participants reported age, sex, race, education, income, marital status, U.S. region, and employment status. The weighted average of reported sleep duration on weekdays and weekends, assessed at follow-up (2008–10), was categorized as <6, 6.0–6.99, 7.0–7.99 [reference], 8.0–8.99, and ≥9 h. Multinomial logistic regression models examined the independent and multivariable associations of sociodemographic factors with sleep duration. Interactions terms between race with education, income, region, and sex were examined.

Results: Average sleep duration was 7.0 h (SD=1.3). Prevalence of short (<6 h) and long(≥9 h) sleep duration was 11.4% (n = 2,260) and 7.0% (n = 1,395), respectively. In the multivariable model, interactions terms race*income, race*sex, and race*region were significant (P < .05). Relative to white adults, black adults, were most likely to have short sleep duration. The magnitude of that likelihood increased across greater levels of household income, but with greatest odds among black adults living outside of the Southeast and Appalachian United States, particularly for men (≥$75k; black men OR = 5.47, 95%CI: 3.94, 7.54; black women OR = 4.28, 95%CI: 3.08, 5.96).

Conclusions: Race in the context of socioeconomic, sex, and regional factors should be examined as key modifiers of sleep duration.

Keywords

Sleep duration; Race; Socioeconomic status; Sex; Geographic region; Health disparities

There is a “u-shaped” risk pattern with both shorter-than-ideal (<5–7 h) and longer-than-ideal (>8–9 h) sleep duration associated with a higher prevalence and incidence of cardiovascular diseases and stroke,[1–2,3] type II diabetes,[4] premature cognitive aging,[5] depression,[6] and all-cause mortality.[7] Prior studies suggest substantial differences in sleep duration between racial/ethnic groups, particularly among black American adults. Systematic reviews, meta-analyses, and large longitudinal cohort studies report that black adults have greater odds of both short and long sleep duration compared to non-Hispanic whites and other racial/ethnic groups,[8,9] and these differences have become more pronounced over the past several decades.[10,11] Many of these studies adjusted for other demographic factors such as socioeconomic position (e.g., income, education, employment, occupation), sex, marital status, and residence (e.g., region, neighborhood context). In most cases, the differences between black and white adults in the odds for short or long sleep duration were attenuated,[8] but remained significant, even when controlling for other confounding variables such as overall health status.[12]

Few studies have investigated the consistency of the association of these demographic factors with sleep duration across race/ethnic groups (i.e., interactions of the demographic factors by race/ethnicity),[13–17] despite known independent and joint associations between these demographic factors and sleep duration. Specifically, suboptimal sleep duration (ages 18–64: <7 and >9 h; ages ≥65: <7 and >8 h)[18] is prevalent among individuals who have low levels of income and/or educational attainment, are unable to work or are unemployed, are not currently married, and/or reside in the southeastern and Appalachian areas of the United States.[8,9,19–21] Of the studies available on interactions between race/ethnicity and other

demographic factors, most have focused on the interactive contribution of race/ethnicity, socioeconomic indicators, and sex on likelihood for short or long sleep duration. A study using data from the 2012 U.S. National Health Interview Survey (NHIS) found that, among African American adults, greater educational attainment was associated with higher prevalence of short sleep duration (<6 h).[13] Similarly, in the 2004 through 2011 U.S. NHIS, prevalence of short sleep duration increased with greater professional responsibility within many industries for black individuals, but decreased among white individuals.[17] In contrast, two smaller, regional studies found no interactions between race/ethnicity with socioeconomic indicators and sex on sleep duration when comparing black and white adults.[14,16]

An intersectional approach to the field of sleep health differences and disparities may provide greater understanding on whether other demographic factors may modify the association between race/ethnicity and sleep duration. Intersectionality theory proposes that multiple socially defined categories of being within individuals may intersect or interact to mirror systemic social structures and influence health and health behaviors.[22] Similar to prior studies,[23] by examining multiple interlocking sociodemographic and socioeconomic categories with race/ethnicity on sleep duration, subpopulations most vulnerable to suboptimal sleep duration can be identified, and perhaps ways to curb the growing disparity in sleep duration among black adults can be discovered. The REasons for Geographic and Racial Differences in Stroke (REGARDS) study, a large national sample of black and white middle-aged to older adults, represents a unique sample perfectly poised to confirm previous findings and assess interactions among these demographic factors to better understand disparities in sleep health. In this study, we describe habitual sleep duration by demographic characteristics independently and jointly, as well as the interactions between race with education, income, sex, and geographic region of residence on odds for short and long sleep duration. Based on previous findings from large samples, we hypothesized that black adults with higher socioeconomic status would have greater odds for short and long sleep duration than their white counterparts.

Participants and methods

Study design

The present study assesses relationships of demographics and self-reported sleep duration from the REGARDS study, a population-based national cohort of 30,239 black and white adults aged ≥45 years from the continental United States. Participants were randomly selected from a commercially available list (Genesys) and were enrolled from 2003 to 2007. The study oversampled black adults and residents of the Southeastern “Stroke Belt” states (Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee). At baseline assessment, participants completed a telephone interview and in-home assessment. Thereafter, follow-up telephone interviews have been conducted every 6 months to assess for suspected stroke events. The participants provided written consent, and the institutional review boards of all participating universities approved the protocol. For more information about the REGARDS study, please see a prior publication.[24]

Analytic sample

From 2008 to 2010, all active participants were asked to complete an ancillary sleep module during a routine follow-up telephone interview. Of the original cohort, 19,888 participants provided both complete information on items within the module inquiring about habitual sleep duration, and sociodemographic data, with the exception of employment status (see Fig. 1); 13,201 (66%) provided complete employment status data. Study participants were not asked about their employment status until later in the recruitment period. Differences in sociodemographic characteristics between the original REGARDS cohort and the analytic sleep subsample were minimal with less than 4% differences in proportions of each sociodemographic category between samples (see Supplementary Table 1). The analytic sleep sample had slightly less black adults, and tended to be younger, more educated, have higher incomes, and were more likely to be married.

Measures

Sleep.—Habitual sleep duration was assessed with two questions using the following format: How many hours of sleep do you usually get a night, or during your main sleep period, 1) on your work days? 2) on your nonwork days? Participants' responses were not constrained to the nearest integer. Habitual sleep duration was computed as the weighted average for the values provided (5 work days to 2 nonwork days), and then categorized as <6, 6.0–6.99, 7.0–7.99 (reference group), 8.0–8.99, ≥9 h.

Sociodemographic characteristics.—Participants self-reported a set of sociodemographic characteristics during baseline assessment including age, sex [reference group: women], race (black vs. white [reference group]), education (<high school [reference group], high school graduate, some college, ≥ college graduate), household income (< $20,000 [reference group], $20,000–$34,000, $35,000–$75,000, $75,000+, refused), relationship status (married [reference group], single, divorced, widowed, other), employment status (employed for wages [reference group], self-employed, retired/homemaker/student, unemployed, unable to work), and region of the U.S. Region of residence was categorized into four U.S. regions based on REGARDS oversampling from the Stroke Belt and Buckle regions, as well as by relevant literature indicating regional differences in sleep duration (see Fig. 2).[19] The four regions were defined as follows:

1. Stroke Buckle: coastal plains areas of NC, SC, and GA
2. Stroke Belt: AL, MS, TN, AR, LA, and remainder of NC, SC, and GA
3. Non-Stroke Buckle or Belt, Appalachian states: KY, WV, VA, PA, MD, and OH
4. All Other: all other regions sampled in the continental United States.

The proportion of participants that refused to report their household income was 11.4% representing a meaningful portion of the analytic sample. To avoid reducing the power of planned analyses and examine the unique subpopulation represented in this income category, these participants were included.

Statistical analysis—In the full analytic sample (n = 19,888), frequencies and proportions of each sociodemographic variable and sleep duration were computed. Next, the following sequence of models were constructed for our primary analyses:

1. *Univariate Models*. Multinomial logistic regression models were constructed to examine the independent associations of each sociodemographic characteristic with sleep duration categories (reference: 7.0–7.99) presented as odds ratios (OR) and 95% confidence intervals (CI).
2. *Multivariable Model*. A multivariable, multinomial logistic model of all sociodemographic variables as independent variables was constructed.
3. *Multivariable Model + All A Priori Interaction Terms*. To examine whether the relationship between race and sleep duration was modified by sociodemographic factors, interaction terms between race with sex, region, education, and income were entered into the Multivariable Model.
4. *Final Model: Multivariable Model + All Significant interaction Terms*. All significant interaction terms were retained in the Final Multivariable Model and the strata for each of those terms were presented in a single interactional model as OR (95%CI) and as adjusted prevalence estimates.

To address multicollinearity, variance inflation factors (VIF) for each model were examined and no concerning multicollinearity was observed (i.e., VIF < 10). As a sensitivity analysis, employment status was entered into all models described in (1)–(4). Since data for this variable was missing not at random, multiple imputation to approach this missingness was not possible. Significance of all main effects was determined based on a priori $\alpha = 0.05$, whereas significance of interaction terms were assessed at $\alpha = 0.1$. All model analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

Results

The mean age of the sample was 63.8 years (±9.1), 56% were women and 38% were black. Average sleep duration was 7.0 h (SD = 1.3).The percentage reporting sleep duration <6 h was 11.4%, and 7.0% reported ≥ 9 h of sleep (Table 1). The percentages within each sleep duration category by race (black vs. white adults), are as follows: <6 h 18.0 vs. 7.3%; 6–6.99 h 28.1 vs. 19.0%, 7–7.99 h 25.3 vs. 33.8%; 8–8.99 h 23.1 vs. 32.0%; and ≥9 h 5.6 vs. 7.8%. Supplementary Table 2 displays the multinomial logistic regression Univariate Models for associations between each sociodemographic characteristic and sleep duration. All sociodemographic characteristics were significantly associated with sleep duration ($P < .05$) with the exception of geographic region of residence ($P = .25$). Each 10-year increase in age was associated with reduced odds of shorter sleep (<6 and 6–6.99 h) and increased odds of longer sleep (8–8.99 and ≥9 h). Men were more likely to be short sleepers (<6 h) than females. Black participants were more likely to have shorter sleep duration than whites (<6 and 6–6.99 h). Each higher level of education or household income group were associated with lower odds for both shorter and longer sleep duration compared to their respective reference groups. Compared to married individuals, any other marital status was associated

with greater odds for shorter sleep. In addition, divorced or widowed individuals had greater odds for long sleep.

Table 2 presents the results of the Multivariable Model of associations between all sociodemographic characteristics and sleep duration such that each factor was adjusted for all other factors simultaneously. In this model, geographic region and sex were not significant. Results for the remaining sociodemographic factors were similar to the results of the Univariate Models with a few exceptions: black adults had lower odds of being long sleepers; single and widowed individuals no longer had greater odds for shorter sleep durations; widowed individuals no longer had greater odds for longer sleep durations; and single individuals had greater odds for long sleep duration.

When all A Priori Interaction Terms were added to the Multivariable Model displayed in Table 2, the race*education interaction term was not significant ($P = .16$) and was removed from the final model. In the Final Model (Multivariable Model + All Significant Interaction Terms), race*sex ($P = .047$), race*income ($P < .0001$), and race*region ($P = .048$) interaction terms remained statistically significant. Fig. 3 and Table 3 displays results from this Full Interaction Model examining the odds for each sleep duration category (reference: 7–7.99 h) among black adults compared to white adults (referent group) across all interaction term strata (i.e., sex, income groups, regions of residence) adjusting for all other sociodemographic factors (i.e., age, education, marital status). Supplementary Tables 3 and 4 display the adjusted prevalence estimates for each sleep duration category across race, income, and region of residence among women and men, respectively.

Shorter sleep duration.

In both men and women, and across regions, the magnitude of racial differences in short sleep duration increased with household income such that with increasing levels of income, black adults had increasingly greater odds for shorter sleep durations compared to white adults. The magnitude of this trend was largest among black adults relative to white adults living in all Other regions of the continental United States, and the least among those living in the Stroke Buckle region of the United States. Although these income and regional differences applied to both black men and women relative to white adults, the odds for shorter sleep durations were consistently greater in magnitude among black men and the greatest magnitude was found among black men with the highest incomes residing in Other regions in the continental United States (black men ≥$75k OR = 5.47, 95%CI: 3.97,7.54; black women ≥$75k OR: 4.28, 95%CI: 3.08–5.96).

Longer sleep duration.

Relative to white men, black men with the lowest reported incomes, regardless of geographic region of residence, had lower odds for long sleep duration (≥9 h) compared to 7–7.99 h sleepers. In addition, black women across regions with the highest reported incomes had lower odds for sleep duration of 8–8.99 h compared to white women with high incomes.

In the sensitivity analyses, employment status was examined (see Supplementary Table 5). The Univariate Model for the association between employment status and sleep duration was

significant ($P < .001$). Compared to participants employed for wages, individuals who were unemployed or unable to work had significantly greater odds of both short and long sleep durations, while the self-employed or retired/homemaker/students had greater odds for long sleep durations. In the Multivariable Model (Supplementary Table 6), employment status was significantly associated with sleep duration ($P < .0001$) along with age, sex, race, education, and relationship status, but income was no longer significantly associated ($P = .08$). The significance and direction of relationships between sleep duration and each employment category were unchanged.

When all interaction terms were added to the Multivariable Model, race*income ($P < .0001$) and race*region ($P = .048$) interaction terms remained significant and were retained. Supplementary Table 7 displays results from this full interaction model examining associations between sleep duration (reference: 7–7.99 h) and race (referent group: white adults) across income groups, and regions of residence while adjusting for employment status and all other sociodemographic characteristics. Results were similar to the full interactional model without employment status (Table 3). Across all regions, among black adults, increasing levels of household income were associated with increasingly greater odds for short sleep durations compared to white adults particularly among black adults living in other continental U.S. regions. However, racial differences in the odds of long sleep duration among low income groups was attenuated, and the lower odds for sleep duration of 8–8.99 h among black adults with the highest household incomes only applied to the Stroke Belt and Stroke Buckle regions.

Discussion

In this large national cohort of middle-aged to older black and white adults, we found that odds for shorter sleep duration was greater among black participants, and the magnitude of these odds was modified by sex, income, and geographical region of residence. Compared to white adults, increasing levels of income among black men and women across the United States were associated with greater odds for short sleep duration, and this association was most pronounced among black men and black adults living in regions of the United States outside of the Southeast and Appalachia. Generally, odds for short sleep duration among black men and women with the lowest incomes, living in regions of the United States traditionally associated with poor health outcomes (e.g., the Stroke Buckle), were greater compared to their white counterparts though of lesser magnitude. Odds for long sleep duration did not differ by race across sex, income, and region strata with the exception of lower odds for long sleep duration among black men with the lowest incomes across U.S. regions.

Our hypothesis that black adults with greater socioeconomic status would have greater odds for short sleep duration was supported. However, the hypothesis that they would also have greater odds for long sleep duration was not supported. In our final model, the interaction between race and education on sleep duration was not significant, yet the interaction between race and income level did demonstrate significant differences for both short (in the hypothesized direction) and long sleep duration (not in the hypothesized direction). These results were maintained even when accounting for employment status. Thus, in this cohort,

when accounting for income, education itself does not explain racial differences in sleep duration, but the likely outcomes of that education do (i.e., higher education yields higher income levels and influences employment status). Two prior large cohort studies that examined race by socioeconomic position on sleep duration did not examine income as a primary modifier. Instead one study focused on race by education without adjusting for income,[13] and the other examined race by occupation/industry status but adjusted for both education and income.[17]

Nonetheless, our results mirror findings from these other large cohorts indicating that higher levels of socioeconomic position do not protect black adults from short sleep duration compared to whites. Our Multivariable Model without examining interaction terms found that increasing levels of income were significantly associated with reduced odds for short and long sleep duration in the overall cohort. This suggests a protective benefit of higher income among white adults only, but not for black adults. Adjusted prevalence estimates (Supplementary Tables 3 and 4) suggest this potential benefit applies only to short sleep duration as there were no substantial differences in long sleep duration prevalence by race in the highest income level. Black men with higher income may experience this disparity in short sleep duration more than black women because of the gender pay and promotion gap. Reasons for this black-white disparity in short sleep duration are uncertain. This disparity among black and white adults employed in generally high-income earning occupations (i.e., professional, administrative, and management roles across industries) may be explained by limited professional/social support networks due to minority status in these occupations, more common workplace discrimination in higher earning occupations, and the perception by black adults in these settings that they must work harder than their white counterparts to overcome these obstacles and thwart negative racial stereotypes (i.e., a form of John Henryism).[17,25] Similarly, the “diminishing returns hypothesis” may explain the disparity, which purports that racial and ethnic minorities receive fewer benefits at high levels of socioeconomic attainment compared to white adults.[13,26] This also is reflected in another national cohort study that found that black adults living in houses or apartments had greater odds for short sleep duration compared to whites living in houses or apartment, and there was no racial difference in the odds for short sleep duration among participants living in mobile homes or trailers.[27] All of these factors may be obstacles to adequate sleep duration due to longer working hours, less access to resources usually afforded to individuals with high incomes, and increased hypervigilance to discrimination and perceived psychosocial stress. Prior research also has found that the magnitude of the relationship between broadly-defined daily stressors and odds for short sleep duration was greatest among highly educated black adults.[28] Despite growing and robust evidence of the black-white disparity in sleep health among adults with higher socioeconomic positions, testing of the aforementioned daily stressors is generally absent from the existing literature.

In the present study, region of residence was a significant modifier of race differences in sleep duration despite no main effect for U.S. region of residence on odds for shorter or longer sleep durations when adjusting for all other sociodemographic factors. In contrast, a prior report on the state-level prevalence of healthy sleep duration (≥7 h) indicated that states in Appalachia, the Stroke Buckle, and Stroke Belt regions had lower prevalence rates compared to other U.S. states.[19] Similarly, in another U.S. national cohort, regional (i.e.,

West, Midwest, South, Northeast) differences in sleep disturbance were not significant after accounting for multiple demographic and health related variables.[29] To determine the factors most responsible, the investigators examined each covariate for its contribution to rendering the relationship nonsignificant. They found that regional differences in race/ethnicity composition had the largest explanatory contribution for regional differences in sleep disturbance. Thus, regional differences in short sleep duration patterns across the United States may be partly driven by differences in the prevalence of minority racial/ethnic groups residing in those regions. Black adults are less represented as a racial group outside of the Southeast U.S. region and, in our analysis, black adults living in regions outside of Appalachian states, the Stroke Buckle, and the Stroke Belt had the greatest odds for short sleep duration across all income levels but with the greatest magnitude among those with the highest incomes. These regional sleep health disparities by race may reflect disparities in income across these regions by race. The majority of states within Appalachia, the Stroke Buckle, and Stroke Belt are some of the poorest states in the United States as measured by median household income for the last decade.[30] Therefore, the race by income gradient on odds for short sleep duration is likely "steeper" in the Other region of the United States partly due to the areas' generally higher income levels. Another contributor might be less social support networks for black Americans residing in the Other region of the United States due to low representation of this racial group. Without social support networks to mitigate psychosocial stressors, sleep health may be compromised.

There was no difference between black and white adults in odds for long sleep duration with the exception of black men with the lowest incomes having lower odds. Contrary to these results, other U.S. cohort studies have found greater odds for long sleep duration among black adults relatives to white adults,[31–33] though the literature is not uniform. Another U.S. cohort found no difference.[34] The former set of cohorts all came from the annual NHIS, which examines nationally representative samples across the lifespan and typically inquires about habitual sleep duration across a 24-h period. In contrast, the latter cohort was from the National Health and Nutrition Examination Survey (NHANES), which typically oversamples older adults and black adults, and asks participants to report habitual sleep duration on weekdays or workdays. Thus, the NHANES cohort is more similar to the REGARDS cohort, which might explain the similarities in findings on long sleep duration. Differences in long sleep duration between black and white adults may diminish with age and other circumstances associated with aging (e.g., medical conditions, retirement).

Our study is one of the first to examine the intersection of multiple sociodemographic and socioeconomic indicators on the relationship between race and odds for short and long sleep duration. Other strengths include access to a large population-based national cohort, oversampling of black adults and residents of the Stroke Belt and Buckle, and assessment of sleep duration using two items to estimate habitual weekday and weekend sleep duration. Limitations include use of self-reported sleep duration, which may be prone to recall, interpretation, and other perception biases that vary by race/ethnicity, socioeconomic status, and/or other psychosocial characteristics.[35–37] Further, sleep duration was assessed one to seven years after demographic variables were measured and it is possible that income, marital status, education region of residence, and employment status varied for some participants. We also were unable to examine or adjust for household and neighborhood

level indicators, occupational history for the retirees, and the occupation status, industry, and shift work status of the employed persons in our sample. Lastly, given the structure of our outcome variable (multi-categorical sleep duration), we were not able to estimate prevalence ratios for sleep duration by sociodemographic factors using Poisson regression modeling despite known benefits of prevalence ratios compared to odds ratios.[38]

Conclusion and implications

Black-white disparities in sleep duration are significantly modified by income, sex, and region of residence in the United States. Relative to white adults, odds for short sleep duration was largest among black adults at the highest income levels, living in areas outside of the Southeast and Appalachian United States, and particularly among men. Greater socioeconomic position, living in more affluent areas of the country, and gender privilege afforded to men were not protective against short sleep duration among middle-aged to older black adults. Our findings suggest that higher "class" is not an "equalizer" of racial sleep disparities as higher social position may exacerbate rather than protect against these disparities. Future investigations should examine the independent roles and interactions among multiple socioecological levels of influence on sleep health within micro-to-regional communities to best target individual, interpersonal, institutional, and community-level changes to support and promote adequate sleep duration.[39]

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sleh.2020.05.004.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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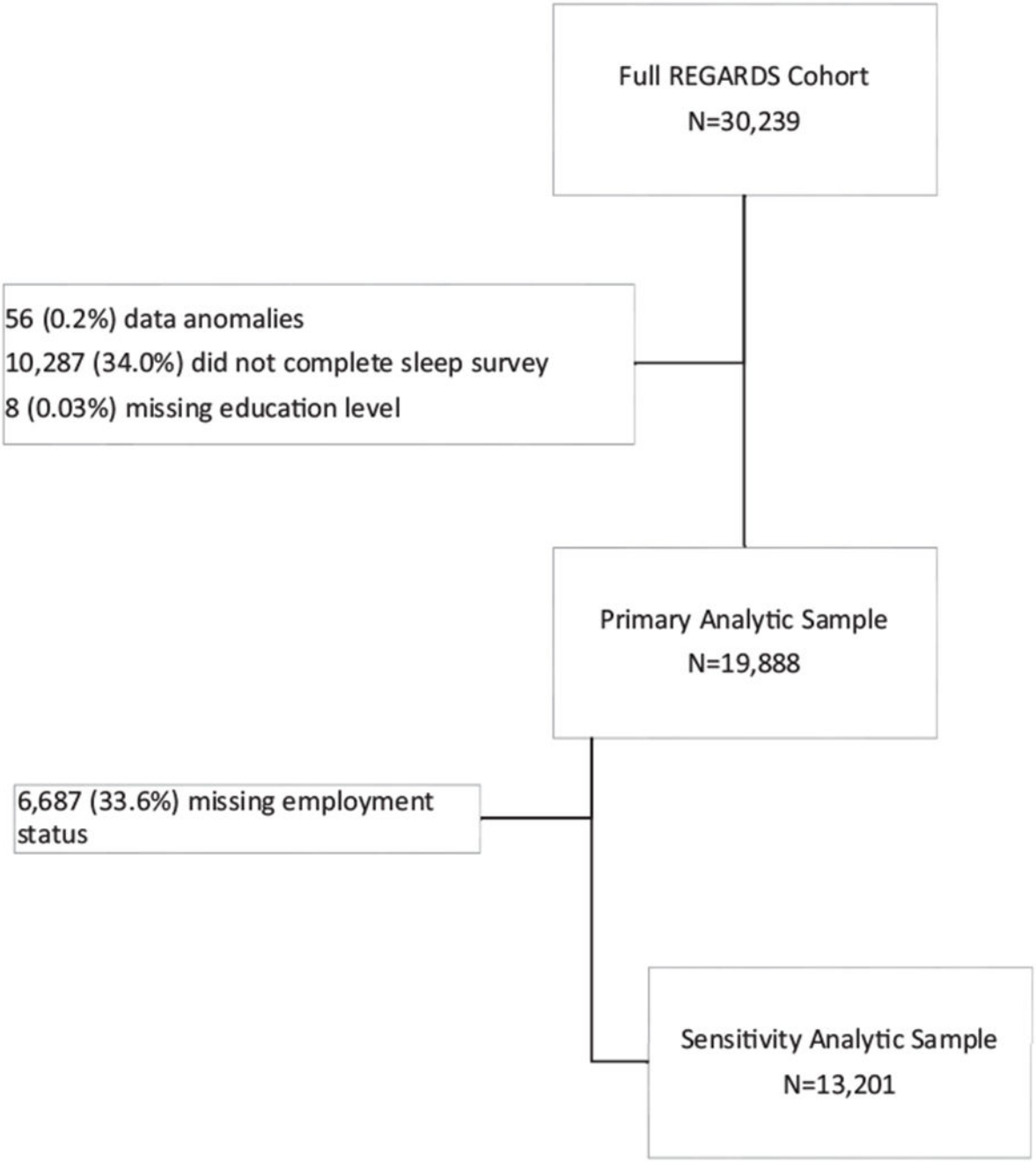

Fig. 1.
Flow chart for study sample inclusion.

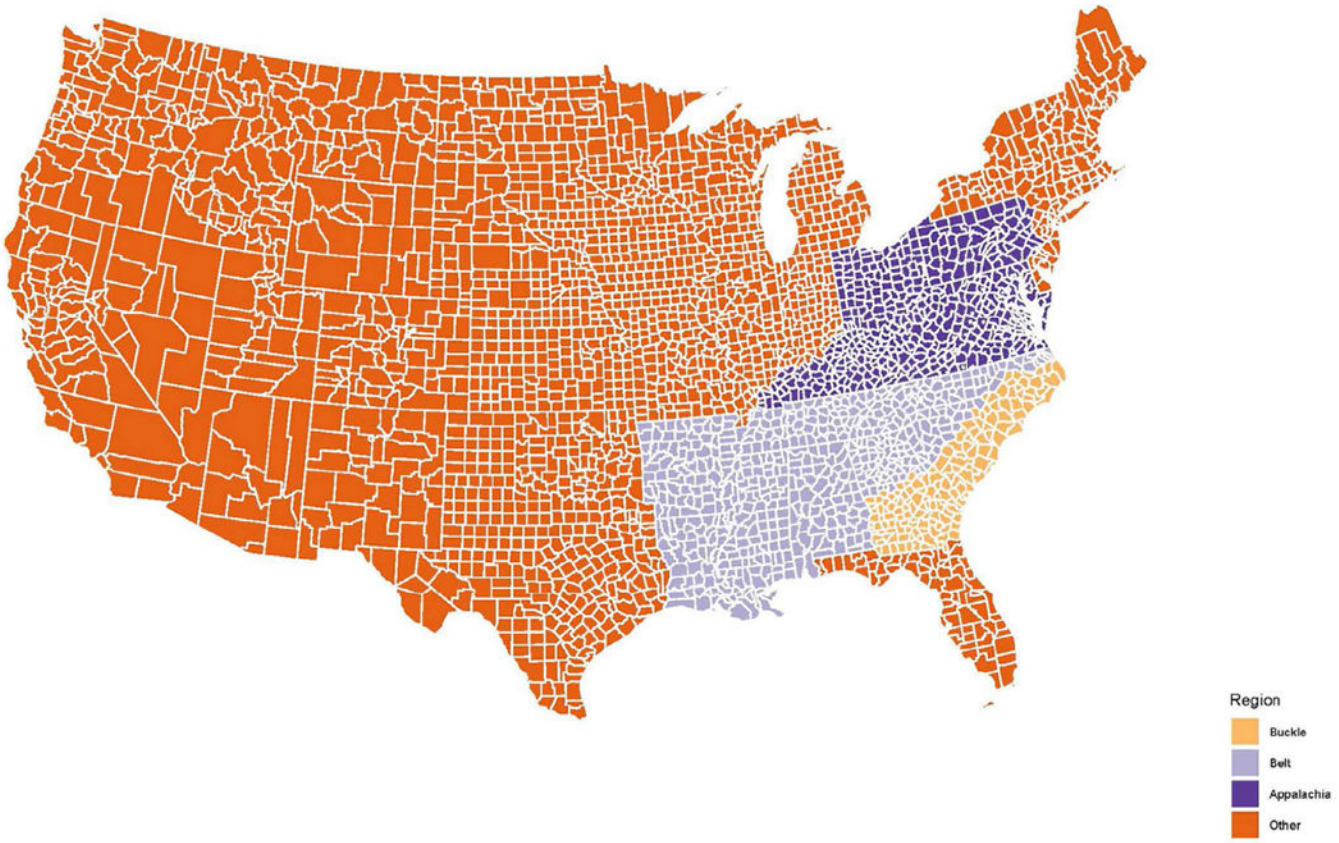

Fig. 2.
Continental U.S. map of regions categorized in the REGARDS Study.

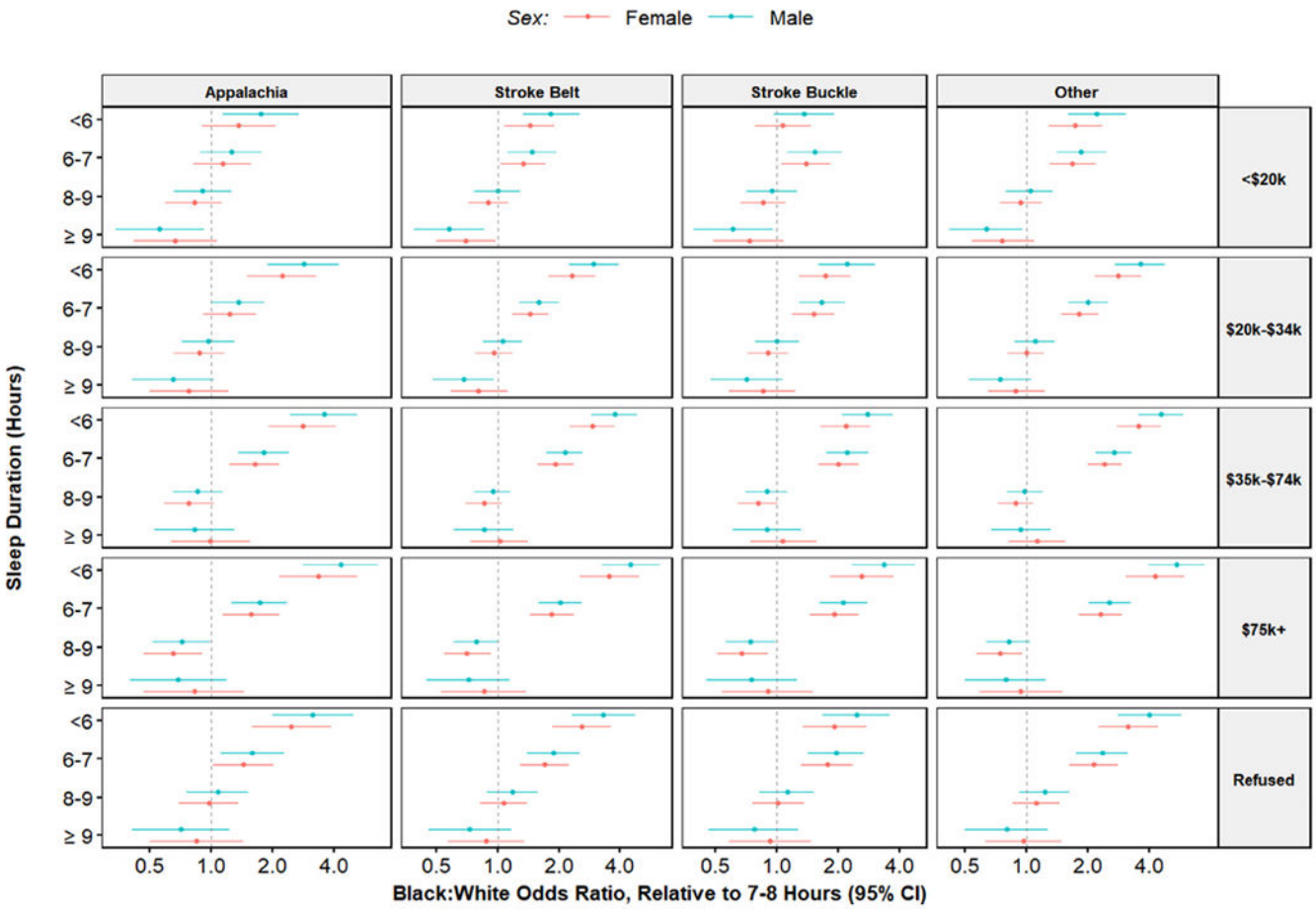

Fig. 3.

Estimated odds ratios for sleep duration groups (relative to 7–7.99 h) among black adults relative to white adults within strata of region (columns), sex (see legend), and income (rows). Estimates are adjusted for all other sociodemographic characteristics (N = 19,888) including age, education, and marital status.

Table 1

Demographic characteristics of REGARDS study participants who reported habitual sleep duration (N = 19,888)

Variable	
Age (M, SD)	63.8(9.1)
Sex, *n* (% female)	11,124(56.0)
Race, *n* (% Black)	7547(38.0)
Education, *n* (%)	
<High school	1908(9.6)
High school grad	4915(24.7)
Some college	5408(27.2)
≥College grad	7657(38.5)
Income, *n* (%)	
<$20K	2880(14.5)
$20K–$34K	4565(23.0)
$35K–$74K	6399(32.2)
≥$75K	3774(19.0)
Refused	2273(11.4)
Marital status, n (%)	
Single	1023(5.1)
Married	12,361(62.2)
Divorced	2809(14.1)
Widowed	3284(16.5)
Other	411(2.1)
Region[a] *n*, (%)	
Non-Stroke Buckle or Belt Appalachian states	1968(9.9)
Stroke Belt	6903(34.7)
Stoke Buckle	4253(21.4)
All other	6674(34.0)
Employment status[b], n (%)	
Employed for wages	4162(20.9)
Self-employed	1396(7.0)
Retired/Homemaker/Student	6403(32.2)
Unemployed	405(2.0)
Unable to work	835(4.2)
Sleep duration (h), *n* (%)	
<6	2259(11.4)
6.0–6.99	4468(22.5)
7.0–7.99	6079(30.6)
8.0–8.99	5689(28.6)
≥9	1393(7.0)

[a]Non-Stroke Buckle or Belt Appalachian states: Kentucky, Maryland, Ohio, Pennsylvania, Virginia, West Virginia; Stroke Buckle: coastal plain region of North Carolina, South Carolina, and Georgia; Stroke Belt: Alabama, Arkansas, Louisiana, Mississippi, Tennessee, and remainder of North Carolina, South Carolina, and Georgia; Other: remainder of contiguous United States.

[b]n = 13,201.

Table 2

Odds ratios (95% confidence intervals) of the multivariable associations between each sociodemographic characteristic and sleep duration (reference group: 7–7.99 h) adjusting for all other sociodemographic characteristics (N = 19,888)

	Sleep duration (in hours)			
Variables	<6	6–6.99	8–8.99	≥9
Age, 10-year increase	0.91(0.86, 0.97)	0.92(0.88, 0.97)	1.19(1.14, 1.24)	1.44(1.34, 1.55)
Male sex [ref: female]	1.13(1.02, 1.26)	1.09(1.00, 1.18)	1.02(0.94, 1.10)	1.00(0.88, 1.14)
Black race [ref: White]	2.73(2.45, 3.03)	1.87(1.72, 2.04)	0.93(0.85, 1.01)	0.84(0.73, 0.96)
Region [ref: other]				
Stroke Buckle	0.98(0.86, 1.13)	0.99(0.89, 1.10)	1.01(0.91, 1.12)	1.02(0.87, 1.21)
Stroke Belt	0.97(0.86, 1.10)	0.98(0.89, 1.08)	1.06(0.97, 1.16)	1.16(1.01, 1.34)
Appalachia states	0.88(0.73, 1.05)	1.03(0.90, 1.19)	0.96(0.84, 1.10)	1.16(0.94, 1.42)
Education [ref: less than high school}				
High school graduate	0.79(0.66, 0.95)	0.99(0.84, 1.16)	0.86(0.74, 0.99)	0.68(0.55, 0.84)
Some college	0.77(0.64, 0.92)	0.94(0.80, 1.10)	0.85(0.74, 0.99)	0.63(0.51, 0.79)
College graduate and above	0.53(0.44, 0.64)	0.78(0.66, 0.92)	0.73(0.63, 0.85)	0.55(0.44, 0.69)
Income [ref: less than $20k]				
$20k–$34k	0.83(0.71, 0.98)	1.09(0.95, 1.26)	0.88(0.77, 1.01)	0.85(0.70, 1.03)
$35k–$74k	0.83(0.70, 0.98)	1.10(0.95, 1.27)	0.86(0.75, 0.98)	0.74(0.60, 0.90)
$75k and above	0.56(0.45, 0.69)	0.98(0.83, 1.16)	0.83(0.71, 0.97)	0.60(0.47, 0.77)
Refused	0.87(0.72, 1.06)	1.06(0.90, 1.25)	0.88(0.75, 1.02)	0.75(0.60, 0.95)
Relationship status [ref: married]				
Single	1.09(0.87, 1.37)	1.04(0.87, 1.26)	1.13(0.94, 1.35)	1.40(1.06, 1.84)
Divorced	1.17(1.01, 1.36)	1.06(0.93, 1.20)	1.03(0.91, 1.16)	1.26(1.05, 1.51)
Widowed	1.10(0.94, 1.28)	1.14(1.01, 1.29)	0.91(0.81, 1.02)	0.87(0.72, 1.04)
Other	1.45(1.08, 1.96)	0.96(0.72, 1.28)	0.90(0.67, 1.21)	1.23(0.80, 1.90)

Table 3

Estimated odds ratios for sleep duration groups (relative to 7–7.99 h) among black adults relative to white adults within strata of region, sex and income.[a] Estimates are adjusted for all other sociodemographic characteristics (N = 19,888)[b]

	Odds ratio vs. 7–7.99 h (95% confidence interval)							
	<6	**6–6.99**	**8–8.99**	**≥9**	**<6**	**6–6.99**	**8–8.99**	**≥9**
	Women				**Men**			
Region	Less than $20k				Less than $20k			
Appalachia [c]	1.37(0.91, 2.07)	1.14(0.82, 1.58)	0.83(0.60, 1.13)	0.67(0.42, 1.07)	1.76(1.15, 2.69)	1.26(0.89, 1.78)	0.91(0.66, 1.27)	0.56(0.34, 0.93)
Stroke Belt	1.44(1.08, 1.91)	1.34(1.04, 1.72)	0.90(0.72, 1.14)	0.70(0.50, 0.98)	1.83(1.34, 2.52)	1.48(1.12, 1.95)	1.00(0.77, 1.29)	0.58(0.39, 0.86)
Stroke Buckle	1.06(0.78, 1.46)	1.39(1.05, 1.83)	0.85(0.66, 1.10)	0.73(0.49, 1.08)	1.36(0.96, 1.92)	1.53(1.13, 2.08)	0.94(0.71, 1.25)	0.61(0.39, 0.95)
Other	1.74(1.29, 2.35)	1.68(1.30, 2.18)	0.94(0.74, 1.19)	0.76(0.54, 1.09)	2.22(1.60, 3.09)	1.86(1.40, 2.47)	1.04(0.79, 1.35)	0.64(0.42, 0.96)
	$20k-$34k				$20k-$34k			
Appalachia [c]	2.23(1.51, 3.29)	1.24(0.92, 1.66)	0.88(0.66, 1.17)	0.78(0.50, 1.22)	2.85(1.91, 4.23)	1.37(1.01, 1.84)	0.97(0.72, 1.30)	0.65(0.41, 1.04)
Stroke Belt	2.33(1.79, 3.03)	1.45(1.18, 1.79)	0.96(0.78, 1.18)	0.81(0.59, 1.12)	2.97(2.24, 3.94)	1.60(1.28, 2.01)	1.06(0.85, 1.32)	0.68(0.48, 0.96)
Stroke Buckle	1.72(1.28, 2.31)	1.51(1.19, 1.91)	0.90(0.72, 1.14)	0.85(0.58, 1.23)	2.20(1.60, 3.02)	1.66(1.29, 2.15)	1.00(0.78, 1.28)	0.71(0.47, 1.06)
Other	2.82(2.16, 3.68)	1.82(1.48, 2.25)	1.00(0.81, 1.22)	0.89(0.65, 1.23)	3.61(2.71, 4.79)	2.01(1.60, 2.52)	1.10(0.88, 1.37)	0.74(0.52, 1.06)
	$35k-$74k				$35k-$74k			
Appalachia [c]	2.81(1.92, 4.11)	1.65(1.24, 2.18)	0.78(0.59, 1.04)	0.99(0.64, 1.55)	3.59(2.46, 5.23)	1.82(1.37, 2.41)	0.86(0.65, 1.15)	0.83(0.53, 1.30)
Stroke Belt	2.93(2.28, 3.77)	1.93(1.58, 2.36)	0.86(0.70, 1.05)	1.03(0.74, 1.42)	3.75(2.90, 4.84)	2.14(1.74, 2.62)	0.95(0.77, 1.16)	0.86(0.61, 1.20)
Stroke Buckle	2.17(1.64, 2.87)	2.00(1.60, 2.51)	0.81(0.64, 1.01)	1.07(0.74, 1.56)	2.77(2.08, 3.70)	2.21(1.75, 2.80)	0.89(0.70, 1.13)	0.89(0.61, 1.32)
Other	3.56(2.77, 4.58)	2.42(1.99, 2.95)	0.89(0.73, 1.08)	1.13(0.82, 1.56)	4.55(3.53, 5.86)	2.68(2.19, 3.28)	0.98(0.80, 1.20)	0.94(0.67, 1.32)
	$75k and above				$75k and above			
Appalachia [c]	3.38(2.18, 5.24)	1.57(1.14, 2.16)	0.65(0.47, 0.91)	0.83(0.47, 1.46)	4.32(2.82, 6.62)	1.73(1.27, 2.36)	0.72(0.52, 0.99)	0.69(0.40, 1.20)
Stroke Belt	3.53(2.52, 4.94)	1.84(1.44, 2.37)	0.71(0.55, 0.93)	0.86(0.53, 1.39)	4.51(3.25, 6.26)	2.04(1.60, 2.60)	0.79(0.61, 1.02)	0.72(0.45, 1.15)
Stroke Buckle	2.61(1.82, 3.75)	1.91(1.45, 2.51)	0.67(0.51, 0.90)	0.90(0.54, 1.50)	3.34(2.33, 4.77)	2.11(1.61, 2.77)	0.74(0.56, 0.99)	0.75(0.45, 1.25)
Other	4.28(3.08, 5.96)	2.31(1.81, 2.95)	0.74(0.57, 0.96)	0.94(0.59, 1.51)	5.47(3.97, 7.54)	2.55(2.02, 3.23)	0.82(0.64, 1.05)	0.79(0.50, 1.25)
	Refused				Refused			
Appalachia [c]	2.48(1.59, 3.87)	1.45(1.03, 2.04)	0.98(0.70, 1.37)	0.85(0.50, 1.45)	3.17(2.01, 5.01)	1.60(1.12, 2.28)	1.08(0.76, 1.53)	0.71(0.41, 1.23)
Stroke Belt	2.59(1.86, 3.62)	1.70(1.29, 2.24)	1.07(0.82, 1.40)	0.88(0.57, 1.35)	3.31(2.32, 4.73)	1.88(1.40, 2.52)	1.18(0.89, 1.57)	0.73(0.46, 1.17)
Stroke Buckle	1.92(1.34, 2.74)	1.76(1.31, 2.36)	1.01(0.76, 1.35)	0.92(0.58, 1.46)	2.45(1.67, 3.59)	1.95(1.42, 2.67)	1.12(0.82, 1.52)	0.77(0.46, 1.27)

	Odds ratio vs. 7–7.99 h (95% confidence interval)							
	<6	6–6.99	8–8.99	≥9	<6	6–6.99	8–8.99	≥9
	Women				Men			
Other	3.15(2.25, 4.40)	2.13(1.62, 2.80)	1.11(0.86, 1.45)	0.97(0.63, 1.49)	4.02(2.81, 5.75)	2.35(1.76, 3.15)	1.23(0.93, 1.63)	0.80(0.50, 1.28)

[a] Single, full interaction model of sleep duration groups including all strata with a separate indicator for race (referent group: white) within each strata.

[b] Other covariates adjusted for in the multivariable model include age, education, and marital status.

[c] Appalachia refers to all remaining Appalachian states outside of the Stroke Buckle and Belt regions of the United States.