Sleep Health 000 (2020) 1–7

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

Opposite educational gradients in sleep duration between Black and White adults, 2004-2018

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ARTICLE INFO

Keywords:
Educational gradients
Short sleep
Racial disparity
Socioeconomic disparity

ABSTRACT

Objectives: To investigate the heterogeneous effects of education on sleep duration for Black and White adults and how the education effects changed between 2004 and 2018.
Methods: A total of 251,994 adult participants in the 2004 to 2018 National Health Interview Survey were included in pooled cross-sectional data analyses. Separately for Black and White men and women, we calculated prevalence ratio and average marginal probability of short sleep (<7 hours) for each education level over the study period based on weighted logistic regression models.
Results: Opposite educational gradients in short sleep were observed between Black and White adults. Greater educational attainment was associated with lower likelihood of short sleep among White adults but higher likelihood of short sleep among Black adults. Such heterogeneous educational gradients were robust after accounting for a set of socioeconomic, family, and health factors and persisted between 2004 and 2018.
Conclusions: The health implications of education are not uniform in the US population, and heterogeneous education effects on sleep duration persisted over the past decade. More scholarly attention is needed to identify challenges and barriers that may be unique for race, sex, and education subpopulations to maintain healthy sleep.

Introduction

Sleep is a fundamental activity of human life and plays a vital role in human health. Growing evidence has linked short sleep duration, defined as less than 7 hours per night on a regular basis,[1] with a wide range of mental and physical health conditions, including obesity, cardiovascular disease, and mental disorders.[2-4] While approximately a third of American adults sleep less than the current recommended minimum of 7 hours per night,[1,5] the prevalence of short sleep is not uniformly distributed among sociodemographic groups.[6] In particular, previous studies have reported an educational gradient in sleep duration; that is, higher education levels are associated with lower likelihood of short sleep.[6-9]

However, little prior research has explored whether the educational gradient in sleep duration differs among sociodemographic groups. Black men and women may have different experiences in schools and work places than White men and women, so social factors such as education that prove to be protective for one race-sex group may not be protective or even counter-productive for other groups.[7,10,11] Race-related differences in sleep duration are already present in young adulthood.[12] Relatedly, prior studies reported that when compared to White individuals, Black individuals tend to exhibit weaker educational gradients in various health indicators including obesity and inflammation markers of chronic stress.[7,13] We thus first hypothesize that the protective effects of greater educational attainment for sleep are weaker for Black adults than for White adults (Hypothesis 1).

Second, prior studies have investigated temporal trends in sleep duration in the U.S. population, and some reported race differences in such trends.[5,14-17] However, earlier studies did not examine the temporal trend in education effects on sleep duration among sociodemographic groups. While educational attainment has increased among all 4 race-sex groups over the past decade,[18] the implications of education for health differ among sociodemographic groups.[19,20] We are the first to explore how race and sex differences in educational gradients in sleep duration may have changed over the study period from 2004 to 2018.

Third, we assess the extent to which employment and work hours may account for the heterogeneities in educational gradients in sleep. Scholars suggested that work hours are the most important activity that competes with sleep time.[17] Race and sex minority groups have

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https://doi.org/10.1016/j.sleh.2020.10.003

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been historically underrepresented in higher education institutes and professional and management occupations.[21,22] In response to a hostile social environment that continuously exposes them to psychological stressors, as the John Henryism hypothesis posits, highly-educated Black individuals and other minority groups may develop a laborious work ethic that leads to more work hours.[23,24] We thus consider how employment status and work hours may account for the differential educational gradients. We expect race-sex differences in educational gradients in sleep to be reduced after adjusting for employment status and work hours (Hypothesis 2). Because education may be related to sleep through other aspects of socioeconomic status (SES) and health factors, we also examine the educational gradients in sleep duration after adjusting for income, occupation, and home ownership and a set of family- and health-related factors.

Data and methods

We used the data from the National Health Interview Survey (NHIS) from 2004 to 2018, harmonized, and distributed by IPUMS NHIS.[25] For every year since 2004, the NHIS asks respondents to report their usual or typical number of hours of sleep in a 24-hour period. Short sleep is defined as less than 7 hours' sleep.[1] We focused on the US-born adult population aged 25 to 69. Based on the "EDUC" variable that reports the respondents' years of schooling and degree, we created 4 educational attainment categories including less than high school, high school graduate, some college, and college and above. We considered a set of socioeconomic covariates including household income ("INCFAM97ON2": 1=$34,999 or less; 2=$35,000-$74,999; 3=$75,000 or above), occupation categories ("OCCUPN204": 1=managerial or professional occupations; 2=supportive occupations; 3=laborer), home ownership ("OWNERSHIP": 1=rent or other; 2=own a home), employment status ("EMPSTAT": 1=out of labor force; 2=unemployed; 3=employed), and work hours ("HOURSWRK": 1=zero hours worked, unemployed, or out of labor force; 2=1-34 hours; 3=35-49 hours; 4=50-80 hours). Other control variables include marital status, family size, and body mass index (BMI); see Table S2 for more details.

The sample consists of 16,662 Black men, 26,053 Black women, 97,355 White men, and 111,924 White women, and the total sample size is 251,994 (Model 1). Removing persons with missing information on employment or work hours for subsequent analyses reduces the sample size by about 1% for each race-sex group (Model 2). For later analyses that include all covariates, we deleted records with missing values on any variable, resulting in approximately 21.2%-25.1% and 17.0%-20.5% reduction for the Black and White adult samples, respectively (Model 3). We performed complete-case analysis because the missing occurs only in covariates and thus does not depend on the dependent variable in the logistic regression models.[26-29]

We examined the educational gradients in sleep among race-sex groups using weighted logistic regression models. The NHIS are household surveys, so for all our analyses of individual-level data we used the recommended weight "SAMPWEIGHT" as the sample weight in the "svyglm" function in R's "survey" package. We began with a model that includes the main effects of education levels and race-sex groups, and their interactions. Because interaction effects in nonlinear logistic regressions are not directly interpretable,[30-32] we conducted subsample analysis for each race-sex group[33] to better illustrate sleep disparities and the heterogeneous educational gradients (Model 1). Specifically, we fit separate weighted logistic regression models for each race-sex group and calculated prevalence ratio[34,35] of short sleep for 3 educational attainment groups compared to high school graduates within each race-sex group. We then assessed how the aforementioned variables may explain the heterogeneity in educational gradients within race-sex groups by adding these variables (Models 2 and 3) to the main analytical model and to subsample analyses for each race-sex group.

Lastly, we investigated whether the educational gradients in short sleep changed over 4 periods of time: 2004-2007, 2008-2010, 2011-2014, and 2015-2018. Because sleep duration changes with age with middle-aged adults having less sleep than the younger and the older, all analyses were adjusted for 9 age groups (25-29, 30-34, …, 60-64, and 65-69). Another dimension of time-related change is the cohort process, in which recently-born cohorts enter the population while the older cohorts exit.[36,37] We chose not to include cohort in the analysis for 2 reasons. First, there is little theoretical basis to expect cohort differences in short sleep. Second, to check robustness, we analyzed the data using the age-period-cohort-interaction model developed by Luo and Hodges[38] and found little cohort variation in short sleep.

Results

Table 1 presents weighted prevalence rates in short sleep by educational attainment in each race-sex subsample. On average, Black adults had higher prevalence of short sleep (40.9% in men and 41.0% in women) than White adults (32.2% in men and 30.7% in women). When further stratifying by education, short sleep was most prevalent among Black men and women with some college education (45.5% and 44.4%, respectively), followed by college-educated Black adults (43.5% in men and 42.2% in women). Among White adults, high school graduates had the highest prevalence of short sleep (36.2% and 37.3% among men and women, respectively), while college-educated White adults had the lowest prevalence (26.8% and 24.6% among men and women, respectively).

A whole-sample analysis that considers the interaction terms between education and race-sex groups reveals that the association between education and sleep duration differs between White and Black adults ($F = 42.675$, $P < .001$; See Table S1 for logistic regression results). Fig. 1 illustrates and Table 2 reports the heterogeneity in educational gradients based on subsample analysis for each of the 4 race-sex groups after adjusting for age and time periods. The symbols

Table 1
Sample size and weighted prevalence of short sleep by educational attaiment for four race-sex groups, the NHIS 2004-2018

Educ level	Black men		Black women		White men		White women	
	Short sleep	*N*	Short sleep	*N*	Short sleep	*N*	Short sleep	*N*
Overall	40.9%	16,662	41.0%	26,053	32.2%	97,355	30.7%	111,924
<HS	37.9%	5,614	37.3%	7,220	34.7%	26,084	33.4%	27,165
HS	33.9%	2,801	37.5%	4,149	36.2%	8,538	37.3%	8,735
SCol	45.5%	5,202	44.4%	9,372	35.0%	29,760	33.7%	37,221
Col	43.5%	3,045	42.2%	5,312	26.8%	32,973	24.6%	38,803

Note: *N* is the unweighted sample size for each race-sex and education group. Table figures are weighted prevalence rates of sleeping for less than 7 hours per 24-hour period in the NHIS data. <HS: less than high school; HS: high school; SCol: some college; Col: college or more. NHIS, the National Health Interview Survey.

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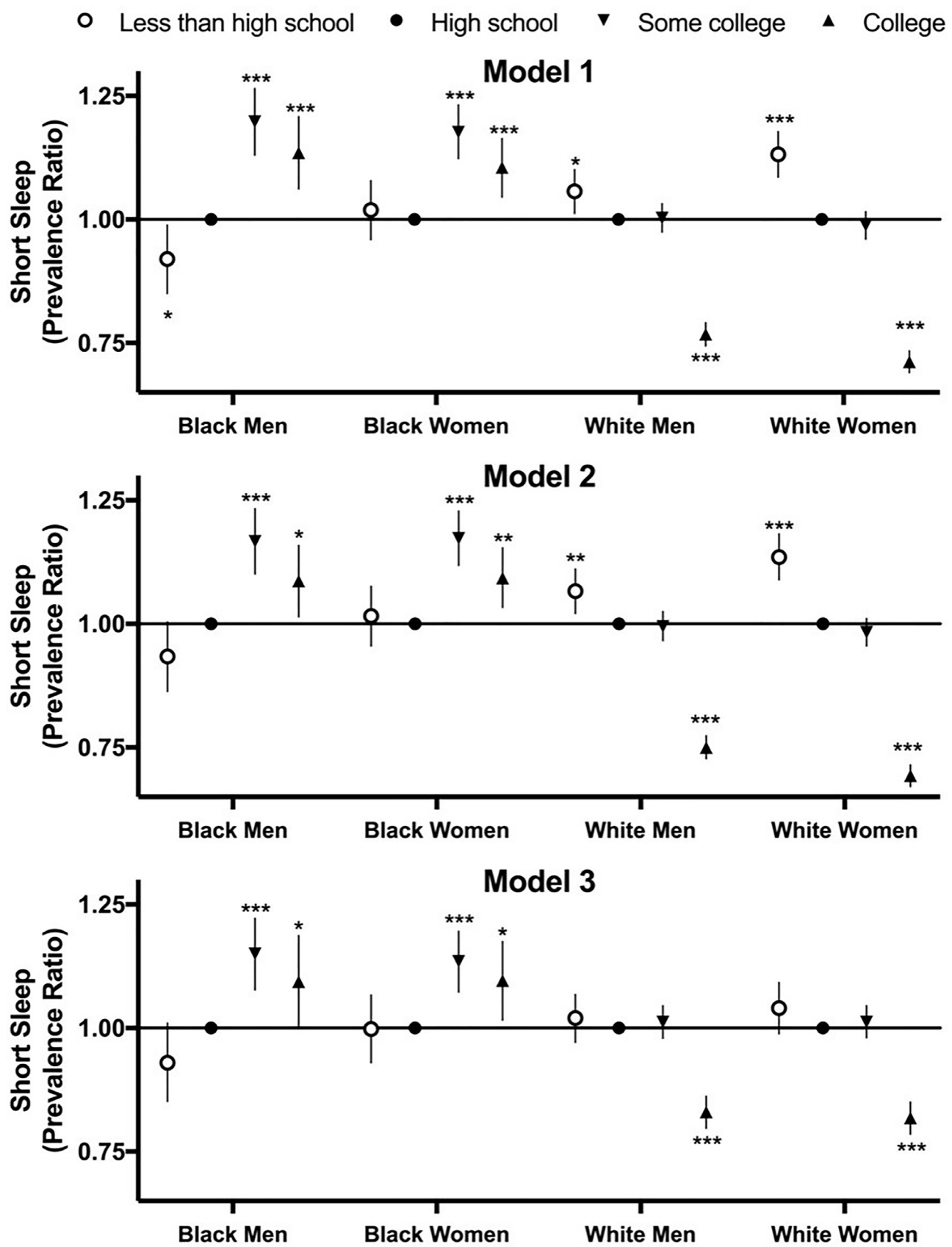

Fig. 1. Predicted prevalence ratio of short sleep for each education level compared to high school graduates by race-sex groups, the NHIS 2004-2018. Model 1: adjusted for age and time periods; Model 2: adjusted for age, time periods, work hours, and employment status. Model 3: adjusted for age, time periods, socioeconomic, family- and health-related factors. Predicted prevalence ratio is calculated using marginal standardization based on a weighted logistic regression model for each race-sex group. NHIS, the National Health Interview Survey. Error bars: 95% CI. *, $P < .05$; **, $P < .01$; ***, $P < .001$.

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Table 2
Heterogeneous educational gradients in short sleep for each race-sex group, before and after adjusting for sociodemographic and health factors, the NHIS 2004-2018

Educ level	Black men			Black women			White men			White women		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
<HS	0.920*	0.934	0.930	1.019	1.016	0.998	1.057*	1.066**	1.020	1.132***	1.135***	1.040
	(0.035)	(0.036)	(0.041)	(0.031)	(0.031)	(0.035)	(0.023)	(0.023)	(0.025)	(0.024)	(0.024)	(0.026)
SCol	1.198***	1.167***	1.150***	1.177***	1.173***	1.135***	1.003	0.995	1.012	0.988	0.983	1.012
	(0.034)	(0.034)	(0.037)	(0.028)	(0.028)	(0.031)	(0.015)	(0.015)	(0.017)	(0.014)	(0.014)	(0.017)
Col	1.135***	1.087*	1.094*	1.105***	1.093**	1.096*	0.768***	0.750***	0.830***	0.712***	0.693***	0.818***
	(0.037)	(0.037)	(0.047)	(0.030)	(0.031)	(0.041)	(0.012)	(0.012)	(0.017)	(0.011)	(0.011)	(0.016)

Note: Table figures are predicted prevalence ratio compared to high school graduates for each race-sex group based on weighted logistic regression models in Table S2. Numbers in parenthesis are standard errors. Model 1: adjusted for age and time periods. Model 2: adjusted for age, time periods, work hours, and employment status. Model 3: adjusted for age, time periods, socioeconomic variables, family- and health-related factors. <HS: less than high school; HS: high school; SCol: some college; Col: college or more. NHIS, the National Health Interview Survey.

* $P < .05$.

** $P < .01$.

*** $P < .001$.

in the top panel represent predicted prevalence ratio (i.e., predicted probability ratio) of short sleep for those with less than high school education, some college, and college degree or more compared to high school graduates without adjusting for the potential impacts of other SES family or health factors. Among White adults, the likelihood of short sleep decreases as education increases, although the some-college group does not appear to differ from those with a high school diploma. For example, compared to White men with high school education, the likelihood of short sleep is 5.7% (se = .023, $P < .05$) higher for White men without a high school diploma and 23.2% (se = .012, $P < .001$) lower among those with a college degree. For White women, the probability is 13.2% (se = .024, $P < .001$) higher for those without finishing high school and 28.8% (se = .011, $P < .001$) lower for the college educated. The educational gradients also appear more pronounced among White women than White men.

For Black adults, high school or less education does not appear to be associated with increased likelihood of short sleep. Among Black men, education seems positively associated with elevated likelihood of short sleep; the probability is 19.8% (se = .034, $P < .001$) and 13.5% (se = .037, $P < .001$) higher for those with some college and college degree, respectively, than Black men with a high school degree. Among Black women, the probability is 17.7% (se = .028, $P < .001$) and 10.5% (se = .030, $P < .001$) higher for the 2 more educated groups, respectively, compared to Black women with a high school degree.

Fig. 2 presents period trends in predictedprevalence of short sleep based on subsample analysis for each education-race-sex group (see Table S3 for logistic regression coefficient estimates). For all education levels, the predicted prevalence of short sleep increased from the 2000s to the 2010s, and this trend was similar across all race-sex groups. Most interestingly, the Black-White disparity in short sleep increases with educational attainment; the Black-White disparity is most pronounced among adults with a college degree, followed by the some-college-education group and the high school graduates. There seems relatively little race-sex variation in the least education group. Overall, these results suggest that race differences in the educational gradients in sleep duration remained stable over the past decade.

The middle panel in Fig. 1 illustrates and Model 2 in Table 2 shows how these educational gradients in short sleep may (not) change after adjusting for employment status and work hours. The educational differences in Model 2 in Table 2 are largely comparable with those from Model 1, and the overall patterns of the educational gradients in short sleep shown in Fig. 1 are largely similar in the top and middle panels. These results suggest that the heterogeneous educational gradients in short sleep may not be explained by work-related factors.

The bottom panel in Fig. 1 and Model 3 in Table 2 show that the higher likelihood of short sleep among White adults without a high school diploma is reduced (2.0% higher, $P > .05$ among men and 4.0% higher, $P > .05$ among women) after adjusting for income, occupation, home ownership, marital status, family size, and BMI, although the protective effect of college education against short sleep remains for White adults (17.0% lower, $P < .001$ among men and 18.2% lower, $P < .001$ among women). In contrast, the opposite educational gradients among Black adults are largely unchanged after controlling for the aforementioned variables.

Discussion

Using the 2004-2018 NHIS data, we found opposite educational gradients in sleep duration between Black and White adults. Specifically, greater educational attainment is associated with lower likelihood of short sleep among White adults, whereas Black adults with some college education or a college degree are more likely to report short sleep than Black adults with less than high school education or a high school degree. As a result, the Black-White difference in sleep duration is most pronounced among the college educated. Within each race, the overall patterns of educational gradients appear to be similar between men and women, although White women showed a steeper educational gradient than White men, whereas Black women showed a somewhat less steep gradient than Black men, suggesting that subtle sex differences may exist within race. These race and sex differences in the educational gradients in sleep duration are robust after accounting for a set of socioeconomic, family, and health-related factors. Such heterogeneous educational gradients and the Black-White disparity in short sleep persisted over the study period from 2004 to 2018.

Education is believed to confer health benefits. We found such benefits of education among White adults: Completing college education is associated with about 25% lower likelihood of short sleep than high school education. However, a college degree implies no protection against—in fact, higher likelihood of—short sleep for Black adults than their peers with high school or less education. Our finding echoes Jackson et al's work[10] on race differences in the occupation-sleep association; they found that professional roles were associated with an elevated risk of short sleep duration among Black adults, whereas the opposite was observed among White adults. It is possible that the differential educational gradients in short sleep duration that we revealed in this study are driven by the occupational gradients because college graduates are more likely than the less educated to have professional and managerial jobs. However, the opposite educational gradients between Black and White adults remain largely unchanged after adjusting for occupation. This may be because education and occupation represent different aspects of socioeconomic positions and different socialization processes. Future research may investigate each factor's unique implications for sleep.

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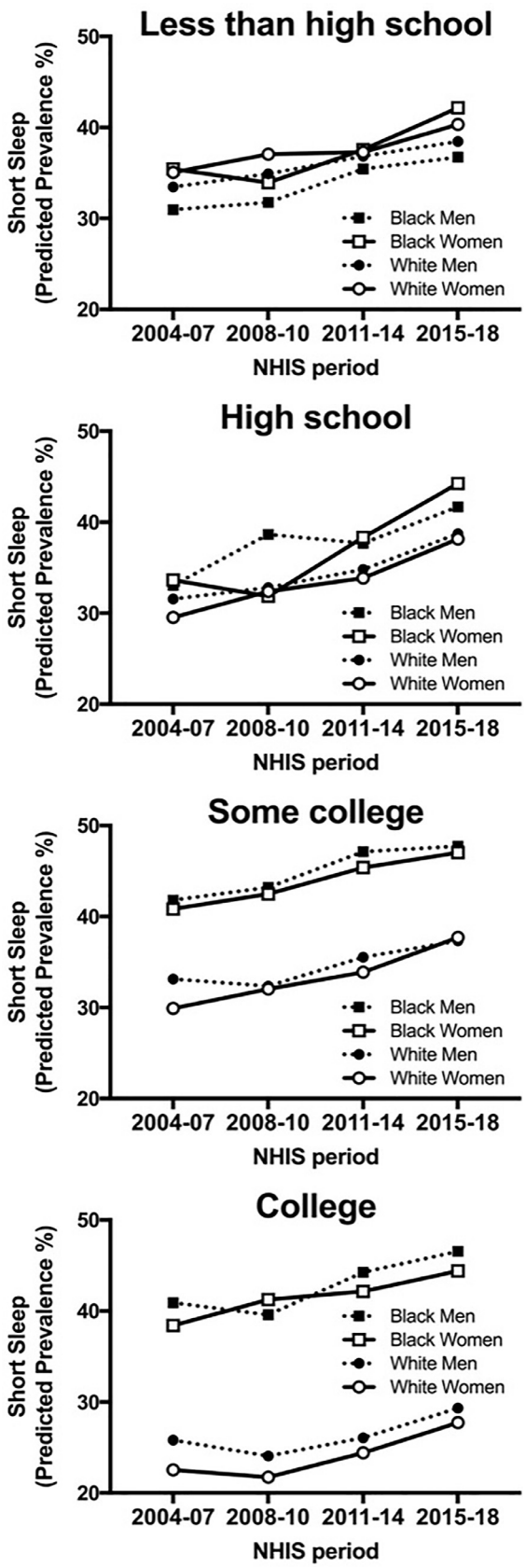

Fig. 2. Predicted prevalence of short sleep for four education levels by race-sex groups, the NHIS 2004-2018. All predicted prevalences of short sleep were higher in the 2015-2018 period than the 2004-2007 period. Predicted prevalences are average marginal probabilities adjusted for age based on a weighted logistic regression model for each educational level in each race-sex group. NHIS, the National Health Interview Survey.

Basner et al[17] showed that work activity is an important determinant that affects sleep. We investigated how employment status and work hours may explain the educational gradients in sleep duration. On the one hand, our main analysis showed that employment status or work hours do not directly account for the differential educational gradients between Black and White adults. On the other hand, the educational gradients appear to be more pronounced among the employed than the unemployed or out of labor force (results available upon request), suggesting that education and its related factors may interact with work environment to influence sleep time.[17] We also note that work hours are just one work-related factor that may affect sleep. Other characteristics including shifts and responsibilities merit future investigation. Moreover, a promising direction for future research is to use longitudinal data that follow participants' work and time allocation pre-, current-, and post-college years. With the rising estimated burden of educational loans,[39] it will be important to explore how acquired educational loans for some of the low-SES college-educated population may further strengthen their need to work at the potential cost of their sleep.

Why are college-educated Black adults more likely to sleep less even after accounting for other social, demographic, and health factors? On the one hand, our findings support the Minorities' Diminished Returns (MDRs) theory, which suggests that SES indicators, such as educational attainment, do not provide Black individuals and other minorities (eg, Hispanics) the same protective health benefits as non-Hispanic White individuals due to systematic barriers inflicted on minorities.[40-42] On the other hand, the results are distinctly different from those in previous studies that supported the MDRs theory: In this study, greater educational attainment was not associated with a merely *smaller* benefit, but rather has an *opposite* effect on sleep duration, suggesting that other mechanisms may be in play.

Scholars have hypothesized that chronic exposure to psychological stress may be a key mechanism underlying the racial and socioeconomic disparities in health behaviors and outcomes.[6,43] In particular, we argue that this could be reflective of Smith's theoretical concept of "racial battle fatigue".[44] This concept states that Black men with higher levels of education may be more susceptible than those with lower education to experiencing mundane, extreme, environmental stress (MEES) in social institutions such as school and workplace lacking racial and gender diversity. As result, Black men are likely to require additional energy and mental effort to process and cope with the MEES, which ultimately could elicit and exacerbate stress responses at psychological (eg, apathy), physiological (eg, sleep disturbances), and emotional/behavioral (eg, overeating) levels.

Relatedly, Sellers et al[45] suggested that college-educated Black men are likely to perceive heightened MEES, particularly when personal aspirations and goals are not achieved. The negative impact of this goal-driving stress on mental health was significantly reduced for college-educated Black men who rationalized the challenge in achieving their goals to an external attribution orientation (eg, lack of personal achievement perceived to be a result of societal discrimination) rather than an internal attribution orientation (eg, lack of personal achievement perceived to be due self-image). Another study[11] from the Sister Study on US working women provides additional support for the concept of "racial battle fatigue". The authors revealed that greater likelihood for shorter sleep duration was associated with occupational discriminatory experiences attributed to racial identity. Unfortunately, the NHIS data lacks reliable measures of these culturally relevant stressors to test whether these prior empirical findings explain the current observations. Future research should explore whether Black men with higher educational levels may be susceptible to sleep disturbances due to MEES and exposure to racial microaggressions, and whether attributional orientations (external/system-blame rather than internal/self-blame[46]) may be protective of sleep health.

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Among White adults, lower levels of education are associated with higher prevalence of short sleep, and White and Black adults with less than high school education have comparable probabilities of short sleep. A possible explanation for these findings is that White adults with lower levels of education are also experiencing social disadvantages and, consequently, psychosocial stressors or goal-driving stress. Prior evidence has suggested that White adults exposed to similar challenging social contexts as Black adults tend to exhibit poor health outcomes.[23] Specifically, in a sample of low-income, urban-dwelling White individuals (n = 573), 38.9% had experienced discrimination, and their perceived discrimination was associated with higher depressive symptomology and anxiety.[47] The authors concluded that discriminatory experiences could be due to their SES and/or racial/ethnic background, particularly in environments where their identified racial/ethnic group is considered a minority population. Finally, it is speculated that low-income White adults may be particularly vulnerable to psychosocial stressors adversely impacting their health because social support networks and coping strategies, commonly utilized by other ethnic minority groups experiencing social challenges, may be less readily available.[47] Again, the current study does not include data to explore whether these prior findings could further explain our current observations. However, future research should attempt to disentangle these incongruent observations between the racial groups by identifying contextual and culturally relevant factors related to sleep health within the racial groups.

There are other socioeconomic parameters (eg, reading literacy, financial strain, and neighborhood disadvantage) that are uniquely linked to sleep, health outcomes, and mortality even after accounting for education quantity. Thus, when exploring the education-sleep association, future research should look beyond strictly including education quantity as a comprehensive metric of SES. Meanwhile, SES including education is linked to health outcomes and mortality through an array of mechanisms including health knowledge, behaviors, and resources.[20] Furthermore, the dynamic sociopolitical climate (eg, new local, state, or national legislation) could alter the relevance of existing mechanisms to explain the SES-health link or could elucidate new pertinent mechanisms. Thus, it is important for researchers to be cognizant that socioeconomic factors, such as education, may not be fully explained by one or a small number of mechanisms, particularly over time. This perspective further warrants more integration of an array of potential social determinants of health, so researchers and policy makers can better track what mechanisms are potential meaningful targets for health prevention/intervention.

It is important to note that our analysis is restricted to US-born Black and White adult samples in the NHIS, and the conclusions may not apply to the Hispanic or Asian population. The majority of the 2 ethnic groups consist of foreign-born respondents (65.4% among Hispanics and 80.7% among Asians). It has been shown that the foreign-born differ from the native-born in many health behaviors and outcomes.[7,48-51] Moreover, there is much heterogeneity among these ethnic groups in their health behaviors and outcomes that requires additional analyses.[52-56] These complexities are beyond the scope of the current study and merit future research.

Our study has 3 other limitations. First, we used educational attainment based on self-reported years of education to investigate the education-sleep relationship. However, such measurement may be inadequate because the type, context, and implications of college education may differ between race and sex groups.[19] It is important to investigate the education-sleep association using other measures of education that consider the institutional, historical, and social contexts that shape the process of formal schooling within race and sex groups. Second, we relied on self-reported measures for sleep duration and explanatory variables that may be inaccurate and subject to recall bias. The heterogenous educational gradients are also observed using other definition of short sleep duration (eg, less than 6 hours per 24-hour period or sleep hours; results are available upon request), but future studies may want to include objective measures. Another limitation is that we were unable to examine whether sleep quality is related to education in the same manner as sleep duration. Third, it is unclear whether the NHIS participants of different racial and/or socioeconomic backgrounds were recruited from similar residential areas. Because racial and gender minorities and/or lower socioeconomic individuals often reside in segregated residential neighborhoods that are susceptible to social disadvantages, sampling strategies used in many large national studies including the NHIS may result in enrolled racial groups with disparate social contexts, which can bias racial differences in health.[23] When participant samples are strategically selected from similarly challenging social contexts, racial disparities in health are often minimized. For example, Gamaldo et al[57] observed nonsignificant differences in sleep durations between Black and White adults enrolled in the HANDLS study, a longitudinal project strategically designed to recruit Black and White participants residing in similar socially disadvantaged neighborhoods of Baltimore City, MD. While racial differences were not observed in sleep disturbances, the authors did observe that sociodemographic correlates of sleep disturbance varied between Black and White individuals, which support that identification of culturally-relevant psychosocial stressors are important for understanding adverse health within race-sex groups.

Conclusion

We caution against a simplistic view of health benefits of education. In particular, the high prevalence of short sleep in low education levels and among Black adults with college education observed in our study suggests that these populations may be at especially high risks for adverse health outcomes related to sleep deficiency such as cardiometabolic conditions and mental disorders,[3,4] and may need more rigorous surveillance and interventions tailored to their special needs. Moreover, although improving upstream social factors such as education generally improve public health, further research is needed to identify the unique challenges and barriers that minority groups including race, sex, and socioeconomic minority may have faced to maintain healthy sleep.

Conflicts of interest

Drs. Liying Luo, Alyssa Gamaldo, David Almeida, and Qian Xiao have nothing to disclose. Dr. Orfeu Buxton discloses that outside of the current work, he received subcontract grants to Penn State from Proactive Life LLC (formerly Mobile Sleep technologies) doing business as SleepScape (NSF/STTR #1622766, NIH/NIA SBIR R43-AG056250, R44-AG056250), received honoraria/travel support for lectures from Boston University, Boston College, Tufts School of Dental Medicine, New York University and Allstate, and receives an honorarium for his role as the Editor in Chief of Sleep Health.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sleh.2020.10.003.

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Please cite this article as: L. Luo et al., Opposite educational gradients in sleep duration between Black and White adults, 2004-2018, Sleep Health (2020), https://doi.org/10.1016/j.sleh.2020.10.003