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## Independent and joint associations of race/ethnicity and educational attainment with sleep-related symptoms in a population-based US sample

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### Abstract

**Objective**—Prior studies have documented disparities in short and long sleep duration, excessive daytime sleepiness, and insomnia by educational attainment and race/ethnicity separately. We examined both independent and interactive effects of these factors with a broader range of sleep indicators in a racially/ethnically diverse sample.

**Methods**—We analyzed 2012 National Health Interview Survey data from 33,865 adults aged 18 years. Sleep-related symptomatology included short sleep duration ( < 6 h), long sleep duration ( > 9 h), fatigue >3 days, excessive daytime sleepiness, and insomnia. Bivariate analyses with chi-square tests and log-linear regression were performed.

**Results**—The overall age-adjusted prevalence was 29.1% for short sleep duration, 8.5% for long sleep duration, 15.1% for fatigue, 12.6% for excessive daytime sleepiness, and 18.8% for insomnia. Educational attainment and race/ethnicity were independently related to the five sleep-related symptoms. Among Whites, the likelihood of most sleep indicators increased as educational attainment decreased; relationships varied for the other racial/ethnic groups. For short sleep duration, the educational attainment-by-race/ethnicity interaction effect was significant for African Americans ( $p < 0.0001$ ), Hispanics ( $p < 0.0001$ ), and Asians ( $p = 0.0233$ ) compared to Whites. For long sleep duration, the interaction was significant for Hispanics only ( $p = 0.0003$ ).

**Conclusions**—Our results demonstrate the importance of examining both educational attainment and race/ethnicity simultaneously to more fully understand disparities in sleep health. Increased understanding of the mechanisms linking sociodemographic factors to sleep health is needed to determine whether policies and programs to increase educational attainment may also reduce these disparities within an increasingly diverse population.

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#### Conflict of interest

The authors declare that there are no conflicts of interest.

## Keywords

Ethnic groups; Minority health; Educational status; Socioeconomic status; Sleeplessness; Insomnia; Fatigue

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## Introduction

Health disparities often reflect differences in socioeconomic status (SES), race/ethnicity, gender, and foreign-born status (Berkman and Kawachi, 2000). In the United States, most health behaviors tend to follow an SES gradient, where unhealthy behaviors are more prevalent among lower SES and some racial/ethnic groups (Williams and Collins, 1995). Furthermore, racial/ethnic differences in health behaviors are often linked to inequalities in socioeconomic resources (Williams et al., 1994). Individuals of various social statuses lead very different lifestyles and often live, play, work, and learn in vastly different social environments (Berkman and Kawachi, 2000; Williams and Collins, 1995).

In the United States, increasing the proportion of adults who obtain sufficient sleep remains a Healthy People 2020 national objective for sleep health. Growing evidence demonstrates that sleep is as fundamental to health as diet and physical activity (Institute of Medicine, 2006; Perry et al., 2013). Hundreds of billions of dollars are spent each year in direct costs associated with insufficient sleep for doctor visits, hospital services, prescriptions, and over-the-counter medications (Institute of Medicine, 2006). Cost estimates for insomnia alone range from \$30 billion to \$107.5 billion (Institute of Medicine, 2006; Stoller, 1994; Walsh and Engelhardt, 1999). Furthermore, the number of office visits for which any sleep related diagnosis was recorded increased by 266% from 1999–2010 (Ford et al., 2014). Furthermore, in prior epidemiologic studies, researchers have observed a relationship between sleep duration and chronic conditions such as anxiety, obesity, diabetes, depression, heart disease, and hypertension and a U-shaped relation between sleep duration and mortality, suggesting that short and long sleep duration are both unfavorable (Cappuccio et al., 2011; Chapman et al., 2013b; Grandner et al., 2010a; Liu et al., 2013a,2013b).

Prior studies have also documented disparities in sleep indicators by race/ethnicity and SES factors (Adenekan et al., 2013; Baron et al., 2010; Chapman et al., 2013a; Grandner et al., 2010b, 2013; Jean-Louis et al., 2008; Liu et al., 2014; Nunes et al., 2008; Patel et al., 2010; Stamatakis et al., 2007; Tomfohr et al., 2010). For the most part, these prior studies examining the effects of race/ethnicity and SES on sleep-related symptoms have examined these two factors independently and often only included three or fewer racial/ethnic groups (Baron et al., 2010; Grandner et al., 2010b, 2013; Jean-Louis et al., 2008; Nunes et al., 2008; Tomfohr et al., 2010). In general, lower social status has been associated with more sleep-related symptoms. Mixed results, however, have been observed. One factor that could account for the conflicting findings is the multidimensional nature of adverse sleep-related symptoms. For example, according to recent meta-analyses, African Americans have shorter, less efficient sleep but fewer insomnia symptoms than do Whites (Ruiter et al., 2010, 2011). Furthermore, findings from the 2005 National Health Interview Survey (NHIS) indicated that African Americans were more likely to report short and long sleep duration

than Whites while findings from the 2006 Behavioral Risk Factor Surveillance System indicated that Whites and people with less education reported more sleep complaints (Grandner et al., 2010b). Thus, it remains unclear whether differences in sleep-related symptoms are best understood as effects of race/ethnicity, SES, or some interaction of the two.

Using data from the 2012 NHIS, we examined the independent and joint associations of race/ethnicity and educational attainment with the prevalence of five separate adverse sleep-related symptoms, namely short sleep duration, long sleep duration, fatigue, excessive daytime sleepiness, and insomnia in a large, nationally representative sample of US adults. One major step towards increasing the proportion of adults who get sufficient sleep is the lessening of existing disparities. Therefore, a better understanding of how SES and race/ethnicity are associated with sleep-related symptoms is critical for improving sleep health. The prevalence of these adverse sleep-related symptoms may be reduced by identifying high-risk groups and offering specific preventive measures.

## Methods

We examined cross-sectional data from the 2012 NHIS, a nationally representative household interview survey of the noninstitutionalized US population. Participants were selected using multistage probability sampling. Sampling weights were constructed based on probabilities of selection with adjustments for nonresponse and post-stratification. We used publicly available 2012 NHIS data for these analyses. Our analytic sample included data on 33,865 adults aged 18 years.

Educational attainment, which was based on the highest level of school completed or the highest degree received, was used as an indicator of SES. Although a number of indicators of SES (e.g. educational attainment, occupation, income, wealth) can be used with various implications, educational attainment was used in the present study because it is the most stable indicator of SES (Adler et al., 1994; Berkman and Kawachi, 2000). For descriptive statistics, we categorized educational attainment in years as less than high school, graduated high school or completed the general educational development (GED) certificate, and more than high school. For inferential statistics, educational attainment was examined continuously as years of completed schooling.

During the course of the in-person interview, participants self-identified their race/ethnicity. Participants were asked, "What race or races do you consider yourself to be?" Participants were also asked about their national origin or family ancestry. In this analysis, participants are categorized as one of five different racial/ethnic categories: non-Hispanic White, Hispanic, non-Hispanic Black or African American, Asian, and other race/ethnicity. Participants may have specified other specific racial group. Additionally, the other race/ethnicity category includes non-Hispanic American Indians and Alaska Natives and individuals of multiple races. Participant characteristics also included age groups (18–44, 45–54, 55–64, or 65 years), gender (men or women), and foreign-born status (US-born or foreign-born).

The following five sleep health indicators were examined separately as outcome variables: short sleep duration; long sleep duration; fatigue; excessive daytime sleepiness; and insomnia. Each respondent was asked about their usual sleep duration during a 24-hour period. Short sleep duration was defined as  $\leq 6$  h of sleep in an average 24-hour period and long sleep duration was defined as  $\geq 9$  h of sleep in an average 24-hour period because the National Institutes of Health recommends 7–8 h of sleep per day for healthy adults (<http://www.nhlbi.nih.gov/health/health-topics/topics/sdd/howmuch>). Fatigue was measured as a response to the question “During the past 12 months, have you had fatigue or lack of energy more than 3 days?” Excessive daytime sleepiness was measured as a response to the question “During the past 12 months, have you regularly had excessive sleepiness during the day?” Insomnia was measured as a response to the question “During the past 12 months, have you regularly had insomnia or trouble sleeping?” Although many of the sleep health indicators examined here are related, a composite indicator was not created because a unidimensional scale is unlikely to capture the multidimensional nature of adverse sleep-related symptoms as clearly as separate indicators.

We utilized SAS (SAS Institute, Cary, NC) and SAS-callable SUDAAN version 11.0 (Research Triangle Institute, Research Triangle Park, North Carolina) to analyze the data. Descriptive statistics included the examination of selected categorical characteristics and differences in these characteristics by race/ethnicity using Chi-square tests. The prevalences of the five sleep-related indicators by educational attainment within the five racial/ethnic groups were estimated and age-standardized to the 2000 United States projected population using four age groups. Orthogonal polynomial contrasts were used to test for significant linear trends. Differences and contrasts were considered significant at  $p < 0.05$ .

To examine the associations of race/ethnicity and educational attainment with the prevalences of the five sleep-related indicators, we fitted two sets of log-linear regression models for each of the indicators separately. The main effects models present the betas for the independent associations of race/ethnicity and educational attainment. The interaction models present the betas for the joint associations of race/ethnicity and educational attainment. That is, we examined the race/ethnicity by educational attainment statistical interaction with the prevalences of the five sleep-related indicators. Age, gender, and foreign-born status were included as covariates in all adjusted regression models.

In addition, we examined independent associations of sleep duration with fatigue, excessive daytime sleepiness, and insomnia and also statistical interactions with race/ethnicity using log-linear regression models. All interactions were considered significant at  $p < 0.10$  because this is a commonly accepted endpoint for statistical significance of interactions in the literature (Lu et al., 2005).

## Results

The overall age-adjusted prevalence was 29.1% for short sleep duration, 8.5% for long sleep duration, 15.1% for fatigue, 12.6% for excessive daytime sleepiness, and 18.8% for insomnia. Table 1 presents the distributions of selected characteristics by race/ethnicity.

Gender, age, foreign-born status, educational attainment, and all sleep-related indicators differed significantly ( $p < 0.001$ ) by race/ethnicity.

Fig. 1 shows age-adjusted percentages for the five sleep indicators varying by race/ethnicity. Asians had the lowest age-adjusted prevalence for four of five indicators. Short sleep duration was the most reported sleep-related indicator. Fig. 2 shows age-adjusted percentages for the five sleep indicators by educational attainment. Adults with less than high school education had significantly higher age-adjusted prevalences for long sleep duration, excessive daytime sleepiness, and insomnia.

Table 2 presents the age-adjusted percentages for the sleep-related indicators by educational attainment and race/ethnicity. Among Whites, the prevalences of short sleep duration, long sleep duration, fatigue, excessive daytime sleepiness, and insomnia were lower among those with higher education ( $p < 0.01$ ). Results were less consistent among African Americans, Hispanics, Asians, and other race/ethnicity adults. The prevalence of short sleep duration was higher among African Americans with more than high school compared with African American high school graduates or those with GED certificates ( $p = 0.013$ ). Among African Americans, the prevalences of long sleep duration and excessive daytime sleepiness were lower among those with higher education ( $p < 0.01$ ). The prevalence of short sleep duration was higher among Hispanics with more than high school education compared with Hispanics with less than high school ( $p < 0.01$ ). Among Hispanics, the prevalence of short sleep duration was higher among those with higher education but the prevalence of long sleep duration was lower among those with higher education ( $p < 0.01$ ).

Table 3 presents the beta coefficients from the log-linear regression analyses examining the independent associations of educational attainment and race/ethnicity. Overall, a unit increase in educational attainment was associated with 0.98 (95% CI: 0.98, 0.99) less short sleep, 0.93 (95% CI: 0.92, 0.94) less long sleep, 0.96 (95% CI: 0.95, 0.96) less fatigue, 0.94 (95% CI: 0.93, 0.95) less excessive daytime sleepiness, and 0.96 (95% CI: 0.95, 0.97) less insomnia. Compared with non-Hispanic White adults, African American adults were 1.28 (95% confidence interval [CI]: 1.21, 1.36) as likely to report short sleep duration, 0.75 (95% CI: 0.68, 0.82) as likely to report fatigue, 0.85 (95% CI: 0.76, 0.94) as likely to report excessive daytime sleepiness, and 0.79 (95% CI: 0.73, 0.86) as likely to report insomnia. Hispanics were 0.82 (95% CI: 0.72, 0.92) as likely to report fatigue and 0.82 (95% CI: 0.72, 0.94) as likely to report excessive daytime sleepiness as Whites. Asians were 1.21 (95% CI: 1.09, 1.35) as likely to report short sleep duration, 0.63 (95% CI: 0.50, 0.78) as likely to report fatigue, and 0.69 (95% CI: 0.58, 0.82) as likely to report insomnia as Whites.

Table 4 presents the beta coefficients from the log-linear regression analyses examining the joint associations of educational attainment and race/ethnicity. Among African American adults, a unit increase in educational attainment was associated with 1.07 (95% CI: 1.05, 1.09) more short sleep. Among Hispanic adults, a unit increase in education attainment was associated with 1.06 (95% CI: 1.04, 1.07) more short sleep, 1.05 (95% CI: 1.02, 1.08) more long sleep, 1.02 (95% CI: 1.00, 1.04) more fatigue, 1.05 (95% CI: 1.03, 1.08) more excessive daytime sleepiness, and 1.04 (95% CI: 1.02, 1.05) more insomnia. Among Asian

adults, a unit increase in educational attainment was associated with 1.03 (95% CI: 1.00, 1.05) more short sleep.

In adjusted regression models including age, gender, foreign-born status, educational attainment, and race/ethnicity as covariates, short sleep was associated with 1.91 (95% CI: 1.79, 2.05) more fatigue and long sleep was associated with 2.12 (95% CI: 1.92, 2.34) more fatigue compared to adults reporting 7–8 h of sleep daily. Short sleep was associated 2.01 (95% CI: 1.86, 2.18) more excessive daytime sleepiness and long sleep was associated with 2.70 (95% CI: 2.43, 3.00) more excessive daytime sleepiness compared to adults reporting 7–8 h of sleep. Lastly, short sleep was associated with 2.95 (95% CI: 2.78, 3.13) more insomnia and long sleep was associated with 1.48 (95% CI: 1.32, 1.66) more insomnia compared to adults reporting 7–8 h of sleep.

The sleep duration-by-race/ethnicity interaction for fatigue was statistically significant at  $p < 0.10$ , but not for excessive daytime sleepiness and insomnia. In models stratified by race/ethnicity and including age, gender, foreign-born status, and educational attainment as covariates, short sleep was associated with 1.82 (95% CI: 1.67, 1.97) more fatigue and long sleep was associated with 2.16 (95% CI: 1.93, 2.43) more fatigue among White adults compared to those reporting 7–8 h of sleep daily. Short sleep was associated 1.89 (95% CI: 1.57, 2.28) more fatigue and long sleep was associated with 1.84 (95% CI: 1.35, 2.51) more fatigue among African American adults. Short sleep was associated with 2.63 (95% CI: 2.18, 3.17) more fatigue and long sleep was associated with 2.34 (95% CI: 1.78, 3.11) more fatigue. Short sleep was associated with 1.56 (95% CI: 1.03, 2.37) more fatigue among Asian adults.

## Discussion

To our knowledge, this study is the first attempt to examine both the independent and joint effects of educational attainment and race/ethnicity on several adverse sleep-related symptoms in a nationally representative sample of adults in the United States. We confirm independent relationships between educational attainment and sleep indicators and between race/ethnicity and sleep indicators and expand the epidemiologic literature on sleep health. Although educational attainment was related to the five sleep-related symptoms, these relationships varied across racial/ethnic groups. The effect of educational attainment differs by racial/ethnic group. The expected SES gradient, where poorer health outcomes are associated with lower SES, occurred among Whites for all five sleep indicators. However, the relationships with educational attainment were less consistent among the other racial/ethnic groups.

Previous studies have observed independent relationships between various SES factors, race/ethnicity, and sleep-related symptoms. In a study of 2005 NHIS of 29,818 adults aged 18 years or older, the prevalence of short sleep duration was significantly higher among African Americans compared to Whites (Nunes et al., 2008). In a study of 159,856 adults aged 18 years or older included in the 2006 Behavioral Risk Factor Surveillance System, Whites reported more sleep complaints than the other racial/ethnic groups, higher income, educational attainment, and employment were all independently associated with fewer sleep

complaints (Grandner et al., 2010b). In another study of 5173 adults aged 45 to 84 years participating in the Multi-Ethnic Study of Atherosclerosis, Whites were significantly more likely to report feeling excessively sleepy 5 days per month, compared with African Americans, Hispanics, and Chinese (Baron et al., 2010). Additionally, in a community-based study of 1440 in Brooklyn, New York, the prevalence of insomnia symptoms among African Americans was 71%, 34% among English-speaking Caribbeans, 33% among Haitians, 73% among Dominicans, 77% among Eastern Europeans, and 70% among European Americans (Jean-Louis et al., 2008).

Observations from the present study deserve particular attention and have important implications, suggesting that higher SES is not always linked to healthy sleep. Remarkably, the typical educational gradient for some adverse sleep-related symptoms among African Americans, Hispanics, and Asians were lacking. For example, among African Americans and Hispanics, higher age-adjusted prevalences for short sleep duration were observed among those with higher levels of education. Although educational attainment and other socioeconomic resources are usually thought to be factors that are protective against adverse sleep-related symptoms, these observations are consistent with the diminishing returns hypothesis, which suggests that racial/ethnic disparities increase with higher levels of SES and some members of racial/ethnic groups often realize lower returns than whites with the same investment in education (Farmer and Ferraro, 2005). High SES African Americans and Hispanics may receive fewer sleep health benefits from increasing SES because they experience discrimination, have had lower quality educations, and have fewer opportunities than Whites to improve their life chances (Haas et al., 2012). Conversely, higher levels of SES may protect African Americans and Hispanics from the adverse sleep-related symptoms that are associated with structural disadvantages (Adler and Newman, 2002). Further research is needed to examine the mechanisms by which race/ethnicity and SES influence sleep health. Future studies ought to consider what sociocultural and behavioral characteristics of racial/ethnic groups are protective against a lack of socioeconomic resources.

## Limitations and strengths

Limitations and strengths of our study need to be considered. Our data are cross-sectional and preclude any causal interpretations. Also, the information is based on self-reported data and was not validated by actigraphy or medical records and might be subject to recall and other response biases (Szklo and Nieto, 2007). Participants might over-report their usual sleep duration or under-report the occurrence of sleep-related symptoms. Because the probability of outcome misclassification is not related to exposure status, non-differential misclassification will likely produce bias towards the null value as educational attainment is modeled primarily as a continuous variable (Flegal et al., 1991). NHIS is the nation's largest in-person household health survey and data are a population-based sample and representative of adults. However, our findings cannot be generalized to other populations. Lastly, information on five sleep health indicators makes our study unique and more comprehensive than previous studies on disparities in sleep health, which were mostly limited to one or two indicators.

## Conclusions

In summary, this study underscores the complex differences in sleep-related symptoms by educational attainment and race/ethnicity and the continuing need for interventions and other preventive measures that target low-education and some racial/ethnic groups in order to meet Healthy People 2020 goals. In this study, relationships between educational attainment and five sleep-related symptoms varied across racial/ethnic groups. Therefore, disparities in sleep health may be better understood by examining joint effects of SES and race/ethnicity rather than examining independent effects alone. A greater understanding of the mechanisms linking sociodemographic factors to sleep health is needed to determine whether policies and programs to increase educational attainment may also reduce these disparities within an increasingly diverse population in the United States.

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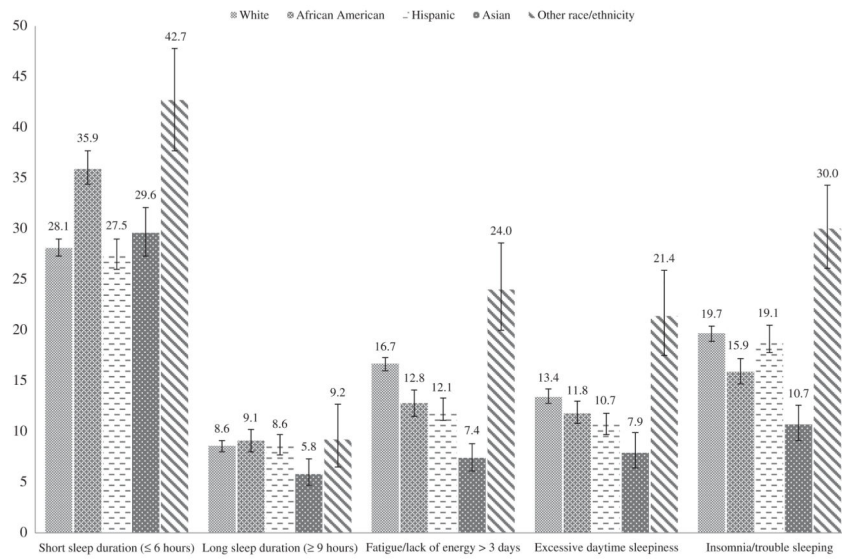
The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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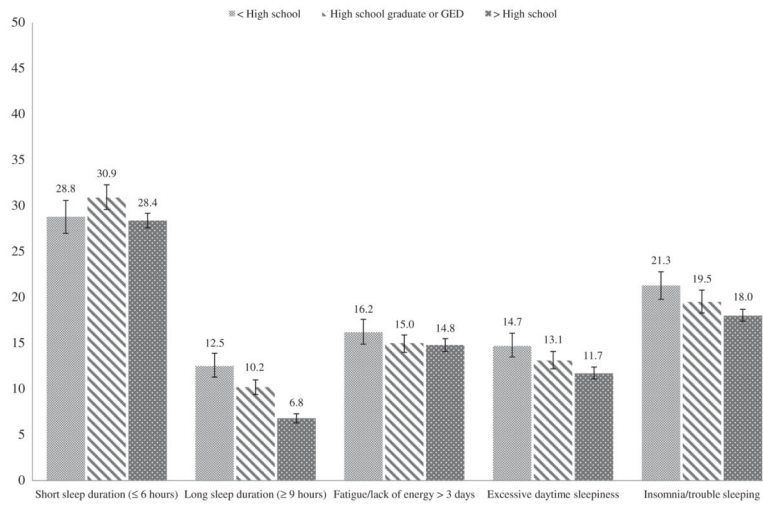
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**Fig. 1.** Age-adjusted percentages of sleep indicators among US adults 18 years by race/ethnicity: National Health Interview Survey, 2012.



**Fig. 2.** Age-adjusted percentages of sleep indicators among US adults 18 years by educational attainment: National Health Interview Survey, 2012.

Distribution of selected characteristics among US adults 18 years by race/ethnicity: National Health Interview Survey, 2012.

Table 1

Characteristic	n	White		African American		Hispanic		Asian		Other race/ethnicity		p-Value for Wald chi-square
		[N = 20,273]	% (S.E.)	[N = 4993]	% (S.E.)	[N = 5739]	% (S.E.)	[N = 2056]	% (S.E.)	[N = 804]	% (S.E.)	
Educational attainment (mean years)	33,865	15.5 (0.03)	14.7 (0.06)	12.7 (0.08)	16.1 (0.11)	15.0 (0.14)						<0.001
Educational attainment												
<High school	5379	9.2 (0.26)	17.3 (0.68)	34.6 (0.78)	8.9 (0.77)	13.6 (1.63)						
High school graduate or GED	8773	26.3 (0.40)	28.9 (0.85)	26.9 (0.75)	16.4 (1.03)	23.7 (2.01)						
>High school	19,713	64.5 (0.43)	53.8 (0.93)	38.5 (0.82)	74.7 (1.21)	62.7 (2.29)						
Nativity status												
US-born	27,460	95.0 (0.20)	89.0 (0.62)	41.2 (0.82)	24.7 (1.29)	91.5 (1.28)						
Foreign-born	6405	5.0 (0.20)	11.0 (0.62)	58.8 (0.82)	75.3 (1.29)	8.5 (1.28)						
Gender												
Men	14,989	48.5 (0.45)	44.7 (0.94)	50.0 (0.84)	46.8 (1.43)	46.4 (2.38)						
Women	18,876	51.5 (0.45)	55.3 (0.94)	50.0 (0.84)	53.2 (1.43)	53.6 (2.38)						
Age												
18–24 years	3376	11.0 (0.34)	15.4 (0.80)	18.3 (0.73)	12.6 (1.06)	23.3 (2.23)						
25–44 years	11,695	30.8 (0.41)	37.2 (0.91)	46.0 (0.83)	42.7 (1.41)	37.4 (2.24)						
45–64 years	11,621	37.1 (0.43)	34.4 (0.86)	27.0 (0.74)	31.9 (1.36)	29.9 (2.16)						
65 years and over	7173	21.1 (0.34)	13.0 (0.52)	8.7 (0.39)	12.7 (0.80)	9.4 (1.27)						

Abbreviation: S.E. standard error.

**Table 2** Age-adjusted percentages for sleep-related symptoms by educational attainment and race/ethnicity among US adults 18 years: National Health Interview Survey, 2012.

Educational attainment	White		African American		Hispanic		Asian		Other race/ethnicity	
	[N = 20,273]	(95% C.I.)	[N = 4993]	(95% C.I.)	[N = 5739]	(95% C.I.)	[N = 2056]	(95% C.I.)	[N = 804]	(95% C.I.)
	% (S.E.)		% (S.E.)		% (S.E.)		% (S.E.)		% (S.E.)	
<b>Short sleep duration/ 6 h</b>										
<High school	33.7 (1.64)	(30.6, 37.0)	34.4 (2.47)	(29.7, 39.4)	23.7 (1.15)	(21.5, 26.1)	28.2 (3.97)	(21.0, 36.6)	45.6 (6.27)	(33.8, 58.0)
High school graduate or GED	31.5 (0.92)	(29.7, 33.3)	33.5 (1.40)	(30.8, 36.3)	27.7 (1.43)	(25.0, 30.6)	30.0 (2.74)	(24.9, 35.7)	37.2 (4.75)	(28.4, 46.9)
>High school	26.3 (0.51)	(25.3, 27.3)	38.0 (1.28)	(35.5, 40.5)	30.5 (1.26)	(28.0, 33.0)	29.2 (1.46)	(26.5, 32.1)	44.8 (2.93)	(39.2, 50.6)
	(p < 0.0001)		(p = 0.1928)		(p < 0.0001)		(p = 0.8124)		(p = 0.9036)	
<b>Long sleep duration/ 9 h</b>										
<High school	13.7 (1.25)	(11.4, 16.3)	12.6 (1.40)	(10.1, 15.6)	11.2 (0.87)	(9.6, 13.1)	<i>a</i>		<i>a</i>	
High school graduate or GED	10.3 (0.55)	(9.3, 11.4)	10.6 (1.03)	(8.7, 12.8)	9.2 (0.83)	(7.7, 10.9)	7.0 (1.83)	(4.2, 11.6)	10.4 (2.52)	(6.4, 16.5)
>High school	7.0 (0.31)	(6.4, 7.6)	7.0 (0.72)	(5.7, 8.5)	5.6 (0.67)	(4.4, 7.1)	5.0 (0.75)	(3.7, 6.7)	6.8 (1.51)	(4.4, 10.4)
	(p < 0.0001)		(p = 0.006)		(p < 0.0001)		(p = 0.1267)		(p = 0.0615)	
<b>Fatigue/lack of energy</b>										
<High school	20.4 (1.29)	(18.0, 23.1)	15.4 (1.52)	(12.6, 18.6)	12.9 (0.98)	(11.1, 14.9)	6.5 (1.60)	(4.0, 10.5)	38.0 (5.76)	(27.5, 49.8)
High school graduate or GED	16.9 (0.69)	(15.6, 18.3)	12.4 (1.17)	(10.2, 14.9)	11.6 (1.15)	(9.5, 14.1)	6.4 (1.74)	(3.7, 10.8)	20.4 (3.88)	(13.8, 29.1)
>High school	16.1 (0.43)	(15.2, 16.9)	12.2 (0.80)	(10.7, 13.9)	11.4 (0.86)	(9.9, 13.2)	7.5 (0.84)	(6.0, 9.3)	24.4 (2.91)	(19.1, 30.6)
	(p = 0.0015)		(p = 0.0538)		(p = 0.2989)		(p = 0.5994)		(p = 0.0373)	
<b>Excessive daytime sleepiness</b>										
<High school	18.5 (1.34)	(16.0, 21.3)	17.4 (1.55)	(14.5, 20.6)	11.1 (0.79)	(9.6, 12.8)	9.2 (2.21)	(5.6, 14.5)	28.6 (6.73)	(17.3, 43.4)
High school graduate or GED	14.3 (0.71)	(13.0, 15.8)	13.2 (1.23)	(11.0, 15.8)	9.3 (0.92)	(7.6, 11.2)	8.1 (1.91)	(5.1, 12.8)	16.3 (3.60)	(10.4, 24.7)
>High school	12.3 (0.40)	(11.6, 13.1)	9.3 (0.67)	(8.1, 10.7)	11.0 (0.85)	(9.4, 12.7)	7.4 (1.06)	(5.6, 9.8)	22.9 (2.67)	(18.1, 28.6)
	(p < 0.0001)		(p < 0.0001)		(p = 0.8995)		(p = 0.4804)		(p = 0.4351)	
<b>Insomnia/trouble sleeping</b>										
<High school	25.4 (1.45)	(22.7, 28.4)	18.9 (1.49)	(16.1, 22.0)	19.8 (1.20)	(17.5, 22.2)	14.1 (3.25)	(8.8, 12.8)	39.7 (6.03)	(28.6, 51.9)
High school graduate or GED	21.3 (0.87)	(19.7, 23.1)	15.0 (1.18)	(12.8, 17.5)	18.4 (1.35)	(15.9, 21.2)	12.2 (2.22)	(8.5, 17.3)	26.2 (4.76)	(17.9, 36.5)
>High school	18.5 (0.41)	(17.7, 19.3)	15.9 (0.92)	(14.2, 17.8)	18.6 (1.19)	(16.4, 21.1)	10.0 (0.96)	(8.2, 12.0)	31.2 (2.80)	(26.0, 37.0)
	(p < 0.0001)		(p = 0.0823)		(p = 0.5211)		(p = 0.2154)		(p = 0.2272)	

The p-value indicates statistical significance of linear trend test. Abbreviations: S.E. standard error, C.I. confidence interval.

<sup>a</sup>Relative standard error >30%; therefore, estimate is unstable and not presented.

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**Table 3**

Log-linear regression analyses testing main effects of educational attainment and race/ethnicity on sleep indicators among US adults 18 years: National Health Interview Survey, 2012.

	Regression coefficient	Standard error	p
Short sleep duration/ 6 h			
Educational attainment	-0.02	0.00	<0.05
Race/ethnicity			
African American	0.25	0.03	<0.0001
Hispanic	0.02	0.03	0.6406
Asian	0.19	0.05	0.0003
Other race/ethnicity	0.40	0.06	<0.0001
Long sleep duration/ 9 h			
Educational attainment	-0.08	0.01	<0.0001
Race/ethnicity			
African American	-0.04	0.07	0.5093
Hispanic	-0.06	0.08	0.4158
Asian	-0.19	0.13	0.1277
Other race/ethnicity	-0.09	0.15	0.5769
Fatigue/lack of energy >3 days			
Educational attainment	-0.05	0.00	<0.0001
Race/ethnicity			
African American	-0.29	0.05	<0.0001
Hispanic	-0.20	0.05	0.0012
Asian	-0.47	0.10	<0.0001
Other race/ethnicity	0.31	0.09	0.0003
Excessive daytime sleepiness			
Educational attainment	-0.06	0.00	<0.0001
Race/ethnicity			
African American	-0.17	0.05	0.0016
Hispanic	-0.20	0.07	0.0033
Asian	-0.18	0.12	0.1336
Other race/ethnicity	0.41	0.10	<0.0001
Insomnia/trouble sleeping			
Educational attainment	-0.04	0.00	<0.0001
Race/ethnicity			
African American	-0.23	0.04	<0.0001
Hispanic	0.01	0.05	0.8155
Asian	-0.37	0.08	<0.0001
Other race/ethnicity	0.41	0.07	<0.0001

Regression coefficients obtained from multivariable log-linear models including educational attainment, race/ethnicity, age, gender, and foreign-born status. Reference group for all race/ethnicity coefficients is Whites. Sleep-related indicators: 0 = no symptom, 1 = presence of symptoms.

**Table 4**

Log-linear regression analyses testing interactive effects of educational attainment and race/ethnicity on sleep indicators among US adults 18 years: National Health Interview Survey, 2012.

	Regression coefficient	Standard error	p
Short sleep duration/ 6 h			
Educational attainment	-0.04	0.00	<0.0001
Race/ethnicity			
African American	-0.72	0.15	<0.0001
Hispanic	-0.79	0.12	<0.0001
Asian	-0.27	0.21	0.1890
Other race/ethnicity	-0.14	0.28	0.6085
Educational attainment × race/ethnicity			
African American	0.06	0.01	<0.0001
Hispanic	0.06	0.01	<0.0001
Asian	0.03	0.01	0.0233
Other race/ethnicity	0.04	0.02	0.0538
Long sleep duration/ 9 h			
Educational attainment	-0.09	0.01	<0.0001
Race/ethnicity			
African American	-0.11	0.22	0.6092
Hispanic	-0.69	0.19	0.0002
Asian	-0.57	0.40	0.1530
Other race/ethnicity	-0.01	0.58	0.9922
Educational attainment × race/ethnicity			
African American	0.00	0.02	0.8070
Hispanic	0.05	0.01	0.0003
Asian	0.02	0.02	0.3621
Other race/ethnicity	-0.01	0.03	0.8637
Fatigue/lack of energy >3 days			
Educational attainment	-0.05	0.00	<0.0001
Race/ethnicity			
African American	-0.57	0.21	0.0074
Hispanic	-0.48	0.17	0.0048
Asian	-0.98	0.43	0.0241
Other race/ethnicity	0.19	0.39	0.6296
Educational attainment × race/ethnicity			
African American	0.02	0.01	0.1931
Hispanic	0.02	0.01	0.0818
Asian	0.03	0.03	0.2358
Other race/ethnicity	0.01	0.03	0.7446
Excessive daytime sleepiness			
Educational attainment	-0.07	0.01	<0.0001



	Regression coefficient	Standard error	p
Race/ethnicity			
African American	0.12	0.21	0.5614
Hispanic	-0.89	0.19	<0.0001
Asian	-1.04	0.49	0.0340
Other race/ethnicity	-0.16	0.44	0.7254
Educational attainment × race/ethnicity			
African American	-0.02	0.01	0.1309
Hispanic	0.07	0.01	<0.0001
Asian	0.05	0.03	0.0919
Other race/ethnicity	0.05	0.03	0.2025
Insomnia/trouble sleeping			
Educational attainment	-0.05	0.01	<0.0001
Race/ethnicity			
African American	-0.47	0.19	0.0114
Hispanic	-0.47	0.14	0.0009
Asian	-0.32	0.30	0.2960
Other race/ethnicity	0.22	0.32	0.4968
Educational attainment × race/ethnicity			
African American	0.02	0.01	0.2103
Hispanic	0.03	0.01	0.0003
Asian	-0.01	0.02	0.7803
Other race/ethnicity	0.01	0.02	0.5714

Regression coefficients obtained from multivariable log-linear models including educational attainment × race/ethnicity, educational attainment, race/ethnicity, age, gender, and foreign-born status. Reference group for all race/ethnicity coefficients is Whites. Sleep-related indicators: 0 = no symptom, 1 = presence of symptoms.