State and Regional Prevalence of Sleep Disturbance and Daytime Fatigue

Michael A. Grandner, Ph.D.¹; Nicholas J. Jackson, M.P.H.¹; Wilfred R. Pigeon, Ph.D., C.B.S.M.^{2,3}; Nalaka S. Gooneratne, M.D., M.Sc.⁴; Nirav P. Patel, M.D., M.P.H.⁵

¹Center for Sleep and Circadian Neurobiology, University of Pennsylvania, Philadelphia, PA; Division of Sleep Medicine, University of Pennsylvania, Philadelphia, PA; ²Sleep & Neurophysiology Research Laboratory, University of Rochester Medical Center, Rochester, NY; ³Center of Excellence for Suicide Prevention, Canandigua VA Medical Center & Center for Integrated Healthcare, Syracuse VA Medical Center, Syracuse, NY; ⁴Center for Sleep and Respiratory Neurobiology, University of Pennsylvania, Philadelphia, PA; Division of Geriatric Medicine, University of Pennsylvania, Philadelphia, PA; ⁵Respiratory Specialists and Reading Hospital and Medical Center, Reading, PA

Study Objectives: Social and demographic influences are important for sleep attainment. Geographic location has not been previously explored.

Methods: Data from the 2006 Behavioral Risk Factor Surveillance System (BRFSS) were used (N = 157,319). Participants answered a question on Sleep Disturbance and Daytime Fatigue. Thirty-six states/regions provided data on these items. Prevalence estimates were adjusted for age, sex, ethnoracial group, education, income, employment, general health, health-care access, and depression. Chi-squared tests were conducted across states and census regions, and pseudo-R² values were computed for the effect of state, relative to other predictors. To evaluate potential mediators of census region differences, an analysis of p value change associated with specific covariates and covariate groups was undertaken.

Results: Adjusted prevalence rates of Sleep Disturbance differed across states/regions overall ($\chi^2 = 412.3$, $p < 0.0001$), as well as separately for men ($\chi^2 = 139.5$, $p < 0.0001$) and women ($\chi^2 = 350.0$, $p < 0.0001$), as did rates of Daytime Fatigue overall ($\chi^2 = 245.7$, $p < 0.0001$), and separately for men

($\chi^2 = 117.5$, $p < 0.0001$) and women ($\chi^2 = 181.2$, $p < 0.0001$). Analysis of pseudo-R² values revealed that despite these significant findings, state differences were an overall weak predictor, representing 1.30% to 1.73% of the magnitude of the effect of the best predictor (mental health). When Census regions were compared, significant differences were found for Sleep Disturbance ($p = 0.002$), but after adjustment for covariates, these were no longer significant. Differences existed for Daytime Fatigue in adjusted analyses overall ($p < 0.0001$), with the West reporting the fewest complaints and the South reporting the most.

Conclusions: These results demonstrate that reports of sleep related complaints vary across states, independent (at least partially) of factors that influence circadian rhythms (e.g., latitude).

Keywords: Sleep, geographic factors, epidemiology, fatigue, health services

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Sleep problems are increasingly recognized as an important health outcome. These various sleep problems, ranging from impaired sleep quality to short sleep duration, may be associated with poor overall health and all-cause mortality,¹⁻⁴ as well as psychiatric (e.g., depression,^{5,6} anxiety⁷⁻⁹), metabolic (e.g., obesity,¹⁰⁻¹² diabetes^{13,14}), cardiovascular (e.g., hypertension^{15,16}), and other outcomes, including serious auto accidents.^{17,18}

Increasing attention has focused on social, demographic, and societal influences on sleep.^{1,2,19,20} One such influence that has received little attention is geographical location. Although several recent reports have discussed how characteristics of neighborhood may influence sleep-related outcomes,²¹⁻²⁵ and many reports have focused on national data,²⁶⁻²⁹ regional and state-level sleep data have not been a focus of previous inquiry. These data could assist health authorities at various levels (national, regional, and state) discern the public health burden of sleep disturbance.

Capitalizing on the existence of a large national sample, we focus on whether there are state or regional differences regarding prevalence of sleep-related complaints such as day-

BRIEF SUMMARY

Current Knowledge/Study Rationale: Sleep disturbance is an important public health concern. However, geographic dispersion of sleep problems, and the factors that may play a role, have been largely unexplored.

Study Impact: This study includes the first sleep maps for the USA that include data on sleep disturbance and daytime fatigue across most states/territories. In addition, this study demonstrates that not only are sleep and fatigue problems distributed differentially by state and region, but that these differences are partially explained by measurable mediators.

time fatigue and sleep disturbance (characterized as problems falling asleep, problems staying asleep, and/or sleeping too much). Our hypotheses are: (1) sleep disturbance and daytime fatigue will be differentially distributed across states, (2) the prevalence of sleep disturbance and daytime fatigue across states will be different for men and women, and (3) prevalence of sleep disturbance and daytime fatigue will differ by Census region, reflecting broad geographical differences in sleep-related complaints.

METHODS

Data Source

Data from the 2006 Behavioral Risk Factor Surveillance System (BRFSS)³⁰ were used for this analysis. The BRFSS is an annual, state-based, random-digit-dialed telephone interview survey of adults aged ≥ 18 years from all over the United States. It is the world's largest telephone survey, designed to monitor health-related behaviors in the general population. The overall response rate (completed interviews relative to total eligible households) varied across states, with a mean of 41.1%, median of 40.5%, and range of 20.5% to 72.5%.³¹ Of those who completed interviews, $> 98\%$ of respondents completed the Sleep Disturbance and Daytime Fatigue items, suggesting that it is likely that the present data accurately represent the sample selected for study. In addition, reliability and validity are improved with the use of BRFSS-specific weighting scores, which weight each respondent's data, taking into account variables such as region, sex, race/ethnicity, and age to ensure that for each telephone area code region, responses match Census distributions.

Thirty-six states/regions were represented. This included 33 states: Alabama, Alaska, Arkansas, California, Delaware, Florida, Georgia, Hawaii, Indiana, Iowa, Louisiana, Maine, Michigan, Minnesota, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming. Also, the non-state regions of the District of Columbia, Puerto Rico, and the U.S. Virgin Islands were included. See Supplementary **Table S1** for the N for each state, by Model, for all participants and separated by sex. The N for each state ranged from 1974 (Alaska) to 9961 (Florida), with a median of 4987.5.

Participants were respondents who had answered a question on Sleep Disturbance: "Over the last 2 weeks, how many days have you had trouble falling asleep or staying asleep or sleeping too much?" and respondents who answered the question, "Over the last 2 weeks, how many days have you felt tired or had little energy?" Answers for both questions ranged from 0-14. However, the distributions were bimodal, with peaks at 0 and 14, with the preponderance of reports ≤ 3 and ≥ 12 days. In this case, linear regression is not appropriate because of violations of the normality and homoscedasticity assumptions. Sleep Disturbance and Daytime Fatigue were thus dichotomized into those who report complaints ≥ 6 days and those who report complaints < 6 days. Although the results did not appreciably change when cutoffs were placed anywhere between 3/14 and 12/14 days, the cutoff used (6/14 days) equates to 3/7 days, which is the clinical cutoff for insomnia.³²

Other variables employed in the current analysis served as covariates included at the individual and geographic levels. Individual-level variables included age, sex, body mass index (BMI), number of alcoholic drinks per month, smoking (never, former, some days, every day), ethnoracial group (White, Black/African American, Hispanic/Latino, Asian/Other, and Multiracial), education (less than high school, high school graduate, some college, college graduate), income level ($< \$10,000$ pre-tax income per year, \$10,000-\$15,000, \$15,000-\$20,000,

\$20,000-\$25,000, \$25,000-\$35,000, \$35,000-\$50,000, \$50,000-\$75,000, $> \$75,000$), employment status (employed, self-employed, retired, student, homemaker, unemployed < 1 year, unemployed > 1 year, unable to work), physical health (days in past 30 poor physical health), mental health (days in past 30 poor mental health), general health (excellent, very good, good, fair, poor), access to healthcare (last checkup within past year, within past 2 years, within past 5 years, more than 5 years ago, never), and depressed mood ("How many days in the last 2 weeks did you feel down or depressed?"). Previous analyses have found that these variables are significant predictors of sleep complaint in this sample.³³ State-based covariates (geographical) were included in the model because they are related to factors that play a role in habitual light exposure. These variables included geographic center of the state (latitude and longitude), mean high temperature, percent sunlight exposure, and shortest day length. These data were gathered from publicly available sources.³⁴

Statistical Analyses

Response bias was addressed by comparing sociodemographics of responders versus non-responders to the Sleep Disturbance and Daytime Fatigue questions. There were no major group differences identified, indicating minimal response bias at least at the individual level. Sunshine exposure was a mean of 63% in the non-missing group versus 58% in the missing group, suggesting that those in states with less sunshine were more likely to not respond to at least one of the outcome items.

All analyses were performed using Stata Version 11 software (StataCorp LP, College Station, TX). Logistic regression was utilized to estimate prevalence and adjust for covariates. Plausible covariates were identified a priori. Sampling weights specifically developed for BRFSS 2006 were applied to address population representativeness.³⁰ Prevalence estimates were calculated using a hierarchical approach. State was included as a fixed effect. The unadjusted model included only Sleep Disturbance or Daytime Fatigue. Adjusted models added known covariates, including age, sex, race/ethnicity, education, income, employment, BMI, alcohol intake, smoking, mental health, physical health, general health, healthcare access, and depressed mood, as well as state-based covariates including latitude and longitude of the state's geographic center, mean temperature, percent sunshine exposure, and length of the shortest day of the year. Analyses then examined both state-level differences and region-level differences separately.

State-level differences were investigated using χ^2 global tests for differences. Because of the large sample size, this study is highly powered to detect even small differences across states. Because of this, a strategy to estimate the relative effect size of geography (i.e., state) in the estimation of Sleep Disturbance and Daytime Fatigue was undertaken, utilizing McFadden's pseudo R^2 to determine the relative importance of state differences, compared to other effects in the adjusted model. Other effects included Demographics (age, sex, race/ethnicity), Socioeconomics (education, income, employment), Body Mass (body mass index), Mental Health (depression, mental health), Physical Health (general health, physical health, checkup), and Substances (alcohol, smoking). Pseudo R^2 values for each independent variable were calculated as the change in pseudo R^2

from the full model to a model without the independent variable category. Because these values can only be evaluated relative to other values, they were transformed so that they expressed the ratio of the pseudo R^2 value, relative to the highest Pseudo R^2 value for that analysis. For all analyses, the largest pseudo R^2 value was for Mental Health, so all values were expressed as $[(\text{pseudo } R^2_{\text{variable}})/(\text{pseudo } R^2_{\text{Mental Health}})]$, expressed as a percentage. Pseudo R^2 values, while analogous to R^2 derived from least squares regression, cannot be interpreted in the same manner (as proportions of variance explained). As a result, pseudo R^2 values cannot be interpreted independently; rather, they can only be interpreted relative to other independent variables in models predicting the same outcome. Despite this limitation, this analysis strategy can provide information on the importance of state differences, relative to other predictors.

To evaluate regional differences, χ^2 global tests for differences were conducted across Census regions³⁵ using the same covariates as in the analysis of state differences. A post hoc analysis exploring which covariates mediated observed relationships was conducted. Because some covariates were conceptually related (e.g., latitude and longitude, sunlight, and day length), some covariates were analyzed together. The following covariates/covariate groups were considered as possible mediators: sex, age, race/ethnicity, socioeconomic (education, income, employment), geography (latitude, longitude), weather (temperature, sunlight, day length), BMI, physical health (physical health, general health), mental health, alcohol, smoking, and medical checkup. The influence of covariates (or covariate groups) on census region effect size was examined to understand how the covariates confound the census region relationships. A measure of covariate influence was computed in terms of percentage change in the census region estimates after adjustment for a given covariate. We examined the confounding influence of the covariates in terms of percentage change in the census region estimates after adjustment. This was calculated by subtracting the unadjusted estimate from the adjusted estimate and dividing by the adjusted estimate $[(\text{Adjusted}-\text{Unadjusted})/(\text{Adjusted})]$. Census region estimates were referenced to the South region. Conventional interpretation of confounding via percentage change in estimates regards a covariate to be a confounder when there is greater than 10% change from the unadjusted estimate.

In addition, the mediational effects of covariates (or covariate groups) on census region significance was examined by calculating the resultant change in statistical significance for census region when unadjusted for each covariate. Each potential covariate set was individually removed from the full model (model 2), and Census region global p values were estimated. Differences in Census region p values in the full model to the model with missing covariate sets were computed. As such, those covariates (or covariate groups) with negative values reflect covariates that would cause the adjusted p value to become smaller by that amount, while those with positive values indicate variables that cause the p value to increase by that amount. Using this approach, if the p value change were 0.05, then even if an analysis that excluded the variable had a very low p value (e.g., $p = 0.00001$), the analysis that includes that variable would be nonsignificant (e.g., $(0.00001 + 0.05 = 0.05001)$). This approach was chosen due to the complications of conducting a

standard mediation analysis (i.e., Sobel-Goodman) because of the binary outcome and multinomial predictor.

RESULTS

A total of 183,436 individuals were included in the unadjusted analyses, and 157,319 individuals were included in the adjusted analyses (due to missing covariates). Sociodemographic, health, and geographic/climatic characteristics of the sample are reported in **Table 1** by presence of absence of self-reported Sleep Disturbance and Daytime Fatigue. Sleep Disturbance was different for groups across all levels of all variables except for temperature. Daytime Fatigue was similarly different for groups across all levels of all variables, except for age, alcoholic drinks/month, and temperature.

State-based prevalence estimates of Sleep Disturbance are reported in **Table S2** (see supplement that follows). In unadjusted analyses, prevalence rates ranged from 7.2% to 26.0%, with a mean rate of 18.5% (SD 3.3%). For men, the range was 6.2% to 22.1%, with a mean of 15.8% (SD 2.9%); for women, the range was 8.1% to 29.6%, with a mean of 21.1% (SD 3.9%). In the adjusted model, prevalence rates for the entire sample ranged from 7.8% to 22.9%, with a mean rate of 18.3% (SD 2.4%). For men, the range was 6.2% to 20.4%, with a mean of 15.4% (SD 2.1%); for women, the range was 9.4% to 25.4%, with a mean of 21.3% (SD 2.8%). Global χ^2 tests demonstrated differences in Sleep Disturbance across states in the entire group ($\chi^2 = 562.8$, $p < 0.0001$), as well as for men ($\chi^2 = 187.6$, $p < 0.001$) and women ($\chi^2 = 493.5$, $p < 0.0001$) separately. After adjustment for covariates, these relationships all remained highly significant at the $p < 0.0001$ level ([all] $\chi^2 = 386.3$, [men] $\chi^2 = 143.6$, [women] $\chi^2 = 286.6$).

State-based prevalence estimates of Daytime Fatigue are reported in **Table S5**. In unadjusted analyses, prevalence rates ranged from 16.4% to 30.0%, with a mean rate of 21.8% (SD 3.4%). For men, the range was 11.4% to 24.8%, with a mean of 17.9% (SD 3.1%); for women, the range was 19.5% to 35.3%, with a mean of 25.5% (SD 4.1%). In the adjusted model, prevalence rates for the entire sample ranged from 18.0% to 25.4%, with a mean rate of 21.6% (SD 2.0%). For men, the range was 13.9% to 22.3%, with a mean of 17.4% (SD 2.0%); for women, the range was 21.2% to 29.6%, with a mean of 25.8% (SD 2.3%). Global χ^2 tests demonstrated differences in Daytime Fatigue across states at the $p < 0.0001$ level in the entire group ($\chi^2 = 649.5$), as well as for men ($\chi^2 = 228.5$) and women ($\chi^2 = 539.8$) separately. After adjustment for covariates, these relationships all remained highly significant at the $p < 0.0001$ level ([all] $\chi^2 = 190.0$, [men] $\chi^2 = 95.9$, [women] $\chi^2 = 140.8$).

Figures 1 and 2 display cartographic representations (by state) of adjusted prevalence rates for Sleep Disturbance and Daytime Fatigue. Adjusted prevalence weights across the total sample (men and women) were pooled and ranked separately for Sleep Disturbance and Daytime Fatigue. Consequently, since women reported higher percentage of Sleep Disturbance and Daytime Fatigue, the image for women displays more states in higher quintiles and the figure for men represents more states in lower quintiles.

A determination of the proportion of variance explained by the State variable for Sleep Disturbance and Daytime Fatigue could

Table 1—Differences in characteristics of participants relative to Sleep Disturbance and Daytime Fatigue

Variable	Category	Sleep Disturbance			Daytime Fatigue		
		No	Yes	p	No	Yes	p
Age	Mean ± Standard Deviation	45.7 ± 17.6	44.7 ± 17.6	< 0.0001	45.5 ± 17.4	45.1 ± 18.2	0.1051
Sex	% Male	50.32%	41.53%	< 0.0001	51.28%	39.19%	< 0.0001
Race/Ethnicity	% White	66.66%	68.54%	0.0013	66.43%	69.08%	< 0.0001
	% Black	8.99%	9.43%		8.79%	10.10%	
	% Other	24.35%	22.04%		24.78%	20.82%	
Education	% < High School	12.21%	16.25%	< 0.0001	12.09%	16.11%	< 0.0001
	% High School Grad	27.67%	32.36%		27.71%	31.52%	
	% Some College	26.41%	28.46%		26.27%	28.79%	
	% College Grad	33.72%	22.93%		33.93%	23.59%	
Income	% < \$10,000	4.85%	9.55%	< 0.0001	4.85%	8.99%	< 0.0001
	% \$10-\$15,000	4.91%	8.45%		4.73%	8.61%	
	% \$15-\$20,000	6.68%	9.95%		6.61%	9.79%	
	% \$20-\$25,000	8.71%	11.06%		8.63%	11.03%	
	% \$25-\$35,000	12.19%	13.37%		12.13%	13.43%	
	% \$35-\$50,000	15.56%	14.71%		15.48%	15.09%	
	% \$50-\$75,000	17.91%	14.01%		17.85%	14.78%	
	% ≥ \$75,000	29.19%	18.90%		29.72%	18.29%	
Employment	% Employed for Wages	54.54%	41.10%	< 0.0001	53.74%	45.74%	< 0.0001
	% Self Employed	9.40%	7.88%		9.76%	6.83%	
	% Out of Work > 1yr	1.59%	3.67%		1.69%	3.10%	
	% Out of Work < 1yr	2.53%	5.49%		2.92%	3.83%	
	% Home Maker	8.21%	9.12%		8.23%	8.92%	
	% Student	4.46%	4.90%		4.72%	3.91%	
	% Retired	16.15%	13.91%		16.16%	13.77%	
	% Unable to Work	3.12%	13.93%		2.79%	13.90%	
Depression	Mean ± Standard Deviation	0.664 ± 1.906	3.860 ± 4.955	< 0.0001	0.597 ± 1.711	3.738 ± 5.019	< 0.0001
Time Since Last Medical Checkup	Never	1.88%	2.16%	< 0.0001	1.84%	2.20%	< 0.0001
	Within Past Year	66.81%	63.78%		66.58%	64.78%	
	Within Past 2 years	14.38%	12.98%		14.35%	13.42%	
	Within Past 5 years	9.11%	10.02%		9.28%	9.31%	
	Over 5 Years	7.83%	11.06%		7.95%	10.29%	
General Health	Excellent	23.13%	11.81%	< 0.0001	23.73%	11.06%	< 0.0001
	Very Good	34.19%	24.24%		35.07%	22.55%	
	Good	29.56%	31.91%		29.44%	31.77%	
	Poor	10.41%	20.10%		9.77%	21.11%	
	Very Poor	2.71%	11.94%		1.98%	13.52%	
Mental Health	Mean ± Standard Deviation	2.21 ± 5.72	9.00 ± 11.30	< 0.0001	2.02 ± 5.32	8.90 ± 11.53	< 0.0001
Physical Health	Mean ± Standard Deviation	2.65 ± 6.68	7.84 ± 11.20	< 0.0001	2.32 ± 6.11	8.42 ± 11.69	< 0.0001
Alcoholic Drinks/Month	Mean ± Standard Deviation	37.4 ± 148.9	44.2 ± 161.5	0.0047	38.9 ± 150.0	37.9 ± 157.4	0.6366
Smoking Status	Current Everyday	12.09%	24.00%	< 0.0001	12.12%	22.54%	< 0.0001
	Current Some Days	4.89%	7.10%		5.00%	6.37%	
	Former	23.91%	24.47%		24.01%	23.93%	
	Never	59.11%	44.44%		58.87%	47.16%	
Body Mass Index	Mean ± Standard Deviation	27.1 ± 5.6	28.1 ± 6.9	< 0.0001	27.0 ± 5.5	28.4 ± 7.2	< 0.0001
Sunlight Exposure	Mean ± Standard Deviation	62.7 ± 7.6	62.4 ± 7.8	0.0062	62.7 ± 7.6	62.3 ± 7.8	< 0.0001
Mean High Temperature	Mean ± Standard Deviation	69.7 ± 9.0	69.8 ± 9.1	0.2536	69.7 ± 9.0	69.8 ± 9.2	0.1935
Mean Day Length	Mean ± Standard Deviation	577 ± 34	578 ± 34	0.0238	577 ± 34	578 ± 34	0.0001

Figure 1—Graphical representation of prevalence rates for Sleep Disturbance by state

Inset boxes for Alaska, Hawaii, Puerto Rico, U.S. Virgin Islands and Washington DC, which do not otherwise appear on the map. Colors denote sextile, which are reported in Table S4. Higher sextile numbers (darker shade) denote higher prevalence rates. States that appear in white (i.e., unshaded) did not collect Sleep Disturbance data.

Figure 2—Graphical representation of prevalence rates for Daytime Fatigue by state

Inset boxes for Alaska, Hawaii, Puerto Rico, U.S. Virgin Islands and Washington DC, which do not otherwise appear on the map. Colors denote sextile, which are reported in Table S4. Higher sextile numbers (darker shade) denote higher prevalence rates. States that appear in white (i.e., unshaded) did not collect Daytime Fatigue data.

not be calculated because State is a nominal variable and our outcomes were binomial. Notwithstanding, a change in model fit was examined relative to other groups of independent variables. In all analyses (total sample and by gender) for both outcomes (Sleep Disturbance and Daytime Fatigue), Mental Health was the strongest predictor and was thus used as the reference value to compute ratios for other variables. These values are displayed in **Table S5**. The improvement in model fit associated with the State variable was of a much smaller magnitude than Mental Health, representing an effect that ranged in size from 1.30% to 1.73% of the size of the effect for Mental Health. Compared to the other independent variables, this effect was of the smallest magnitude, followed by Body Mass (range 2.20% to 5.06%).

State prevalence rates were next pooled by census region, with states divided into West, Midwest, South, and Northeast regions. See **Table 2** for sample characteristics by Census region, with one-way ANOVAs showing regional differences in all covariates except for sex. Prevalence rates by Census region are reported in **Table 3** before and after inclusion of covariates. In unadjusted analysis (of the combined sample and in women), a significantly differential rate of report of Sleep Disturbance was found, with the least prevalence in the West and the most in the South. This difference was no longer significant after adjustment. For Daytime Fatigue, unadjusted prevalence rates were lowest in the West and highest in the South for the combined sample and women, and in the Midwest for men. After adjustment, significant differences remained, with the lowest values in the West and the highest values in the South for the combined sample and for women, and in the Northeast for men.

When men were evaluated alone, no differential rates of reporting were found among Census regions for Sleep Disturbance, but differences for Daytime Fatigue were found in unadjusted analysis, with the highest rates in the Midwest and

the lowest in the West, and adjusted analyses, with the highest rates in the South and, again, the lowest rates in the West. When women were evaluated separately, the pattern for Sleep Disturbance was the same as when the groups were combined, with a significant difference in unadjusted analyses only (fewest complaints in the West and the most in the South). For Daytime Fatigue, there were significant differences for both adjusted and unadjusted models, demonstrating the highest rate of problems in the South and the fewest problems in the West.

A confounding analysis regarding percent change in estimates due to inclusion of covariates was conducted. Mental health had the greatest effect on Sleep Disturbance for the Western region, such that adjusting for mental health resulted in > 15% change in the estimate regardless of gender. No other covariates showed confounding at a > 10% level for any of the other regions. For the daytime fatigue outcome, geography (latitude and longitude) and mental health produced > 20% change in the Western region estimate, regardless of gender. Weather was a substantial confounder (> 10%) for the overall and men-only models. For the Northeast region, geography was the most influential confounder across genders (> 10%) followed by weather for the overall and men-only models (> 10%). For complete results see **Table 4**.

To determine which covariates were mediators of the relationship between Census region and both Sleep Disturbance and Daytime Fatigue, we examined the change in p value associated with each covariate set. For the present analyses, these results are displayed in **Table S6**. For Sleep Disturbance, the largest change in p value was seen for Race/Ethnicity. In the combined sample, p value change of > 0.05 (which would produce a non-significant result regardless of other covariates) was produced by (in order of magnitude) Medical Checkup, Weather (day length, temperature, sunshine), BMI, and Geography (latitude,

Table 2—Differences in characteristics of participants relative to Census region

Variable	Category	West	Midwest	South	Northeast	p
Age	Mean ± Standard Deviation	44.6 ± 16.4	46.0 ± 17.2	45.4 ± 16.7	46.8 ± 37.3	< 0.0001
Sex	% Male	49.31%	48.53%	48.63%	48.03%	0.4840
Race/Ethnicity	% White	54.67%	85.95%	67.48%	93.08%	< 0.0001
	% Black	3.18%	6.69%	13.99%	1.14%	
	% Other	42.15%	7.36%	18.53%	5.78%	
Education	% < High School	16.62%	8.21%	12.69%	6.86%	< 0.0001
	% High School Grad	23.81%	32.52%	29.38%	29.79%	
	% Some College	26.43%	28.49%	26.60%	26.03%	
	% College Grad	33.13%	30.78%	31.33%	37.32%	
Income	% < \$10,000	7.39%	3.44%	4.96%	3.28%	< 0.0001
	% \$10-\$15,000	7.15%	3.86%	5.05%	4.23%	
	% \$15-\$20,000	7.26%	6.03%	7.61%	5.52%	
	% \$20-\$25,000	8.07%	8.54%	9.83%	7.50%	
	% \$25-\$35,000	11.21%	13.18%	12.76%	11.30%	
	% \$35-\$50,000	13.47%	17.53%	15.85%	16.52%	
	% \$50-\$75,000	16.15%	20.13%	16.95%	20.12%	
	% ≥ \$75,000	29.31%	27.28%	26.99%	31.53%	
Employment	% Employed for Wages	51.71%	54.50%	52.00%	54.76%	< 0.0001
	% Self Employed	10.00%	8.25%	8.85%	10.79%	
	% Out of Work > 1yr	2.04%	1.63%	2.09%	1.58%	
	% Out of Work < 1yr	3.86%	2.87%	2.84%	2.60%	
	% Home Maker	9.09%	6.80%	8.39%	5.85%	
	% Student	4.17%	4.85%	4.45%	4.52%	
	% Retired	14.38%	16.99%	15.65%	15.68%	
	% Unable to Work	4.73%	4.10%	5.75%	4.22%	
Depression	Mean ± Standard Deviation	1.32 ± 2.84	1.15 ± 2.73	1.26 ± 2.89	1.09 ± 5.96	< 0.0001
Time Since Last Medical Checkup	Never	2.91%	1.27%	1.73%	0.46%	< 0.0001
	Within Past Year	61.62%	66.35%	67.82%	72.75%	
	Within Past 2 years	15.83%	14.05%	13.38%	13.44%	
	Within Past 5 years	11.02%	9.29%	8.65%	7.30%	
	Over 5 Years	8.63%	9.04%	8.42%	6.05%	
General Health	Excellent	21.39%	19.20%	21.70%	24.08%	< 0.0001
	Very Good	31.38%	36.71%	31.71%	36.92%	
	Good	30.09%	30.08%	29.76%	26.67%	
	Poor	12.94%	10.32%	11.92%	9.08%	
	Very Poor	4.21%	3.69%	4.90%	3.23%	
Mental Health	Mean ± Standard Deviation	3.66 ± 6.95	3.27 ± 7.06	3.46 ± 7.35	3.21 ± 15.52	0.0002
Physical Health	Mean ± Standard Deviation	3.68 ± 7.36	3.40 ± 7.53	3.59 ± 7.64	3.42 ± 16.63	0.0169
Alcoholic Drinks/Month	Mean ± Standard Deviation	41.2 ± 131.3	39.1 ± 100.5	37.3 ± 166.4	44.9 ± 203.7	0.0002
Smoking Status	Current Everyday	10.71%	16.52%	15.69%	14.86%	< 0.0001
	Current Some Days	5.54%	5.11%	5.29%	4.51%	
	Former	24.04%	25.48%	23.36%	29.82%	
	Never	59.71%	52.89%	55.66%	50.82%	
Body Mass Index	Mean ± Standard Deviation	26.8 ± 5.2	27.5 ± 5.7	27.4 ± 5.8	26.8 ± 11.5	< 0.0001
Sunlight Exposure	Mean ± Standard Deviation	69.1 ± 7.5	54.7 ± 3.7	62.8 ± 4.6	52.1 ± 13.4	< 0.0001
Mean High Temperature	Mean ± Standard Deviation	69.2 ± 5.1	57.5 ± 4.6	75.2 ± 4.5	52.6 ± 11.4	< 0.0001
Mean Day Length	Mean ± Standard Deviation	564 ± 31	542 ± 14	598 ± 15	538 ± 20	< 0.0001

Table 3—Unadjusted and adjusted differences in prevalence of Sleep Disturbance and Daytime Fatigue by Census region*

	West (%)	Midwest (%)	South (%)	Northeast (%)	p
Sleep Disturbance					
Overall					
Unadjusted	17.6	19.0	19.5	18.1	0.002
Adjusted	17.4	19.3	19.0	19.5	0.348
Men					
Unadjusted	14.9	16.6	16.5	15.3	0.090
Adjusted	14.0	16.1	16.4	16.2	0.394
Women					
Unadjusted	20.3	21.2	22.2	20.6	0.014
Adjusted	20.8	22.5	21.9	23.0	0.737
Daytime Fatigue					
Overall					
Unadjusted	18.8	21.6	22.8	20.1	< 0.001
Adjusted	17.6	22.3	23.0	23.7	< 0.001
Men					
Unadjusted	14.7	18.7	18.1	16.6	< 0.001
Adjusted	12.9	19.2	18.4	21.0	0.001
Women					
Unadjusted	22.9	24.2	27.2	23.4	< 0.001
Adjusted	22.4	25.5	27.7	26.6	0.017

*Census Regions include **West** (Alaska, California, Hawaii, Montana, Nevada, New Mexico, Oregon, Utah, Wyoming); **Midwest** (Indiana, Iowa, Michigan, Minnesota, Missouri, North Dakota, Wisconsin); **South** (Alabama, Arkansas, Delaware, Florida, Georgia, Louisiana, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Washington DC, West Virginia); and **Northeast** (Maine, Rhode Island, New Hampshire, Vermont).

Table 4—Examination of covariate mediation on Census region effects, expressed as percent change in Census region estimate after adjustment (reference = South)

Covariate/Covariate Group	All			Men			Women		
	West	Midwest	Northeast	West	Midwest	Northeast	West	Midwest	Northeast
Sleep Duration									
Sex	-0.1	-0.7	-1.3	—	—	—	—	—	—
Age	0.9	1.0	1.3	0.8	1.7	2.6	0.6	0.5	0.4
Race/Ethnicity	3.0	-1.9	-3.0	0.8	-3.2	-3.8	4.3	-0.9	-2.4
Socioeconomics	1.8	1.8	-0.9	3.5	-1.6	-6.6	-0.2	3.6	3.2
Geography	-6.6	0.7	5.3	-8.9	-0.7	4.1	-5.9	1.8	6.9
Weather	-1.6	-1.1	0.4	-7.8	-4.4	-4.3	2.5	1.2	3.7
Body Mass Index	1.1	-0.4	-1.1	2.5	0.6	-0.3	-0.1	-1.3	-1.8
Physical Health	-0.4	-0.1	-0.4	-2.5	-0.5	0.2	0.4	-0.1	-1.0
Mental Health	-17.8	0.3	4.0	-20.7	0.8	6.1	-15.9	-0.3	2.8
Alcohol	0.6	-0.2	-1.2	-0.5	-1.2	-3.3	0.9	0.3	0.1
Smoking	-0.2	-0.1	0.8	0.4	-1.5	0.7	-0.5	0.7	0.7
Medical Checkup	1.9	-0.4	-0.4	2.4	0.3	1.2	1.8	-0.7	-1.4
Daytime Fatigue									
Sex	-0.4	-1.2	-1.9	—	—	—	—	—	—
Age	1.5	1.0	1.0	0.3	0.9	1.2	3.0	1.1	0.7
Race/Ethnicity	6.5	-2.3	-3.3	6.6	-3.0	-4.5	6.2	-2.0	-2.6
Socioeconomics	0.1	0.8	-2.1	3.4	2.2	1.9	-1.7	-0.9	-6.2
Geography	-35.1	1.4	20.1	-49.6	5.4	30.9	-24.2	-1.8	10.2
Weather	-11.5	3.3	13.4	-17.8	7.1	22.7	-6.7	0.2	4.9
Body Mass Index	2.3	0.3	1.2	5.3	0.3	-0.5	-0.2	-0.1	2.2
Physical Health	1.6	0.5	-1.8	1.1	0.9	-1.7	1.2	-0.4	-2.3
Mental Health	-22.4	0.6	5.9	-24.3	3.1	9.7	-20.8	-1.5	3.4
Alcohol	-0.4	-0.4	-1.1	-0.9	-0.8	-2.3	0.4	0.0	-0.2
Smoking	0.4	-0.2	0.0	1.0	-1.2	-0.3	0.2	0.6	0.4
Medical Checkup	3.9	-0.2	-0.3	4.2	-0.5	-0.6	4.4	0.2	0.0

longitude). When men and women were examined separately, variables with a p value change > 0.05 for men included Geography, Smoking, Medical Checkup, Race/Ethnicity, and BMI, while variables for women included Race/Ethnicity, Weather, and Medical Checkup.

DISCUSSION

The present study evaluated state-based prevalence of self-reported Sleep Disturbance and Daytime Fatigue across 36 states/non-state regions. We created a cartographic map of the United States representing the population burden for sleep related problems, adding a new dimension to current knowledge of population level sleep problems that has some translational value at the clinical level. Furthermore, we examined differences in Sleep Disturbance and Daytime Fatigue across Census regions and examined potential mediators of these differences.

Overall, the prevalence of Sleep Disturbance was differentially distributed across states in the entire sample and by gender. Adjusting for a large number of plausible confounders did not completely account for the geographical differences observed. This suggests that there is an independent effect of “place” on Sleep Disturbance and Daytime Fatigue that is not completely explained by demographics, socioeconomic, health, regional differences in sunlight and weather patterns, and other factors. It is unclear why individuals in different places would report different levels of these outcomes, though other factors not assessed, such as regional differences in public policy, social norms, beliefs and attitudes, or habitual health-related behaviors, may explain some of these differences.

Pseudo R^2 values were computed to address the question of how much of Sleep Disturbance and Daytime Fatigue is an effect of State, relative to other potential determinants. The results of these analyses showed that although there was a discernable state effect, it was small compared to the effects of mental health. The effects of State were much closer in magnitude to the effects of Body Mass and Substance Use. This demonstrates, though, that the effects of geography on these complaints are comparable to those of other determinants of sleep disturbance that are well-described and known to play an important role in the interface between sleep and public health.³⁶ Further, this suggests that in addition to recent initiatives to better understand the relationship of sleep to obesity,^{10,37-43} attention should be paid to geography as well.

When comparing Census regions instead of specific states, interesting patterns emerged. Overall, the findings suggest that, in general, those in the South are often most likely to report Sleep Disturbance and Daytime Fatigue, and those in the West are often least likely. This finding is consistent with other geographic studies, showing that states in the South are often at the greatest risk of negative health outcomes.⁴⁴

To evaluate which factors explain differences in Sleep Disturbance and Daytime Fatigue across Census regions, we conducted an analysis that evaluated the change in the region p value for given sets of covariates. This process is analogous to performing multiple and prespecified backward selection procedures, but for the purposes of examining covariate influence rather than model selection. Caution should be applied

when interpreting these results. While conventional procedures for examining confounders make use of similar p value based assessments, it is important that relative change in effect size is not ignored. While examining a single measure of relative effect size change is complicated by the categorical independent variable, one cannot simply look at significance as the determinant of confounding. Given these limitations, the results showed that very few of these factors explained differences in Daytime Fatigue across Census regions—none of these covariates produced a p value increase ≥ 0.01 in the overall sample or when men were examined alone. When women were examined alone, changes ≥ 0.01 but ≤ 0.05 (necessary to render the effect non-significant) were seen for race/ethnicity, healthcare access, and weather. Regarding Sleep Disturbance, though, many variables impacted the p value. In the overall analysis (men and women combined), the largest p value change was seen for race/ethnicity, followed by healthcare access, weather, BMI, and latitude/longitude. The inclusion of any of these would render regional differences nonsignificant. Other notable effects were seen for age and smoking. When men were examined alone, a p value change ≥ 0.05 was found for latitude/longitude, smoking, medical checkup, race/ethnicity and BMI. P value changes of ≥ 0.01 were seen for age and socioeconomic factors. Similarly, when women were examined alone, p value change ≥ 0.05 was found for race/ethnicity, weather, healthcare access, and BMI. P value change ≥ 0.01 was seen only for physical health. These results suggest that regional differences in Sleep Disturbance are best explained by regional differences in race/ethnicity (separate from socioeconomic), healthcare access and BMI, with strong effects for latitude/longitude and smoking in men and weather in women.

There are a number of limitations to this study. First, not all states reported these outcome measures, including some of the most populous, including New York and Illinois. A better map of population burden across the U.S. will hopefully be drawn at a time when more states begin reporting these outcomes. Second, the measures of Sleep Disturbance and Daytime Fatigue are very broad compound measures, and those reporting these complaints likely include a wide variety of individuals, including those with sleep disorders (e.g., sleep apnea, insomnia), opposing or orthogonal complaints (e.g., insomnia and hypersomnia), and subclinical problems. Furthermore, they do not specifically address the issue of short sleep duration, which can be voluntary or due to other sleep disorders. Thus, it is impossible to extrapolate further than these broadly defined subjective complaints that have relatively high sensitivity but consequently low specificity. This limits the abilities of this study to meet the aim of informing allocation of resources. Third, Age $\times$ State and Sex $\times$ State interactions were not included, as this would introduce an additional 36 variables into the model for each interaction; this would greatly impact our statistical power and contribute disproportionately to likelihood of type II error. To address potential interactions, we conducted both a combined analysis and an analysis stratified by gender. It is possible that geographic relationships were confounded by age and sex. Fourth, this study is based on a telephone survey with a modest (though acceptable) response rate. This is further complicated since not all survey respondents responded to both sleep-related items; however, those that responded were generally similar to

those who did not respond to both items. The primary problem associated with the selection bias that inevitably occurs with phone surveys is generalizability of the sample to the general population. The present study addresses generalizability in a number of ways. First, the very large sample size mitigates some of the bias inherent in nonresponse. Further, generalizability of the sample to the general population is maximized with the use of weighting scores, which ensure that each region $\times$ age $\times$ sex $\times$ race/ethnicity group is accurately weighted in analyses. The combination of large sample size and individual subject weights specifically developed for BRFSS 2006 ensure that the results closely represent the characteristics of the American population.

Despite these limitations, this analysis contributes to the current literature in three ways. First, we demonstrate that sleep-related complaints vary by geographical area at the State and Census region level. Few epidemiological studies of sleep have taken geography into account,²⁹ and even fewer experimental studies have recognized this limitation.² These results demonstrate that geographical region should be included in models of sleep in the population, as they have in other important health domains, such as obesity.⁴⁴ Second, this analysis suggests that regional differences in sleep-related complaints are likely to be independent (or at least partially so) of the geographical factors that influence circadian rhythms (i.e., amount of sunlight and temperate climate),^{45,46} as the distribution did not consistently favor brighter, more comfortable regions. Third, these state-based prevalence rates allow for comparison to other state-based rates. For example, many of the states that report worse sleep and fatigue problems are the same states that tend to report higher prevalence of other conditions, such as obesity.⁴⁴

In addition, these unique extensions of population level sleep data have research, public health policy and clinical pertinence. From a research perspective, this analysis sets the stage for several future research questions, including: (1) What would a complete map of data look like? (2) Why are there persistent interstate adjusted differences? (4) Are there intrastate driving factors not captured in our analysis? and (5) How might these representations change with time?

Developing a state-level understanding of rates of sleep-related problems (and tracking these over time) may have a number of important clinical and public health implications. As a model, the CDC has tracked the obesity epidemic over for more than 2 decades and shared this publicly by publishing BMI maps of the USA.⁴⁷ This cartographic data has been used to implement important public health programs and policies and track their effects.

Also, health authorities in certain states may regard the sleep disturbance and fatigue as significantly burdensome to their population's health, especially if they are overseeing a region with particularly high prevalence rates. Certain regions (e.g., states with higher prevalence of Sleep Disturbance) might benefit from screening programs for sleep symptoms, as we better understand the extent these problems represent health risks (these items in particular have been associated with a number of health risks^{33,48}) or possible sleep disorders. Although daytime fatigue is a common feature of a number of sleep disorders, it can be an indicator of many other types of adverse health outcomes, such as cardiometabolic disease, cancer, and depres-

sion. An increased prevalence may indicate that the clinical importance of access to sleep specialists may be more pronounced in these regions, though an increase in screening for sleep disorders might be helpful regardless of prevalence.

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Address correspondence to: Michael A. Grandner, Ph.D., Center for Sleep and Circadian Neurobiology, University of Pennsylvania, 3624 Market Street, Suite 201, Philadelphia, PA 19104; Tel: (215) 615-1756; Fax: (215) 701-1831; E-mail: grandner@upenn.edu

DISCLOSURE STATEMENT

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Figure S1—Graphical representation of prevalence rates for Sleep Disturbance by state

Inset boxes for Alaska, Hawaii, Puerto Rico, U.S. Virgin Islands, and Washington DC, which do not otherwise appear on the map. Figures represent (A) men and (B) women. Colors denote sextile, determined separately for the total sample, men, and women. Sextiles are reported in Table S4. Higher sextile numbers (darker shade) denote higher prevalence rates. States that appear in white (i.e., unshaded) did not collect Sleep Disturbance data.

Figure S2—Graphical representation of prevalence rates for Daytime Fatigue by state

Inset boxes for Alaska, Hawaii, Puerto Rico, U.S. Virgin Islands, and Washington DC, which do not otherwise appear on the map. Figures represent (A) men and (B) women. Colors denote sextile, determined separately for the total sample, men, and women. Sextiles are reported in Table S4. Higher sextile numbers (darker shade) denote higher prevalence rates. States that appear in white (i.e., unshaded) did not collect Daytime Fatigue data.

Table S1—Sample sizes by state for men and women in unadjusted and adjusted analyses

	Total		Men		Women	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
All	183436	157319	70208	62321	113228	94998
Alabama	3034	2519	1032	877	2002	1642
Alaska	1974	1730	897	799	1077	931
Arkansas	5175	4443	1918	1707	3257	2736
California	5283	4890	2105	1983	3178	2907
District of Columbia	3671	3105	1430	1242	2241	1863
Delaware	3904	3293	1455	1286	2449	2007
Florida	9961	8387	3779	3298	6182	5089
Georgia	6907	5805	2503	2200	4404	3605
Hawaii	6133	5201	2591	2251	3542	2950
Indiana	6095	5196	2259	2016	3836	3180
Iowa	4993	4335	1997	1812	2996	2523
Louisiana	6481	5233	2226	1885	4255	3348
Maine	3798	3289	1480	1320	2318	1969
Michigan	5375	4574	1967	1734	3408	2840
Minnesota	4188	3812	1678	1567	2510	2245
Mississippi	5629	4840	1875	1668	3754	3172
Missouri	4982	4364	1888	1708	3094	2656
Montana	5617	4810	2298	2027	3319	2783
Nevada	3397	2936	1535	1360	1862	1576
New Hampshire	5506	4692	2144	1886	3362	2806
New Mexico	6104	5420	2333	2110	3771	3310
North Dakota	4437	3776	1789	1608	2648	2168
Oklahoma	6588	5677	2422	2162	4166	3515
Oregon	4536	3983	1725	1543	2811	2440
Puerto Rico	4465	3831	1561	1403	2904	2428
Rhode Island	4194	3470	1522	1297	2672	2173
South Carolina	8473	7125	3280	2869	5193	4256
Tennessee	4091	3403	1411	1231	2680	2172
Texas	6238	5173	2237	1916	4001	3257
Utah	4887	4344	2089	1926	2798	2418
Vermont	6643	5815	2656	2377	3987	3438
Virgin Islands	2955	2474	1089	924	1866	1550
Virginia	5005	4181	1934	1693	3071	2488
West Virginia	3641	3197	1438	1298	2203	1899
Wisconsin	4349	3835	1750	1596	2599	2239
Wyoming	4727	4161	1915	1742	2812	2419

Table S2—Unadjusted and adjusted prevalence rates (with 95% confidence interval) of Sleep Disturbance by state

State	Unadjusted			Adjusted		
	All	Women	Men	All	Women	Men
Alabama	22.3 (19.9-24.6)	24.6 (22.2-27.1)	19.7 (15.5-23.8)	21.5 (19.7-23.3)	24.8 (22.4-27.1)	18.0 (15.2-20.9)
Alaska	19.2 (16.5-21.9)	21.6 (18.2-25.1)	17.0 (12.9-21.1)	17.8 (15.4-20.2)	20.0 (16.6-23.3)	16.0 (12.6-19.3)
Arkansas	22.1 (20.6-23.5)	24.9 (23.0-26.8)	19.1 (16.9-21.2)	21.6 (20.2-22.9)	25.5 (23.6-27.3)	17.7 (15.8-19.6)
California	17.1 (15.8-18.4)	19.5 (17.7-21.3)	14.6 (12.7-16.6)	17.2 (16.0-18.4)	19.9 (18.2-21.6)	14.6 (13.0-16.2)
Delaware	7.2 (6.0-8.5)	8.1 (6.7-9.5)	6.3 (4.2-8.4)	7.6 (6.7-8.4)	9.5 (8.3-10.8)	5.6 (4.5-6.8)
District of Columbia	16.6 (14.9-18.4)	18.0 (15.7-20.2)	15.1 (12.4-17.7)	15.8 (14.1-17.5)	17.6 (15.5-19.6)	13.8 (11.1-16.6)
Florida	19.6 (18.4-20.8)	22.6 (21.1-24.1)	16.4 (14.4-18.4)	19.8 (18.6-21.1)	23.3 (21.7-24.8)	16.5 (14.5-18.4)
Georgia	19.1 (17.7-20.5)	22.6 (20.8-24.3)	15.4 (13.2-17.6)	18.8 (17.4-20.2)	22.4 (20.6-24.1)	15.3 (13.2-17.4)
Hawaii	15.4 (14.1-16.6)	18.1 (16.3-19.9)	12.6 (10.8-14.3)	15.1 (13.8-16.3)	18.2 (16.4-20.1)	12.1 (10.4-13.9)
Indiana	19.7 (18.4-21.0)	21.0 (19.4-22.6)	18.4 (16.3-20.4)	19.2 (18.0-20.5)	21.1 (19.5-22.6)	17.5 (15.5-19.5)
Iowa	16.6 (15.3-17.9)	18.0 (16.4-19.6)	15.2 (13.1-17.2)	16.4 (15.2-17.7)	17.9 (16.3-19.6)	15.0 (13.1-16.9)
Louisiana	20.8 (19.5-22.1)	24.2 (22.6-25.8)	17.1 (15.1-19.1)	20.7 (19.4-22.1)	25.0 (23.3-26.7)	16.5 (14.4-18.5)
Maine	17.9 (16.5-19.4)	19.6 (17.7-21.5)	16.2 (14.0-18.4)	18.0 (16.6-19.4)	20.0 (18.1-21.9)	16.0 (13.8-18.1)
Michigan	20.4 (19.0-21.9)	23.0 (21.3-24.8)	17.7 (15.5-20.0)	20.0 (18.7-21.3)	23.7 (22.0-25.4)	16.3 (14.3-18.3)
Minnesota	16.7 (15.3-18.1)	18.9 (17.0-20.8)	14.4 (12.4-16.4)	16.5 (15.1-17.8)	18.6 (16.8-20.4)	14.3 (12.3-16.2)
Mississippi	22.4 (20.9-23.9)	27.5 (25.6-29.4)	16.7 (14.4-19.0)	21.9 (20.5-23.4)	27.4 (25.6-29.1)	16.2 (13.8-18.6)
Missouri	21.3 (19.3-23.2)	24.5 (22.0-27.0)	17.7 (14.8-20.7)	21.0 (19.1-22.8)	24.4 (22.1-26.6)	17.4 (14.5-20.4)
Montana	17.1 (15.9-18.4)	19.4 (17.7-21.1)	14.8 (12.9-16.7)	16.9 (15.7-18.2)	18.9 (17.2-20.6)	15.1 (13.3-16.8)
Nevada	20.0 (18.0-22.1)	23.5 (20.6-26.5)	16.5 (13.7-19.4)	19.8 (17.8-21.8)	23.5 (20.7-26.3)	16.3 (13.5-19.2)
New Hampshire	17.0 (15.7-18.3)	20.5 (18.7-22.4)	13.3 (11.5-15.1)	16.4 (15.1-17.7)	20.1 (18.2-22.1)	12.8 (11.1-14.5)
New Mexico	18.4 (17.0-19.7)	21.4 (19.6-23.1)	15.2 (13.2-17.2)	18.0 (16.7-19.2)	20.9 (19.2-22.6)	15.0 (13.2-16.9)
North Dakota	14.6 (13.2-16.1)	15.0 (13.2-16.8)	14.3 (12.1-16.5)	14.1 (12.8-15.4)	13.8 (12.1-15.5)	14.4 (12.4-16.3)
Oklahoma	24.7 (23.4-26.1)	27.2 (25.5-28.9)	22.1 (20.0-24.2)	24.9 (23.5-26.2)	27.7 (26.0-29.3)	22.1 (20.0-24.2)
Oregon	18.8 (17.4-20.3)	22.2 (20.3-24.2)	15.3 (13.1-17.5)	18.2 (16.8-19.5)	22.3 (20.5-24.1)	14.2 (12.2-16.1)
Rhode Island	19.8 (18.1-21.6)	23.1 (20.8-25.4)	16.2 (13.6-18.8)	19.2 (17.5-20.9)	22.6 (20.3-24.9)	15.6 (13.1-18.1)
South Carolina	17.8 (16.7-18.9)	21.2 (19.7-22.7)	14.2 (12.6-15.8)	17.7 (16.6-18.8)	21.3 (19.8-22.9)	13.9 (12.4-15.5)
Tennessee	19.6 (17.9-21.4)	22.0 (19.8-24.2)	17.1 (14.3-19.9)	18.7 (17.1-20.3)	21.6 (19.6-23.6)	15.8 (13.3-18.4)
Texas	18.2 (16.4-20.0)	20.5 (18.2-22.7)	15.9 (13.0-18.8)	18.1 (16.2-20.0)	21.2 (18.8-23.6)	15.0 (12.2-17.9)
Utah	21.0 (19.3-22.6)	25.5 (23.1-27.9)	16.4 (14.2-18.6)	20.7 (19.2-22.2)	25.2 (22.9-27.6)	16.6 (14.6-18.7)
Vermont	17.4 (16.3-18.6)	18.9 (17.4-20.3)	15.8 (14.1-17.6)	17.1 (15.9-18.2)	19.1 (17.6-20.7)	15.0 (13.3-16.7)
Virginia	17.0 (15.3-18.8)	19.1 (16.8-21.3)	14.9 (12.2-17.7)	16.3 (14.6-18.0)	18.7 (16.7-20.7)	14.1 (11.4-16.7)
West Virginia	26.0 (24.3-27.7)	29.6 (27.3-32.0)	22.1 (19.6-24.7)	25.7 (24.1-27.2)	30.2 (27.9-32.5)	21.0 (18.8-23.1)
Wisconsin	16.9 (15.5-18.4)	19.1 (17.2-21.1)	14.6 (12.4-16.7)	16.8 (15.4-18.3)	19.8 (17.8-21.8)	13.9 (11.8-16.1)
Wyoming	17.2 (15.9-18.5)	19.2 (17.5-20.9)	15.1 (13.2-17.1)	16.7 (15.4-18.1)	18.6 (16.9-20.3)	15.1 (13.1-17.0)
Puerto Rico	18.2 (16.9-19.6)	20.9 (19.2-22.7)	15.2 (13.1-17.2)	17.8 (16.4-19.2)	20.6 (18.8-22.5)	14.8 (12.7-16.8)
Virgin Islands	12.9 (11.3-14.4)	15.8 (13.7-17.9)	9.4 (7.3-11.6)	12.8 (11.2-14.3)	15.8 (13.7-17.9)	9.5 (7.1-11.9)

Table S3—Unadjusted and adjusted prevalence rates (with 95% confidence interval) of Daytime Fatigue by state

State	Unadjusted			Adjusted		
	All	Women	Men	All	Women	Men
Alabama	27.1 (24.7-29.5)	30.2 (27.7-32.8)	23.6 (19.4-27.9)	27.1 (25.0-29.1)	31.4 (28.9-34.0)	22.4 (19.2-25.5)
Alaska	18.8 (16.4-21.2)	23.6 (20.1-27.2)	14.3 (11.1-17.4)	17.8 (15.3-20.4)	23.6 (20.1-27.1)	12.9 (9.3-16.4)
Arkansas	26.8 (25.3-28.3)	30.5 (28.5-32.5)	22.8 (20.6-25.1)	26.2 (24.8-27.6)	30.6 (28.7-32.4)	21.9 (19.8-23.9)
California	17.9 (16.6-19.2)	22.1 (20.2-24.0)	13.6 (11.8-15.4)	18.2 (17.1-19.4)	22.9 (21.2-24.6)	13.7 (12.1-15.3)
Delaware	23.5 (21.4-25.6)	28.5 (25.7-31.4)	18.0 (15.0-20.9)	23.3 (21.4-25.2)	28.8 (26.1-31.4)	17.8 (15.1-20.4)
District of Columbia	18.2 (16.5-20.0)	21.4 (19.1-23.8)	14.5 (12.0-17.1)	17.4 (15.7-19.1)	20.9 (18.8-23.0)	13.6 (10.9-16.2)
Florida	20.3 (19.1-21.5)	24.8 (23.3-26.4)	15.6 (13.8-17.4)	20.3 (19.1-21.5)	25.2 (23.7-26.8)	15.5 (13.7-17.3)
Georgia	22.2 (20.9-23.6)	27.2 (25.4-29.1)	17.0 (15.0-19.0)	21.8 (20.5-23.1)	27.6 (25.7-29.5)	16.1 (14.3-17.9)
Hawaii	19.9 (18.5-21.3)	21.7 (19.8-23.5)	18.1 (16.1-20.2)	19.7 (18.4-21.1)	22.2 (20.4-24.0)	17.5 (15.4-19.5)
Indiana	23.1 (21.7-24.4)	25.8 (24.1-27.5)	20.2 (18.1-22.2)	22.6 (21.3-23.9)	25.9 (24.2-27.6)	19.4 (17.5-21.3)
Iowa	19.4 (18.1-20.8)	20.5 (18.8-22.2)	18.4 (16.1-20.6)	19.0 (17.5-20.4)	19.9 (18.2-21.7)	18.0 (15.8-20.3)
Louisiana	25.4 (24.0-26.7)	30.3 (28.6-32.0)	20.0 (17.9-22.2)	24.4 (22.9-25.8)	29.7 (27.9-31.5)	19.1 (16.9-21.3)
Maine	20.6 (19.1-22.2)	23.0 (21.0-25.1)	18.0 (15.7-20.4)	20.7 (19.2-22.1)	22.7 (20.7-24.8)	18.7 (16.6-20.7)
Michigan	22.2 (20.7-23.6)	25.3 (23.5-27.1)	18.9 (16.7-21.2)	22.3 (21.0-23.6)	26.1 (24.4-27.8)	18.5 (16.5-20.4)
Minnesota	18.7 (17.2-20.3)	21.9 (19.9-24.0)	15.4 (13.2-17.6)	18.5 (17.2-19.9)	22.1 (20.2-24.0)	15.0 (13.0-16.9)
Mississippi	30.0 (28.4-31.6)	34.7 (32.7-36.7)	24.8 (22.2-27.4)	29.9 (28.4-31.3)	34.7 (33.0-36.4)	24.8 (22.5-27.1)
Missouri	25.2 (23.2-27.1)	28.3 (25.7-30.9)	21.7 (18.9-24.6)	25.1 (23.3-26.9)	27.9 (25.6-30.1)	22.2 (19.4-25.1)
Montana	19.3 (17.9-20.6)	21.6 (19.8-23.3)	16.9 (14.8-18.9)	18.4 (17.1-19.7)	21.1 (19.3-22.9)	15.8 (13.9-17.7)
Nevada	22.6 (20.4-24.7)	27.0 (23.9-30.1)	18.2 (15.2-21.1)	22.7 (20.6-24.9)	26.3 (23.5-29.1)	19.4 (16.1-22.6)
New Hampshire	19.0 (17.6-20.3)	22.3 (20.4-24.2)	15.4 (13.5-17.3)	18.3 (17.0-19.6)	22.0 (20.2-23.9)	14.6 (12.7-16.5)
New Mexico	21.6 (20.2-23.0)	25.0 (23.1-26.9)	18.0 (15.8-20.2)	21.4 (20.1-22.7)	24.9 (23.1-26.6)	17.9 (15.9-19.8)
North Dakota	18.1 (16.6-19.7)	19.5 (17.5-21.6)	16.7 (14.3-19.0)	17.5 (16.0-19.0)	18.6 (16.7-20.6)	16.5 (14.3-18.6)
Oklahoma	27.7 (26.4-29.1)	31.7 (29.9-33.4)	23.6 (21.5-25.8)	27.7 (26.4-29.0)	32.5 (30.8-34.1)	23.0 (21.0-24.9)
Oregon	19.7 (18.2-21.1)	22.7 (20.8-24.6)	16.5 (14.4-18.7)	19.3 (17.9-20.6)	22.7 (20.9-24.5)	16.0 (13.9-18.0)
Rhode Island	21.6 (19.9-23.3)	26.0 (23.7-28.3)	16.7 (14.3-19.2)	20.7 (19.2-22.2)	25.4 (23.2-27.5)	15.8 (13.6-18.0)
South Carolina	23.2 (22.0-24.5)	27.7 (26.1-29.4)	18.3 (16.5-20.1)	22.4 (21.2-23.6)	27.2 (25.6-28.9)	17.5 (15.8-19.2)
Tennessee	24.4 (22.5-26.4)	28.9 (26.4-31.5)	19.6 (16.7-22.5)	24.0 (22.1-25.9)	28.9 (26.5-31.3)	19.1 (16.2-22.0)
Texas	21.1 (19.3-22.8)	25.8 (23.4-28.1)	16.3 (13.8-18.8)	21.2 (19.4-23.0)	26.7 (24.2-29.2)	15.8 (13.3-18.4)
Utah	23.8 (22.0-25.5)	30.0 (27.4-32.6)	17.5 (15.3-19.7)	23.7 (22.1-25.3)	30.2 (27.6-32.7)	17.9 (15.9-19.9)
Vermont	19.0 (17.8-20.1)	22.0 (20.4-23.6)	15.8 (14.1-17.5)	18.4 (17.3-19.4)	21.9 (20.3-23.4)	14.9 (13.4-16.4)
Virginia	20.3 (18.5-22.1)	23.8 (21.5-26.1)	16.6 (13.8-19.5)	20.1 (18.3-21.9)	23.9 (21.5-26.2)	16.5 (13.9-19.2)
West Virginia	29.9 (28.1-31.7)	35.3 (32.8-37.8)	24.1 (21.5-26.7)	29.9 (28.2-31.6)	35.6 (33.2-38.1)	23.9 (21.7-26.2)
Wisconsin	19.2 (17.7-20.8)	21.1 (19.1-23.1)	17.3 (14.9-19.6)	19.4 (17.9-20.9)	21.9 (20.0-23.9)	16.9 (14.6-19.1)
Wyoming	20.6 (19.2-22.0)	23.3 (21.4-25.1)	17.9 (15.8-20.0)	20.0 (18.5-21.4)	22.3 (20.5-24.1)	17.9 (15.7-20.1)
Puerto Rico	19.4 (18.0-20.7)	23.8 (22.0-25.6)	14.3 (12.3-16.3)	19.7 (18.3-21.1)	24.7 (22.7-26.6)	14.3 (12.2-16.3)
Virgin Islands	16.4 (14.7-18.1)	20.7 (18.4-22.9)	11.4 (8.9-13.9)	16.4 (14.7-18.1)	21.0 (18.7-23.3)	11.4 (8.8-13.9)

Table S4—Sextiles of prevalence rates for Sleep Disturbance and Daytime Fatigue

Group	1 st Sextile (%)	2 nd Sextile (%)	3 rd Sextile (%)	4 th Sextile (%)	5 th Sextile (%)	6 th Sextile (%)
Sleep Disturbance						
All	7.2-16.6	16.7-17.1	17.2-18.2	18.4-19.6	19.7-21.0	21.3-26.0
Men	6.3-14.3	14.4-15.1	15.1-15.4	15.9-16.4	16.5-17.7	17.7-22.1
Women	8.1-18.1	19.9-19.4	19.5-21.0	21.2-22.6	22.6-24.5	24.9-29.6
Daytime Fatigue						
All	16.4-18.8	19.0-19.5	19.7-20.6	21.1-22.6	23.1-25.2	25.4-30.0
Men	11.4-15.4	15.4-16.6	16.7-17.5	17.9-18.2	18.3-20.2	21.7-24.8
Women	19.5-21.6	21.7-22.7	23.0-24.8	25.0-27.0	27.2-30.0	30.2-35.2

Table S5—Pseudo R^2 and ratio^a that describe relative change in model fit for each group of independent variables

	Overall		Men		Women	
	R^2	Ratio	R^2	Ratio	R^2	Ratio
Sleep Disturbance						
States	0.106	1.30%	0.126	1.57%	0.130	1.57%
Demographics	0.681	8.33%	0.589	7.36%	0.243	2.94%
Socioeconomics	0.893	10.92%	1.194	14.91%	0.690	8.36%
Body Mass	0.180	2.20%	0.020	0.25%	0.288	3.49%
Mental Health	8.180	100.00%	8.007	100.00%	8.258	100.00%
Physical Health	1.273	15.56%	1.250	15.61%	1.395	16.89%
Substances	0.524	6.41%	0.709	8.85%	0.373	4.52%
Daytime Fatigue						
States	0.156	1.73%	0.260	2.99%	0.146	1.56%
Demographics	1.159	12.87%	0.407	4.68%	0.571	6.09%
Socioeconomics	0.560	6.22%	0.742	8.54%	0.421	4.49%
Body Mass	0.314	3.49%	0.157	1.81%	0.474	5.06%
Mental Health	9.007	100.00%	8.692	100.00%	9.371	100.00%
Physical Health	3.042	33.77%	2.834	32.60%	3.341	35.65%
Substances	0.187	2.08%	0.215	2.47%	0.152	1.62%

^a R^2 is expressed as McFadden's pseudo R^2 which can only be evaluated relative to other values. Thus, the ratio represents the ratio of that R^2 to the largest value for that analysis (Mental Health, in all cases).

Table S6—Effects of covariates on Census region differences in Sleep Disturbance and Daytime Fatigue (expressed as p value difference)

Covariate	Sleep Disturbance			Daytime Fatigue		
	All	Men	Women	All	Men	Women
Sex	0.0098	—	—	-0.000004	—	—
Age	0.0139	0.0394	-0.0090	0.00003	-0.00001	0.0097
Race/Ethnicity	0.1966	0.0892	0.2421	0.00005	0.0008	0.0126
Socioeconomics	-0.0749	0.0222	-0.1739	-0.00001	0.0006	-0.0073
Geography	0.0612	0.1377	-0.1475	-0.0014	-0.0163	-0.0172
Weather	0.1114	-0.1716	0.2382	-0.00003	-0.0043	0.0127
Body Mass Index	0.0766	0.0654	0.1130	0.0001	0.0007	0.0067
Physical Health	-0.0154	-0.0488	0.0388	0.00004	0.0003	0.0084
Mental Health	-0.6346	-0.4570	-0.1391	-0.0525	-0.0614	-0.1289
Alcohol	0.0015	-0.0687	0.0129	-0.00002	-0.0002	0.0027
Smoking	0.0457	0.1358	-0.0688	0.00002	0.0005	0.0013
Medical Checkup	0.1318	0.1204	0.1304	0.0001	0.0007	0.0104