

Socioeconomic Status Predicts Objective and Subjective Sleep Quality in Aging Women

ELLIOT M. FRIEDMAN, PhD, GAYLE D. LOVE, PhD, MELISSA A. ROSENKRANZ, HEATHER L. URRY, PhD,
RICHARD J. DAVIDSON, PhD, BURTON H. SINGER, PhD, AND CAROL D. RYFF, PhD

Objective: To test the hypothesis that socioeconomic status (SES) would be associated with sleep quality measured objectively, even after controlling for related covariates (health status, psychosocial characteristics). Epidemiological studies linking SES and sleep quality have traditionally relied on self-reported assessments of sleep. **Methods:** Ninety-four women, 61 to 90 years of age, participated in this study. SES was determined by pretax household income and years of education. Objective and subjective assessments of sleep quality were obtained using the NightCap sleep system and the Pittsburgh Sleep Quality Index (PSQI), respectively. Health status was determined by subjective health ratings and objective measures of recent and chronic illnesses. Depressive symptoms and neuroticism were quantified using the Center for Epidemiological Studies Depression Scale and the Neuroticism subscale of the NEO Personality Inventory, respectively. **Results:** Household income significantly predicted sleep latency and sleep efficiency even after adjusting for demographic factors, health status, and psychosocial characteristics. Income also predicted PSQI scores, although this association was significantly attenuated by inclusion of neuroticism in multivariate analyses. Education predicted both sleep latency and sleep efficiency, but the latter association was partially reduced after health status and psychosocial measures were included in analyses. Education predicted PSQI sleep efficiency component scores, but not global scores. **Conclusions:** These results suggest that SES is robustly linked to both subjective and objective sleep quality, and that health status and psychosocial characteristics partially explain these associations. **Key words:** socioeconomic status, sleep, health, neuroticism.

SES = socioeconomic status; PSQI = Pittsburgh Sleep Quality Index; GCRC = General Clinical Research Center; CES-D = Center for Epidemiological Studies Depression Scale.

INTRODUCTION

Epidemiological studies have consistently shown that social position predicts the quality of nightly sleep. Specifically, those with low status occupations are more likely to report difficulty falling and staying asleep, more frequent early morning awakenings, and increased daytime sleepiness compared with those with higher occupational status (1–4). Similarly, household income and years of education are positively correlated with sleep quality (5). To date, however, most epidemiological assessments of sleep quality have been limited to subjective sleep reports, largely due to the technical challenges of gathering objective sleep data outside of the laboratory. Because subjective and objective sleep measures often do not correlate well with one another (6), it is important to determine whether objectively measured sleep quality is also predicted by indicators of socioeconomic status (SES) (5). In the current study, we examine the extent to which SES predicts both objective and subjective assessments of sleep quality in a sample of community-dwelling women. We also

probe the extent to which associations of SES and sleep are influenced by health status and psychosocial characteristics.

The NightCap sleep monitoring system provides objective measures of multiple sleep parameters, including sleep latency and sleep efficiency (total time asleep/total time in bed)—the two variables that were the focus of the current analyses. Data obtained using the NightCap system has compared favorably with those gathered using traditional polysomnography (7,8), and the NightCap method has been used previously to examine associations between psychosocial variables, such as loneliness or social well-being, and sleep quality (9,10). Use of the NightCap system in the present study facilitated the collection of sleep data in the participants' homes. Participants also completed the Pittsburgh Sleep Quality Index (PSQI), a measure of self-rated sleep quality. Originally developed as a questionnaire for the detection of potential sleep pathology (11), the PSQI has been used in population-based research, including a recent study of Japanese civil servants in which sleep quality was associated with incremental differences in occupational status (4).

In addition to assessing the associations between SES and sleep parameters, we also examined the influences of health status and psychosocial characteristics on the association of SES and sleep. Low social position is reliably associated with increases in morbidity and mortality and with higher levels of negative affect, including depression and chronic stress (12–14). Low social position is also associated with greater exposure to severe stressors (15) along with a greater likelihood that those stressors will be considered threatening to well-being (16,17), leading to greater psychological distress and an increased number of physical symptoms (17). Finally, neuroticism, the stable tendency to respond to stressors with negative affect, is more prevalent at low SES levels (18). Sleep is strongly linked to health status (19–21), to biological processes associated with the host's physiological response to disease (22,23), to psychosocial adversity (24–26), and to the psychological and biological responses to psychosocial adver-

From the Department of Population Health Sciences (E.M.F.), Robert Wood Johnson Health and Society Scholars Program; Institute on Aging (G.D.L., C.D.R.); Department of Psychology (M.A.R., R.J.D., C.D.R.), University of Wisconsin-Madison, Madison, Wisconsin; Department of Psychology (H.L.U.), Tufts University, Medford, Massachusetts; Office of Population Research (B.H.S.), Princeton University, Princeton, New Jersey.

Address correspondence and reprint requests to Elliot Friedman, Department of Population Health Sciences, 624 WARF Office Bldg., 610 N. Walnut Street, Madison, WI 53726. E-mail: friedman1@wisc.edu

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sity (27). These lines of research converge on the hypothesis that health status and prevalence of negative affect might account for the association of SES and sleep quality. The present study thus sought to test associations of SES and sleep quality after accounting for these potential influences. Health was operationalized with three measures of subjective and objective health status. Depression and neuroticism were assessed using the Center for Epidemiological Studies Depression Scale (CES-D) and the Neuroticism subscale of the NEO Personality Inventory, respectively.

METHODS

Participants

Respondents were recruited from a prior longitudinal study of aging women ($n = 301$) undergoing community relocation (28,29). Women who were ≥ 55 years of age, able to participate in an interview and complete self-administered materials, and had plans to move in the following year to an independent setting, but not to a private home, were eligible for participation. Potential respondents for the original study were identified through working with housing facility managers, various organizations providing services to the elderly, and the media. For the current study, participants in the prior study were contacted by mail and invited to participate in an additional study involving collection of biological samples and in-home sleep assessments. There were no inclusion or exclusion criteria, except the ability and willingness to travel to the General Clinical Research Center (GCRC) on the University of Wisconsin-Madison campus for an overnight stay. All procedures were approved by the University of Wisconsin Human Subjects Institutional Review Board, and participant consent was obtained during the

GCRC visit. The data for this study were collected between March 2000 and November 2001. Among those from the prior study who did not participate, 16% were ineligible (due to death, severe morbidity, or moving out of the area), whereas 42% declined to participate (in some cases, due to travel difficulties or for health reasons). However, the newly recruited sample of 135 participants was not significantly different from the original longitudinal sample with regard to health (chronic conditions, health symptoms), income, or marital status, but was significantly younger and had more education.

Complete data for objective and subjective sleep assessments were available on 94 women from this sample of 135. Compared with those without complete sleep data, those with complete data were comparable on all measures used in this study. The characteristics of the 94 participants are shown in Table 1.

Procedure

Self-administered questionnaires were sent to respondents 3 to 4 weeks before a visit to the UW-Madison campus for the biomarker assessments. These were completed independently and returned to investigators at the time of the participant's campus visit. After completing the self-administered questionnaires, the participants were admitted to the GCRC located within the UW Hospital and Clinics for an overnight stay. A trained nurse or physician took the respondent's medical history and conducted a physical health examination.

Medication Use

Participants were asked to bring all prescription and over-the-counter medication that they were currently taking to the GCRC visit, and a complete inventory of these medications was completed by the GCRC staff. Medications were then coded by type, dosage, and frequency of use. Analyses in the current study controlled for any use of sleep medication or other medication

TABLE 1. Descriptive Statistics for Study Participants ($n = 94$)

Variable	Mean	SD	Range	%
Age	73.5	7.0	61–90	
Marital status				
Married				20.2
Widowed				55.3
Divorced				16.0
Never married				6.4
Socioeconomic status indicators				
Years of education	14.4	8.4	8–23	
Median pretax family income	\$25,000	\$7,500	\$6,000–>\$100,000	
Nightcap sleep assessment				
Latency to sleep onset (min)	22.2	15.3	3.3–75	
Sleep efficiency (duration/time in bed)	0.9	0.1	0.7–1.0	
Pittsburgh Sleep Quality Index	0.9	0.7	0–3	
Component 1: Subjective sleep quality	1.0	0.9	0–3	
Component 2: Sleep latency	0.6	0.6	0–3	
Component 3: Sleep duration	0.7	0.9	0–3	
Component 4: Habitual sleep efficiency	1.4	0.6	0–3	
Component 5: Sleep disturbances range	0.8	1.2	0–3	
Component 6: Use of sleeping medication	0.9	0.6	0–3	
Component 7: Daytime dysfunction	0.9	0.7	0–3	
Global score (scale range 0–21)	6.3	3.1	1–16	
Percent scoring >5				54.9
Health indicators				
Self-rated health (1 = poor; 7 = excellent)	5.2	0.9	2–7	
Number of days sick (past 6 months)	7.1	21.5	0–183	
Number of chronic health conditions	2.1	1.3	0–5	
Psychosocial measures				
Depression (CES-D; scale range 0–60)	8.3	9.3	0–52	
Neuroticism (scale range 12–60)	29.1	7.1	13–52	

SD = standard deviation; CES-D = Center for Epidemiological Studies Depression Scale.

that might affect either sleep or psychosocial measurements (e.g., antidepressants, antihypertensives). The number of such medications used by each participant was summed into a single measure that was introduced into multivariate analyses at the first step (along with demographic and health behavior control measures).

Socioeconomic Status

SES was operationalized by two variables: pretax household income and years of education completed. Data for these measures were obtained during face-to-face interviews during the GCRC stay. Given the hypothesis of linear associations between SES and sleep parameters, both items were treated as continuous variables in statistical analyses.

Sleep Assessments

Both objective (NightCap) and subjective (PSQI) assessments of sleep quality were used in the present study.

NightCap Sleep Recordings

Participants received instructions on using the NightCap and wore the NightCap for 1 night during their stay at the GCRC. They then collected sleep data for 4 consecutive nights at home immediately after their stay at the GCRC. The NightCap is a two-channel device that records eyelid and head movements using sensors that are mounted in a bandana worn on the head during each night of sleep. The eyelid sensor consists of a piezoelectric self-adhesive mylar sensor that is attached to the left eyelid. Body movements were detected with a multi-polar cylindrical mercury switch on the forehead. Activity in these sensors is recorded at 250-ms intervals and output to a small recording device. Participants were instructed to turn on the recording unit when they were ready to try to fall asleep; activation of the unit was marked "bedtime." If they typically read or watched TV in bed, they were asked not to turn on the unit until they turned out the lights and were ready to fall asleep. Similarly, participants were instructed to turn off the unit immediately on awakening; the time at which the unit was switched off was determined to be "risetime." Total time in bed was calculated by subtracting "bedtime" from "risetime."

The majority of participants provided complete (i.e., 4 consecutive nights) or nearly complete data (mean = 3.55 nights; standard deviation (SD) = 0.78). Missing data were generally due to participant error (failing to turn on the recording unit) or to artifact (i.e., poor quality data). Sleep records were visually inspected for data quality by one rater, and subjective quality ratings were assigned to each record (i.e., night) from 0 = very poor to 6 = excellent. Records scoring 0 or 1 were discarded. Data from the first night of sleep at the GCRC, which was considered to be an accommodation night, were also discarded. Of a total of 478 records collected from in-home recordings, 90 records were excluded across 48 participants. Average quality ratings for the remaining records was good (mean = 3.13; SD = 0.76). Subjects having at least 2 nights of good data (i.e., quality ratings of 2–6) after the accommodation night were retained for subsequent analyses. Overall, of the 94 participants in the current study, 11 participants provided 2 nights of good data, 26 provided 3 nights, and 57 had 4 nights.

Data for each night were visually scored in 1-minute epochs using algorithms described in the work of Ajilore, Stickgold, Rittenhouse, and Hobson (8). Each epoch was scored for eyelid movement, body movement, or no movement. If an epoch contained both eyelid and body movement, the epoch was scored as body movement. Starting at "bedtime," each sleep record was scored as WAKE until there were five consecutive epochs with no movement. The next epoch was then scored as NREM, and NREM continued until there was a transition to either WAKE or REM. An epoch was scored as REM after three consecutive eye movement epochs occurred during NREM sleep. Epochs were scored as WAKE after three consecutive epochs of body movement. In an earlier study validating the NightCap method in young adults, comparisons of NightCap and polysomnographic data showed an 87% overall agreement rate for WAKE, NREM, and REM states (8). Additional analyses focused specifically on sleep latency in younger and middle-aged adults showed a 93% agreement rate between the NightCap algorithm and traditional polysomnography (7). Estimates of latency to sleep onset (time

from "bedtime" to first NREM epoch) and sleep efficiency (total NREM and REM epochs divided by total time in bed) were determined for each participant for each night of sleep.

Night-to-night reliability of both the sleep efficiency and sleep latency measures was acceptable. The intraclass correlation coefficient (ICC) for sleep efficiency across 4 nights ($n = 57$) was 0.75 and for sleep latency, it was 0.62. ICCs were calculated using a two-way random effects model (subjects and nights treated as random effects) for the average measure with the variability across nights included in the denominator (i.e., absolute agreement). Sleep latency and sleep efficiency were of particular interest given previous studies showing that objectively measured sleep latency tends to increase with age whereas sleep efficiency typically declines (6,30,31). Moreover, a recent analysis of sleep/wake actigraphy data from the Coronary Artery Risk Development in Young Adults (CARDIA) study showed that both of these parameters were linked to both income and education, with low SES predicting increased sleep latency and reduced sleep efficiency (31). Finally, increased sleep latency (32) predicted increased mortality in large, population-based studies using subjective sleep ratings. Although we are aware of no studies to date in which the use of the NightCap to assess sleep quality in older adults has been expressly validated, the values obtained for latency to sleep onset and sleep efficiency in the present study were comparable with those reported in a recent meta-analysis of polysomnographic or actigraphic assessments of sleep across the human lifespan (30).

Pittsburgh Sleep Quality Index (PSQI)

The PSQI was included in the self-administered questionnaire packet that participants completed before their GCRC stay. Participants were asked about their sleep habits during the preceding month. The PSQI has 17 items, most of which are rated on a 4-point scale, designed to assess seven components of sleep: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. These items generate a global score with a possible range of 0 to 21. Typically, a global sleep score of >5 indicates significant sleep problems (11). The PSQI has well-established reliability and validity for the assessment of sleep in younger and older adults (11,33,34) and is widely used in clinical research.

Health Assessments

Subjective and objective health status was operationalized using a set of three (3) variables.

Self-Rated Health

As part of the detailed medical interview during the GCRC visit, participants were asked to rate their current overall physical health using a visual 7-point scale (1 = poor; 7 = excellent). This measure has been used in many epidemiological and health investigations and has been found to correlate with respondents' perceptions of their functioning and vitality level as well as current medical conditions and healthcare utilization (35). It also predicts subsequent functional, morbidity, and mortality outcomes (36–39).

Recent Illnesses

During the GCRC medical interview, participants were asked the following question: "In the past 6 months, about how many days, in total, were you sick enough that you did not carry on with your usual activities, such as working around the house or going out for any activities?" This question was used as an indicator of recent health history.

Chronic Illnesses

As part of the GCRC medical interview, participants were asked about histories of chronic disease as well as current disease diagnoses. A continuous variable was then created to indicate the number of chronic conditions that participants reported. This question was used as an indicator of chronic health problems.

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Psychosocial Assessments

Psychosocial dimensions of associations between SES and sleep were probed using two (2) variables: depressive symptoms and neuroticism. These data were obtained from questionnaires completed by the participants 3 to 4 weeks before their visit to the GCRC. Internal consistency assessments (α coefficients) presented below are based on responses from study participants.

Depression

The CES-D (40) was used to assess depressive symptoms. This 20-item instrument (scale range = 0–60) was included among the questionnaires that participants completed in advance of their GCRC visit. Respondents answered each item with regard to how much they had experienced each symptom over the past week ($\alpha = 0.89$).

Neuroticism

Proneness to negative affect was measured using the Neuroticism subscale of the NEO Personality Inventory (41,42). The 12-item scale was included among the self-administered questionnaires, and participants were asked to indicate how strongly they agreed or disagreed with each statement. Response options ranged from 1 (strongly disagree) to 5 (strongly agree). Individuals who score high on the neuroticism scale are sensitive, emotional, and prone to experience upsetting feelings. Those who score low are secure, hardy, and generally relaxed under most conditions, including stressful conditions ($\alpha = 0.86$).

Smoking, Alcohol Use, and Caffeine Intake

Heavy use of tobacco and alcohol is linked to both low SES (43,44) and disrupted sleep (45). Caffeine is also known to interfere with sleep (46). To control for potential confounding effects of these health behaviors on the association of SES and sleep quality, smoking, alcohol use, and caffeine consumption by study participants were determined from the GCRC medical history interview. None of the participants was a current smoker, so current smoking status was not included as a control measure. Almost half ($n = 36$; 46.2%) of the sample had smoked at some time in their lives, and a dummy-coded variable indicating smoking history was included in all multivariate analyses. Participants were asked how many alcoholic drinks (beer, wine, liquor) they consumed on average per day, and this number was included in statistical analyses. Most (56.4%) participants consumed an average of one or fewer alcoholic beverages per day. Thirty-one (39.7%) participants responded that there was a time in their lives when they consumed at least one drink 3 days a week, and this dummy-coded variable was included in statistical analyses. Finally, participants were asked how many caffeinated beverages (coffee, tea, other) they consumed on average per day, and this number was included in statistical analyses. A little over half (51.1%) of the participants reported consuming one or fewer caffeinated drinks per day; the mean for the sample was 1.7 drinks per day.

Statistical Analysis

Associations among SES, sleep parameters, health status, and psychosocial characteristics were examined initially with bivariate analyses. Multivariate linear regression analyses were then used to determine the extent to which the associations between specific SES and sleep variables were confounded by sociodemographic characteristics, health status, and psychosocial characteristics. Variance in participants' means on the NightCap sleep measures varied as a function of the number of nights of data collected. To ensure that less reliable means did not have a disproportionate influence on regression models, each participant's data were weighted by the reciprocal of the SD of multi-night sleep latency or sleep efficiency values, and weighted least squares (WLS) regression models were estimated. Ordinary least squares (OLS) estimates were used for models involving the PSQI variables. An α level of 0.05 was used to determine statistically significant associations. In three instances, data distributions were sufficiently skewed that transformations were warranted. Sleep efficiency data were cubed; sleep latency data were Winsorized; and data on illnesses in the previous 6 months were square-root transformed. Otherwise, data presented herein are untransformed.

RESULTS

Descriptive statistics for the participants are shown in Table 1. The average age of the women in this study was 74 years; they had some college education; and most (55%) were widowed. Significantly, although mean sleep efficiency was high (0.9), almost 55% of the sample had a global score of >5 on the PSQI—typically an indication of significant sleep problems.

Bivariate Analyses

Bivariate associations between subjective and objective sleep measures and between sleep assessments and SES, health, and psychosocial variables were determined. As shown in Table 2, although PSQI global scores were not correlated with any of the NightCap measures, subjective and objective assessments of sleep latency ($r = .36$; $p < .01$) were correlated in the expected directions. Sleep efficiency as determined by the NightCap was also correlated with PSQI sleep latency ($r = -.33$; $p < .01$) and sleep disturbance ($r = -.24$; $p < .05$) scores, but not with the PSQI sleep efficiency component score.

Table 3 shows the associations between sleep measures and SES, health, and psychosocial assessments. As hypothesized, higher SES levels were associated with better objective and subjective sleep quality. More years of education significantly predicted reduced sleep latency ($r = -.32$; $p < .01$) and increased sleep efficiency ($r = .26$; $p < .05$) as assessed by the NightCap and lower PSQI sleep efficiency component scores ($r = -.31$; $p < .01$). Greater pretax household income also significantly predicted reduced sleep latency ($r = -.28$; $p < .01$) and increased sleep efficiency ($r = .28$; $p < .01$) NightCap values and lower global ($r = -.23$; $p < .05$) and sleep efficiency scores ($r = -.26$; $p < .05$) on the PSQI.

Of the health measures, higher subjective health ratings were associated with lower PSQI global scores ($r = -0.31$; $p < .01$) and with the subjective sleep ($r = -.31$; $p < .01$), sleep disturbance ($r = -.31$; $p < .01$), and use of sleeping medication ($r = -.24$; $p < .05$) component scores. Greater number of illnesses within the previous 6 months was associated with reduced objective sleep efficiency ($r = -.33$; $p <$

TABLE 2. Bivariate Correlations Between NightCap Measures and Pittsburgh Sleep Quality Index Component and Global Scores

	Sleep Latency	Sleep Efficiency
PSQI component scores		
Subjective sleep	0.03	-0.18
Sleep latency	0.36**	-0.33**
Sleep duration	-0.02	-0.01
Habitual sleep efficiency	0.05	-0.01
Sleep disturbance	0.14	-0.24*
Use of sleeping medication	0.01	0.01
Daytime dysfunction	-0.01	0.09
Global score	0.15	-0.14

* $p < .05$; ** $p < .01$.

PSQI = Pittsburgh Sleep Quality Index.

TABLE 3. Bivariate Associations of Sleep Parameters, Socioeconomic Indicators, and Health Assessments

	Years of Education	Pretax Household Income	Self-Rated Health (1 = poor; 7 = excellent)	No. Days Sick (Past 6 Months)	No. Chronic Health Conditions	CES-D	Neuroticism
NightCap measures							
Latency to sleep	-0.32**	-0.28**	-0.14	0.19	0.01	0.04	0.10
Sleep efficiency	0.26*	0.28**	0.12	-0.35**	0.10	-0.18	-0.03
PSQI component scores							
Subjective sleep	0.06	-0.09	-0.31**	0.12	0.11	0.07	0.22*
Sleep latency	-0.06	-0.13	-0.18	0.16	0.13	0.16	0.23*
Sleep duration	-0.12	-0.08	-0.12	0.05	0.12	0.17	0.20*
Habitual sleep efficiency	-0.31**	-0.26*	-0.02	-0.01	-0.11	-0.01	0.18
Sleep disturbance	-0.05	-0.10	-0.31**	0.34**	0.20	0.08	0.31**
Use of sleeping medication	0.06	-0.09	-0.24*	0.06	0.23*	-0.11	0.21*
Daytime dysfunction	0.08	-0.19	-0.18	0.28**	0.26*	-0.04	0.29**
PSQI global score	-0.08	-0.23*	-0.31**	0.19	0.20	-0.01	0.37**

* $p < .05$; ** $p < .01$.

No. = number; CES-D = Center for Epidemiological Studies Depression Scale; PSQI = Pittsburgh Sleep Quality Index.

.01) and with higher PSQI sleep disturbance ($r = .34$; $p < .01$) and daytime dysfunction ($r = .28$; $p < .01$) component scores. Chronic health conditions predicted higher scores on the sleeping medication ($r = .23$; $p < .05$) and daytime dysfunction ($r = .26$; $p < .01$) PSQI components. Finally, neuroticism was correlated with all of the PSQI component scores, except sleep efficiency, and with the global scores; neither of the psychosocial measures was associated with any of the NightCap parameters.

Multivariate Analyses

Objective Sleep Assessments

Latency to fall asleep was significantly negatively predicted by years of education, even after controlling for participant age, marital status, medication use, alcohol consumption, smoking, and caffeine intake. This association was unaffected by the addition of health status and psychosocial measures into the regression models (Table 4). The full model accounted for 18% of the variance in sleep latency ($p < .01$). Similarly, greater income significantly predicted reduced sleep latency. This association was preserved after the inclusion of control variables, health status, and psychosocial factors (Table 5).

The full model accounted for approximately 2% of the variance in sleep latency ($p > .05$). None of the control variables was significantly associated with sleep latency (data not shown).

More years of education also significantly predicted greater sleep efficiency even after the inclusion of control variables (Table 6, Model 1). In contrast to sleep latency, however, the association of education and sleep efficiency was significantly attenuated by the inclusion of health status and psychosocial measures into the regression model (Table 6, Model 4). In the full model, which accounted for 23% of the variance in sleep efficiency ($p < .001$), the association of years of education and sleep efficiency was marginally statistically significant ($\beta = 0.21$; $p = .06$).

Finally, greater pretax household income significantly predicted greater sleep efficiency after the inclusion of control variables (Table 7, Model 1). The addition of health status and psychosocial measures (Table 7, Models 2–4) attenuated the association of income and sleep efficiency, but this association remained statistically significant in each model. The full model explained 24% of the variance in sleep efficiency ($p <$

TABLE 4. Multivariate Analysis of NightCap Sleep Latency Regressed on Years of Education. Standardized Regression Coefficients are Shown for Each Analysis

Predictors	Model 1	Model 2	Model 3	Model 4
Years of school completed	-0.45***	-0.44***	-0.46***	-0.50***
Health indicators				
Self-rated health (1 = poor; 7 = excellent)		-0.15		-0.25
Number of days sick (past 6 months)		0.14		0.04
Number of chronic health conditions		-0.14		-0.02
Psychological characteristics				
Depression (CES-D; scale range 0–60)			-0.02	-0.02
Neuroticism (scale range 12–60)			-0.05	-0.21
Adjusted R ² for full model	0.19**	0.18**	0.17**	0.18**

Covariates in all models: age, marital status, medication use, smoking, alcohol and caffeine consumption.

* $p < .05$; ** $p < .01$; *** $p < .001$.

CES-D = Center for Epidemiological Studies Depression Scale.

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TABLE 5. Multivariate Analysis of NightCap Sleep Latency Regressed on Pretax Household Income

Predictors	Model 1	Model 2	Model 3	Model 4
Pretax household income	-0.30*	-0.32*	-0.29*	-0.33*
Health indicators				
Self-rated health (1 = poor; 7 = excellent)		-0.21		-0.26
Number of days sick (past 6 months)		-0.03		-0.02
Number of chronic health conditions		-0.07		-0.06
Psychological characteristics				
Depression (CES-D; scale range 0–60)			-0.01	0.01
Neuroticism (scale range 12–60)			0.05	-0.09
Adjusted R ² for full model	0.08	0.09	0.06	0.06

Standardized regression coefficients are shown for each analysis.

Covariates in all models: age, marital status, medication use, smoking, alcohol and caffeine consumption.

* $p < .05$.

CES-D = Center for Epidemiological Studies Depression Scale.

TABLE 6. Multivariate Analysis of NightCap Sleep Efficiency Regressed on Years of Education. Standardized Regression Coefficients are Shown for Each Analysis

Predictors	Model 1	Model 2	Model 3	Model 4
Years of school completed	0.28*	0.23*	0.24*	0.21
Health indicators				
Self-rated health (1 = poor; 7 = excellent)		0.15		0.13
Number of days sick (past 6 months)		-0.14		0.20
Number of chronic health conditions		0.18		-0.12
Psychosocial measures				
Depression (CES-D; scale range 0–60)			-0.20*	-0.21*
Neuroticism (scale range 12–60)			-0.09	-0.07
Adjusted R ² for full model	0.18**	0.19**	0.22***	0.23***

Covariates in all models: age, marital status, medication use, smoking, alcohol and caffeine consumption.

* $p < .05$; ** $p < .01$; *** $p < .001$.

CES-D = Center for Epidemiological Studies Depression Scale.

TABLE 7. Multivariate Analysis of NightCap Sleep Efficiency Regressed on Pretax Household Income

Predictors	Model 1	Model 2	Model 3	Model 4
Pretax household income	0.30**	0.23*	0.25*	0.26*
Health indicators				
Self-rated health (1 = poor; 7 = excellent)		0.15		0.14
Number of days sick (past 6 months)		-0.19		-0.13
Number of chronic health conditions		0.18		0.24*
Psychosocial measures				
Depression (CES-D; scale range 0–60)			-0.19	-0.20*
Neuroticism (scale range 12–60)			-0.11	-0.08
Adjusted R ² for full model	0.13**	0.16**	0.22***	0.24***

Standardized regression coefficients are shown for each analysis.

Covariates in all models: age, marital status, medication use, smoking, alcohol and caffeine consumption.

* $p < .05$; ** $p < .01$; *** $p < .001$.

CES-D = Center for Epidemiological Studies Depression Scale.

.001). Moreover, although the coefficients for chronic health conditions and CES-D were not statistically significant in Models 2 and 3, respectively, they were statistically significant in the full model, potentially indicating a suppression effect. Of the control variables, alcohol consumption and a history of smoking were both significantly associated with greater sleep efficiency (data not shown).

Subjective Sleep Assessments

Years of education did not predict global PSQI scores in bivariate analyses, and this association was therefore not examined in multivariate analyses.

As shown in Table 8, greater pretax household income significantly predicted lower PSQI global scores (i.e., better sleep quality), even after the inclusion of control variables

TABLE 8. Multivariate Analysis of PSQI Global Scores Regressed on Pretax Household Income

Predictors	Model 1	Model 2	Model 3	Model 4
Pretax household income	-0.31**	-0.27*	-0.21	-0.19
Health indicators				
Self-rated health (1 = poor; 7 = excellent)		-0.20		-0.04
Number of days sick (past 6 months)		0.18		0.18
Number of chronic health conditions		-0.04		-0.03
Psychosocial characteristics				
Depression (CES-D; scale range 0–60)			-0.03	-0.01
Neuroticism (scale range 12–60)			0.35***	0.32**
Adjusted R ² for full model	0.16*	0.20**	0.25**	0.25**

Standardized regression coefficients are shown for each analysis.

Covariates in all models: age, marital status, medication use, smoking, alcohol and caffeine consumption.

* $p < .05$; ** $p < .01$; *** $p < .001$.

CES-D = Center for Epidemiological Studies Depression Scale.

(Table 8, Model 1). The inclusion of health status measures (Table 8, Model 2) and psychosocial factors (Table 8, Model 3) slightly reduced the partial correlation between income and PSQI global scores. Self-rated health (Model 2) and scores on the neuroticism scale (Model 3) specifically seemed to account for these respective effects. The full model with both health status and psychosocial factors included (Table 8, Model 4) explained 25% of the variance in PSQI global scores and also attenuated the association of income and PSQI scores to the point that the partial correlation was not statistically significant. Of the control measures, past frequent alcohol consumption predicted higher PSQI global scores in all models ($p < .01$), and current medication use predicted higher global scores in Model 1 ($p < .05$), but not in subsequent models (data not shown).

The bivariate association between the education and the PSQI sleep efficiency component score was examined further in multivariate analyses. As shown in Table 9, this association persisted after the inclusion of control variables (Table 9, Model 1), health measures (Table 9, Model 2), and psychosocial measures (Table 9, Model 3). The full model (Table 9, Model 4) explained approximately 6% of the variance in PSQI sleep efficiency scores, and this was statistically nonsignifi-

cant. None of the control variables was significantly associated with PSQI sleep efficiency (data not shown).

Multivariate analyses examining the association of income and PSQI sleep efficiency component scores are not shown as they seemed to be redundant with the analyses of PSQI global scores. Moreover, the variance in PSQI global scores explained by the full multivariate model (25%) (Table 8) was significantly greater than the variance accounted for in the full model for sleep efficiency component scores (3%).

DISCUSSION

This study tested the hypothesis that indicators of SES would be positively associated with sleep quality assessed using both subjective and objective measures, and the results strongly supported this hypothesis. Higher pretax household income significantly predicted reduced sleep latency and increased sleep efficiency, determined over the course of multiple nights using the NightCap sleep monitoring system, as well as lower PSQI global scores, an indication of good sleep quality. Similarly, more years of education were associated with reduced sleep latency and increased sleep efficiency and with better subjective ratings of sleep efficiency. Each of these associations persisted after adjustments for potential con-

TABLE 9. Multivariate Analysis of PSQI Habitual Sleep Efficiency Component Score Regressed on Years of Education

Predictors	Model 1	Model 2	Model 3	Model 4
Years of education	-0.32**	-0.30**	-0.30**	-0.26*
Health indicators				
Self-rated health (1 = poor; 7 = excellent)		0.13		0.11
Number of days sick (past 6 months)		0.01		0.01
Number of chronic health conditions		-0.15		-0.14
Psychosocial characteristics				
Depression (CES-D; scale range 0–60)			-0.07	-0.06
Neuroticism (scale range 12–60)			0.07	0.19
Adjusted R ² for full model	0.07	0.06	0.06	0.06

Standardized regression coefficients are shown for each analysis.

Covariates in all models: age, marital status, medication use, smoking, alcohol and caffeine consumption.

* $p < .05$; ** $p < .01$.

CES-D = Center for Epidemiological Studies Depression Scale.

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findings, including age, marital status, medication use, smoking, and use of alcohol, tobacco, or caffeine. These results are consistent with prior research linking SES to both subjective sleep quality (4,5,47) and to actigraphic sleep/wake assessments (31), and they extend this work to include objective sleep assessments using the NightCap.

We also tested the hypothesis that health status and psychosocial characteristics would influence the strength of the associations between SES and sleep quality, and the results offered partial support for this hypothesis. However, the impact of the inclusion of health and psychosocial measures in multivariate analyses varied by both SES indicator and sleep measure.

The links between SES and sleep efficiency, for example, were explained in part by psychosocial measures, particularly depressive symptoms. A potential interpretation of these results is that depression, which is associated with lower SES levels (12), may also be associated with disrupted sleep. Interestingly, the influence of psychosocial measures on the SES-sleep efficiency association was greater for education than for income; the partial correlation between education and sleep efficiency was not significant in the full regression model (Table 6). Thus, to the extent that earlier educational attainment is linked to sleep quality late in life, it may be due to the ways in which education level predicts later health. In contrast, the association between income and sleep efficiency was only modestly reduced by the inclusion of health measures in multivariate analyses and remained statistically significant in the full regression model (Table 7), suggesting that income may have an ongoing relationship to sleep quality over and above the established links between income and health (13,14). That lower CES-D scores and fewer chronic health conditions both significantly predicted greater sleep efficiency in the full model, but not in their respective partial models, and that the coefficient for income in Table 7 was higher in Model 4 than in Models 2 and 3, collectively suggests a complex relationship among income, sleep, health, and psychosocial characteristics in this sample, although the size of the sample precluded in-depth examination of these interactions. Finally, the measures of SES, health, and psychosocial characteristics accounted for 23% (education) and 24% (income) of the variance in sleep efficiency, indicating that these aspects of later life are profoundly associated with sleep quality in this population.

In contrast, inclusion of health status and psychosocial measures in multivariate analyses did not affect the association of either SES indicator with sleep latency. We probed these associations further with measures of financial strain and work outside the home (data not shown), but these additional measures did not add explanatory power to the regression models. Thus, whereas both falling asleep and staying asleep are predicted by indicators of social position, different pathways seem implicated by the two sleep measures. Falling asleep, for example, may be more strongly tied with activities during the day, or rituals (routine practices) for getting to sleep (e.g., reading, watching television). Staying asleep, in con-

trast, may be more closely linked with health problems and psychosocial discomforts that can intrude on sleep.

Global scores on the PSQI were significantly associated with pretax household income, but not with educational attainment. These results parallel those of Moore et al. (5) who found that whereas education was correlated with self-reported sleep quality, this correlation was completely mediated by income. Individuals' educational attainment typically occurs earlier in the life course, and although years of education can have a lasting impact on sleep, health, and well-being, these effects may be mediated by more proximate influences that flow from educational attainment, such as current income or health behaviors and practices. They are also consistent with the larger epidemiological literature documenting a positive association between SES and subjective sleep quality (2–4,47,48). Importantly, however, multivariate analyses showed that the association of SES and PSQI global scores was significantly attenuated by the inclusion of scores on the Neuroticism scale into the regression models. As shown in Table 8 (Model 4), neuroticism scores accounted for a significant portion of the association of self-rated health and PSQI global scores. These results suggest that a modest fraction of the relationship between SES and subjective sleep quality may be attributed to general negative affect that is also graded by social position (18). Additional research with a larger, more diverse sample is needed to bolster this conclusion.

Although PSQI global scores were not associated with years of education, sleep efficiency component scores were associated with both indices of SES. The association of education and PSQI sleep efficiency was not altered by the inclusion of control, health, and psychosocial covariates, although the full model including education and all of the covariates was not statistically significant. Collectively, these results suggest that although education may be significantly associated with subjective and objective sleep quality in later life, there are likely to be more proximate variables, such as current income, health, and psychological state that are more closely linked to sleep quality. Income was also significantly correlated with PSQI sleep efficiency, but whereas the PSQI global score underestimated the association of education and subjective sleep quality, it captured the association of income and subjective sleep quality. In multivariate analyses, the coefficients for the association of PSQI global scores and income were almost identical to the coefficients for the sleep efficiency component scores, and models including the global score accounted for a much larger portion of the variance in sleep quality than did the sleep efficiency component score (full models: 25% for global score versus 3% for sleep efficiency component score (data not shown)).

Comparisons of objective and subjective sleep measures showed that sleep latency component scores were correlated with the equivalent NightCap measure, although sleep efficiency was not correlated with NightCap sleep efficiency (and the latter was associated with PSQI sleep latency and sleep disturbance component scores). Discrepancies between subjective and objective sleep measures are not uncommon

(6,21,31,49,50), although it is more typical that older individuals underreport sleep problems. Given the significant associations of all but one of the PSQI component scores with neuroticism, it seems plausible that at least some portion of the subjective sleep ratings reflected a more general lack of well-being.

The link between SES indices and sleep quality is one part of a larger focus on how SES is linked to health. Social gradients in health are well-established (13,14,51), and sleep is hypothesized to be a potential mediator of the link between SES and health (52). Two large-scale studies have recently tested this hypothesis, but this work utilized only subjective sleep assessments. Moore et al. (5) analyzed data on approximately 1000 men and women from the Detroit Area Study and found that self-reported sleep quality, but not sleep duration, mediated the relationship between income and health. In a study of 3600 Japanese civil servants, Sekine et al. reported that the relationship between occupational status and physical and mental health was substantially weakened when adjusted for PSQI global scores; this finding was true for men, but not for women (4). Given their findings involving subjective sleep assessments, Moore et al. concluded that it is important that analyses of the role of sleep in mediating the SES-health link include objective sleep measures (5). The present study bolsters this earlier work in showing that SES also predicts sleep quality assessed both subjectively and objectively in community-dwelling women. In examining the extent to which sleep quality mediates the association of SES and health, however, longitudinal assessments are critically important given the evidence, such as reported herein, that at single points in time SES, sleep, and health are all interrelated. Only by tracking their cross-time dynamics can rigorous tests of how sleep mediates links between SES and health be conducted.

Although the simultaneous measurements of subjective and objective sleep parameters along with detailed health and psychosocial assessments represent significant strengths of the current study, interpretations of these findings should be tempered given the homogeneity of the sample, its relatively small size, and cross-sectional design. Moreover, the current sample was more educated than the larger sample from which it was drawn, and the reduced variability may have contributed to the lack of an association between education and PSQI global scores. Finally, the 3 to 4 weeks that elapsed between completion of the psychosocial assessments and objective sleep measures may have produced an underestimation of the links between the health status and psychosocial measures and the NightCap sleep parameters. That said, the fact that SES-sleep relationships emerged in this sample, which was also relatively healthy both physically and emotionally (53), suggests that the association of social position and objectively measured sleep parameters may be robust. Future efforts will focus on extending these observations to a larger, more diverse sample and to testing the hypothesis that objective sleep parameters mediate the association of SES and health.

These results join a growing literature on behavioral and biological implications of gradations in social position as well

as the importance of sleep in investigations of how social position may be linked to health outcomes and biological processes related to health. A recent Institute of Medicine Report estimated that 50 to 70 million Americans suffer from a disorder of sleep and wakefulness, but that 80 to 90% of these are undiagnosed (54). Our results and those of others suggest that a larger percentage of these disorders are to be found in low social positions than in high ones. The current findings also suggest that, although subjective sleep reports may reflect in part more general deficits in well-being, there is a robust relationship between SES and objective measures of sleep quality. Given the established links between sleep impairments and increased morbidity and mortality, the need to examine the potential contribution of sleep pathology to social health inequalities is pressing.

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