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Stress and sleep: Results from the Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study



Carmela Alcántara^{a,*}, Sanjay R. Patel^b, Mercedes Carnethon^c, Sheila F. Castañeda^d, Carmen R. Isasi^e, Sonia Davis^f, Alberto R. Ramos^g, Elva Arredondo^d, Susan Redline^h, Phyllis C. Zeeⁱ, Linda C. Gallo^j

^a School of Social Work, Columbia University, 1255 Amsterdam Avenue, Room 810, MC4600, New York, NY 10027, USA

^b Department of Medicine, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

^c Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

^d School of Public Health, San Diego State University, San Diego, CA, USA

^e Albert Einstein College of Medicine, Bronx, NY, USA

^f Department of Biostatistics, University of North Carolina at Chapel Hill- Gillings School of Global Public Health, Chapel Hill, NC, USA

^g University of Miami Miller School of Medicine, Miami, FL, USA

^h Department of Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

ⁱ Department of Neurology, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

^j Department of Psychology, San Diego State University, San Diego, CA, USA

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ABSTRACT

Hispanics/Latinos face specific sociocultural stressors associated with their marginalized status in the United States. While stress is known to cause poor sleep, the differential effects of the specific stressors faced by Hispanics/Latinos have not been evaluated. Using cross-sectional data from the Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study, we conducted weighted generalized linear models to evaluate the associations of acculturation stress, ethnic discrimination, and chronic moderate/severe stress with self-reported sleep outcomes (insomnia symptoms, daytime sleepiness, sleep duration) in individual and aggregate models adjusted for site, socio-demographics, behavioral, and medical conditions. Participants included 5313 Hispanic/Latino adults; 43.5% \geq age 45, 54.8% female, and 22.0% US-born. Chronic moderate/severe stress, ethnic discrimination, and acculturation stress were each positively associated with sleep. In the adjusted aggregate model, only chronic moderate/severe stress was associated with insomnia symptoms ($\exp(b) = 1.07$ for each additional stressor, 95% CI = 1.05, 1.09). Both acculturation stress ($\exp(b) = 1.05$ for each additional SD, 95% CI = 1.02, 1.10) and ethnic discrimination ($\exp(b) = 1.05$ for each additional SD, 95% CI = 1.01, 1.08) were associated with daytime sleepiness. Each SD increase in ethnic discrimination related to a 16% and 13% increased prevalence of short (< 7 h) (RRR = 1.16, 95% CI = 1.02, 1.31) and long sleep duration (> 9 h) (RRR = 1.13, 95% CI = 1.00, 1.27), respectively. These associations were consistent across sex. Acculturation stress and ethnic discrimination are associated with poor sleep in Hispanics/Latinos. Future research should explore whether behavioral sleep interventions minimize the impact of sociocultural stressors on sleep.

Introduction

Annually over 50 million adults in the United States (US) suffer from sleep disturbances such as short sleep duration, insomnia, and daytime sleepiness (Luyster, Strollo, Zee & Walsh, 2012; Sleep Disorders and

Sleep Deprivation, 2006; Unhealthy sleep-related behaviors–12 States, 2009). While acute and chronic stressors have been linked to sleep disturbances (Ross, Ball, Sullivan & Caroff, 1989; Hall et al., 2004; Lewis et al., 2013; Akerstedt, 2006; Kim & Dimsdale, 2007), most sleep research has drawn from non-Hispanic white samples. Further, few

Abbreviations: AHI, apnea-hypopnea index; CES-D, Center for Epidemiological Studies Depression Scale; CI, Confidence Interval; ESS, Epworth Sleepiness Scale; HCHS/SOL, Hispanic Community Health Study/Study of Latinos; HSI, Hispanic Stress Inventory; NREM, Non-rapid eye movement; OR, Odds Ratio; PEDQ-CV, Perceived Ethnic Discrimination Questionnaire – Community Version; RRR, Relative Risk Ratio; SCAS, Sociocultural Ancillary Study; US, United States; VIF, variance inflation factor; WHIIRS, Women's Health Initiative Insomnia Rating Scale; SD, Standard deviation

* Corresponding author.

E-mail address: ca2543@columbia.edu (C. Alcántara).

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studies on stress and sleep have examined how exposure to the various psychosocial and sociocultural stressors (e.g., ethnic discrimination, acculturation stress) faced by Hispanics/Latinos and other marginalized racial/ethnic minority groups affects sleep. Consequently, though stress is known to cause poor sleep, the differential effects of the specific stressors faced by Hispanics/Latinos on sleep have not been evaluated. Knowledge into these factors could inform the development of targeted health promotion campaigns to reduce stress and improve sleep among Hispanics/Latinos.

Scientific support for the adverse association between acute and chronic stress and sleep comes from both prospective and cross-sectional research. For example, some prospective studies documented a direct relationship between acute psychological stress during one night and fragmented sleep on the following night (Hall et al., 2004; Akerstedt, Kecklund & Axelsson, 2007). Additionally, other prospective research found that high chronic stress over a nine-year period predicted both self-reported and objectively-measured sleep disturbances (Hall et al., 2015). Recent research with a cohort of African Americans has also documented a strong and consistent relationship between psychosocial stress and short sleep duration (Johnson et al., 2016). Similarly, other work has found that burnout, work stress, and life stress precede the onset of insomnia in otherwise healthy adults (Healey et al., 1981; Linton, 2004; Morin, Rodrigue & Ivers, 2003; Akerstedt et al., 2015).

While racial/ethnic disparities in poor sleep are well documented (Chen et al., 2015), most explanations for these differences focus on the differential distribution of stress and cumulative disadvantage among racial/ethnic minorities compared to Whites, which in turn heightens the risk for adverse health outcomes and health risk behaviors such as poor sleep (Jackson, Redline & Emmons, 2015). To this end, a small but growing body of cross-sectional research has focused on understanding whether and how exposure to specific psychosocial and sociocultural stressors associated with experiences of marginalization are linked to sleep. Most of this research has evaluated how exposure to racial/ethnic discrimination is associated with poor sleep quality among racial/ethnic minority groups living in the United States. Indeed, a recent systematic review of 17 studies found that measures of discrimination on balance were associated with several indicators of poor sleep in multi-ethnic samples, though the associations were not always consistent (Slopen, Lewis & Williams, 2016). Further, other research has found that discrimination explains some of the White vs. non-White differences in objectively and subjectively measured sleep continuity and quality (Owens, Hunte, Sterkel, Johnson & Johnson-Lawrence, 2017). While the prevalence of reported ethnic discrimination among US Hispanics/Latinos is as high as 78% (Arellano-Morales et al., 2015), few studies have analyzed how ethnic discrimination is associated with Hispanic/Latino sleep (Hicken, Lee, Ailshire, Burgard & Williams, 2013; Steffen & Bowden, 2006; Slopen & Williams, 2014).

Moreover, to our knowledge, no extant studies have explored the association of acculturation stress with sleep in Hispanics/Latinos. Acculturation stress, a psychosocial stressor, refers to the psychological distress/worry associated with the multidimensional process of acculturation (Cervantes, Padilla & Salgado de Snyder, 1991) that is the individual process of adaptation and integration resulting from contact with an unfamiliar culture (Schwartz, Unger, Zamboanga & Szapocznik, 2010; Berry, Chun, Balls Organista & Marín, 2003). Instead, most research has examined whether acculturation proxies, such as nativity status (US-born vs. foreign-born) and language proficiency, are associated with sleep in racial/ethnic communities (Hale, Troxel, Kravitz, Hall & Matthews, 2014; Seicean, Neuhauser, Strohl & Redline, 2011; Heilemann, Choudhury, Kury & Lee, 2012; Hale & Rivero-Fuentes, 2011; Patel et al., 2015). Observed nativity status or language differences in sleep are often attributed to the differential distribution of concentrated stress exposures for US- vs. foreign-born or English vs. non-English speaking adults, but the stress associated with the experience of integrating and adapting to US culture is often not directly

measured or tested.

Acute and chronic stressors may disrupt sleep through psychological and physiological mechanisms. Exposure to stressors and subsequent stress may facilitate the development of perseverative cognitions, specifically rumination and worry about past and future stressors, and the prolonged activation of physiological stress responses that over time increase risk of morbidity and mortality (Ottaviani et al., 2016; Brosschot, Verkuil & Thayer, 2010; Hall et al., 2004). Indeed, a recent meta-analysis found that perseverative cognitions were associated with markers of cardiovascular reactivity and other maladaptive physiological risk profiles (Ottaviani et al., 2016).

Importantly, sex interacts in complex ways to shape exposure to and appraisal of psychosocial stress, as well as the physiological and psychological responses to stress, which in turn influence differential morbidity and mortality profiles across sexes (McEwen, 1998; Myers, 2009; Geronimus, 1992; Gallo & Matthews, 2003; Gallo, Bogart, Vranceanu & Matthews, 2005; Hammen, 2005; Kendler, Kuhn & Prescott, 2004). While some studies find that females report increased exposure to stressful life events compared to males and that this exposure partly accounts for higher rates of mental health conditions such as depression (Hammen, 2005; Kessler & McLeod, 1984; Maciejewski, Prigerson & Mazure, 2001), other studies do not (Kendler, Thornton & Prescott, 2001). With regard to sex differences in sleep, multiple studies document that females are more likely than males to report poor subjective sleep quality, including a higher prevalence of insomnia (Hall et al., 2009; Mezick et al., 2008; Arber, Bote & Meadows, 2009; Armitage & Hoffmann, 2001). Further, research suggests that the differential distribution of health risk factors in males and females do not account for differences in observed sleep profiles (Elovainio et al., 2009), which implies that other factors may account for these differential sex effects. Similar to sex effects, it is possible that gender modifies the appraisal of psychosocial and sociocultural stressors and its effect on sleep quality.

We used cross-sectional data from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) Sociocultural Ancillary Study (SCAS) to: (a) examine the independent association of three different psychosocial and sociocultural stressors (chronic stress, ethnic discrimination, acculturation stress) with self-reported poor sleep (insomnia symptoms, daytime sleepiness, short and long sleep duration) in Hispanics/Latinos; and (b) explore whether sex moderates the stress-sleep association. We hypothesized that each of the psychosocial and sociocultural stressors would be associated with self-reported poor sleep after controlling for potential confounders in individual and aggregate models. We also hypothesized that the association between stress and self-reported poor sleep would be stronger among females than males. Our working conceptual model was that psychosocial and sociocultural stressors would disrupt sleep through psychophysiological mechanisms (e.g., tendency to develop and sustain perseverative cognitions [e.g., rumination], dysregulated stress responses) as described above. Further, the association of stress with self-reported sleep would be stronger among females compared to males because under settings of stress, females are more likely to develop and maintain perseverative cognitions such as rumination, which in turn would lead to greater impairments in sleep quality.

Methods

Data source and sample

The Hispanic Community Health Study/ Study of Latinos (HCHS/SOL) is a community based prospective cohort study of 16,415 self-identified Hispanic/Latino persons (ages 18–74) selected from a two-stage probability sampling design from four US field centers (Chicago, IL; Miami, FL; Bronx, NY; San Diego, CA) with the baseline exam between 2008 and 2011. The goals of the HCHS/SOL are to describe the prevalence and incidence of, and risk and protective factors for, chronic

medical conditions (e.g. cardiovascular disease, diabetes and pulmonary disease). The HCHS/SOL SCAS was conducted to examine socio-cultural correlates of health (for more details see Gallo et al., 2014). Overall, 5313 participants or 72.6% of eligible HCHS/SOL participants were enrolled in SCAS across all four field centers between February 2010 and June 2011. Participants completed 1–2 h in-person interviews where psychosocial assessments were conducted in either English or Spanish (Gallo et al., 2014). Institutional Review Board approvals were obtained from all study sites, and all participants provided written informed consent.

Measures

Sociocultural and psychosocial stressors

Sociocultural and psychosocial stressors were measured in the HCHS/SOL SCAS exam between February 2010 and June 2011. *Acculturation stress* was measured using the abbreviated 17-item Hispanic Stress Inventory (HSI) that measures distress/worry associated with interpersonal, economic, and immigration conflict accompanying the process of adaptation and integration into a new non-native culture within the past three months (Cervantes et al., 1991; Cavazos-Rehg, Zayas, Walker & Fisher, 2006). Each question asks about the presence of a specific conflict (No [0] or Yes [1]), and then the extent of distress/worry associated with each conflict on a 5-point scale, where 1 corresponds to “not at all worried/tense” and 5 corresponds to “extremely worried/tense.” Responses were summed to compute a total score. *Ethnic discrimination* was measured with the 17-item Brief Perceived Ethnic Discrimination Questionnaire – Community Version (Brief PEDQ-CV) (Brondolo et al., 2005). The Brief PEDQ-CV measures exposure to four different types of ethnic discrimination: exclusion/rejection, stigmatization, discrimination at work/school, and threat aggression. Each question is scored on a 5-point scale, where 1 corresponds to “never happened” and 5 corresponds to “happened very often.” Responses to the 17 items were summed and a total score across the four types of ethnic discrimination was generated. *Chronic moderate/severe stress* was measured with an 8-item instrument that assesses exposure and extent of psychological stress that spans for at least six months or more across multiple life domains, including work, relationships, finances, personal or family health problems (Bromberger & Matthews, 1996). A summary score was generated that refers to a count of total number of stressors with a minimum of six months duration and self-endorsed moderately stressful to very stressful distress.

Sleep

Self-report questionnaires were used to measure sleep at the baseline HCHS/SOL examination between 2008 and 2011. *Insomnia* was measured at baseline using the Women’s Health Initiative Insomnia Rating Scale (WHIIRS) (Levine et al., 2003). The WHIIRS is a 5-item questionnaire that asks respondents to rate how frequently they experience difficulty with sleep initiation and maintenance over the past four weeks. Each question is scored on a 5-point scale (0 to 4), where 0 corresponds to “no, not in the past 4 weeks” and 4 corresponds to “yes, 5 or more times a week.” Scores range from 0 to 20. WHIIRS scores ≥ 10 were considered clinically significant insomnia. *Daytime sleepiness* was measured at baseline using the Epworth Sleepiness Scale (ESS) (Johns, 1991). The ESS is an 8-item questionnaire that asks respondents to rate their likelihood of falling asleep in eight different contexts. Each question is rated on a 4-point scale (0–3); scores range from 0–24. Excessive daytime sleepiness was defined as an ESS score > 10 . *Sleep duration* at baseline was calculated from self-report based on responses to two items that inquired about the average weekday bedtime and wake time. Self-reported sleep duration at baseline was categorized a priori as short (< 7 h), average (7–9 h), and long (> 9 h) sleep duration based on previous research (Cappuccio, Cooper, D’Elia, Strazzullo & Miller, 2011).

Covariates

Socio-demographics were collected at the baseline HCHS/SOL exam between 2008 and 2011. Age (< 45 or ≥ 45 years), sex (male, female), Hispanic/Latino ancestry (Central American, Cuban, Dominican, Mexican, Puerto Rican, South American, more than one), annual household income ($< \$30,000$ or $\geq \$30,000$), nativity status (born in US mainland, immigrated ≥ 10 years, immigrated < 10 years), and education (less than high school, high school or beyond) were all self-reported. *Medical Conditions* were derived from the baseline HCHS/SOL examination. Hypertension was defined as a systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg, or use of anti-hypertensive medication (Chobanian, Bakris, Black, Cushman, Green & Izzo, 2003). Diabetes mellitus was defined as a fasting plasma glucose ≥ 126 mg/dL, 2-h postload plasma glucose ≥ 200 mg/dL, HbA1c $\geq 6.5\%$, or use of hypoglycemic medications (Diagnosis and classification of diabetes mellitus, 2010). Prevalent coronary heart disease was defined as a physician diagnosis of heart attack or history of coronary artery bypass surgery, balloon angioplasty, or stent placement in one or more coronary arteries based on self-report (Davignus et al., 2012). Obstructive lung disease was based on a forced expiratory volume in one second to forced vital capacity ratio less than 0.70 (Barr et al., 2016). At baseline, participants underwent limited channel sleep apnea monitoring at home using the ARES Unicorder 5.2 (B-Alert, Carlsbad, CA) (Westbrook et al., 2005). The use of this device and the process for centralized scoring in HCHS/SOL have been described elsewhere (Redline et al., 2014). Respiratory events, identified based on a 50% or greater reduction in airflow lasting 10s or more and associated with a 3% oxyhemoglobin desaturation, were used to compute the apnea-hypopnea index (AHI). AHI ≥ 15 /h was used to denote moderate or more severe obstructive sleep apnea. *Health Behaviors* were ascertained at the baseline HCHS/SOL examination. Alcohol use (never, former, current) and cigarette use (never, former, current) were derived from self-report. Body mass index (BMI) was calculated from baseline height and weight collected at the baseline HCHS/SOL examination. Depressive symptoms were measured with the 10-item version of the Center for Epidemiologic Studies Depression scale (CES-D10) at the HCHS/SOL SCAS examination between February 2010 and June 2011. The CES-D10 asks respondents to rate how often in the past-week they have experienced depressive symptoms on a 4-point scale (0–3) (Radloff, 1977; Kohout, Berkman, Evans & Cornoni-Huntley, 1993; Irwin, Artin & Oxman, 1999). Responses were summed to generate a total score.

Analyses

Analyses were weighted to adjust for disproportionate selection probabilities into HCHS/SOL and SCAS, and to adjust for bias due to differential nonresponse at the household and person levels (Lavange et al., 2010; Sorlie et al., 2010). All analyses accounted for cluster sampling and the use of stratification in sample selection. Estimates are applicable to the study target population, defined as Hispanics/Latinos, ages 18–74 years, living in the four study communities.

Of the 5313 participants, only 3673 had complete data for all exposures, outcomes, and covariates; 30.9% had missing data for income and apnea-hypopnea index (AHI). We used multiple imputation by chained equations (20 imputed datasets) to address missing data. Interaction terms were created before imputation and included in the imputation model. Design variables were also included in the imputation model as regular variables. We used an augmented regression approach to address instances of perfect prediction. Results across the imputed datasets were combined using Rubin’s combining rules (Rubin, 1987). All of the analyses were conducted in STATA v.12. (Stata Corporation, 2011).

We estimated descriptive statistics for the overall sample and report unweighted Ns and weighted percentages. Acculturation stress and ethnic discrimination measures were transformed to z-scores to

facilitate comparisons across stressor types. To confirm that there were no extreme interrelations among the primary independent variables (ethnic discrimination, acculturation stress, chronic moderate/severe stress) a formal test of multicollinearity was performed with the unweighted data. The variance inflation factor (VIF) for each of the predictors was well below 10 (range = 1.14 – 1.22), which implies that the three stress exposures can be examined in the same model. Further, the unweighted Pearson's correlations among the three stress exposures ranged between $r = .30$ – $.40$. Given the skewed nature of the continuous sleep outcomes (i.e., insomnia, sleepiness) toward lower values, we estimated generalized linear models with a gamma distribution and a log link. The exponentiated coefficients for these models have a multiplicative interpretation (Faraway, 2006). We conducted either weighted generalized linear models or weighted multinomial logistic regressions (dependent on the outcome) to evaluate the association of each stressor with sleep outcomes in individual and aggregate models with three progressive levels of adjustment: model 1 adjusted for study site, age, sex, Hispanic/Latino background group, nativity status, household income, and education; model 2 additionally adjusted for body mass index, hypertension, cardiovascular disease, obstructive lung disease, diabetes mellitus, alcohol use, cigarette smoking, and obstructive sleep apnea; and model 3 additionally adjusted for depressive symptoms. Individual models evaluated the association of each stressor separately with the sleep outcomes. The aggregate models included all stress exposures in the same model.

We also conducted six supplemental analyses. First, we re-ran our analyses treating insomnia as a dichotomous outcome variable (WHIIRS ≥ 10). Second, we re-ran our analyses treating daytime sleepiness as a dichotomous outcome variable (ESS > 10). Third, we included an adjustment for employment status in the models that evaluated the association of stress with sleep duration. Fourth, we tested whether the relationship between stress and sleep was modified by sex using interaction terms. Fifth, we conducted a sensitivity analysis using the non-imputed (raw) data from participants with complete data ($n = 3673$). Estimates from models using complete cases did not differ appreciably from those using the imputed data. We present results from the imputed analyses below. Sixth, we computed a modified CES-D score that removed the sleep item (“My sleep was restless”) from the total score, and reran the final models using the modified CES-D score.

Results

Table 1 presents the weighted demographic characteristics and descriptive statistics (10th imputation). The estimated ancestry distribution across the four field centers was: 7.6% Central American, 20.3% Cuban, 11.7% Dominican, 36.5% Mexican, 15.7% Puerto Rican, 4.8% South American, and 3.3% more than one. Overall, 43.5% were age 45 years or older, 54.9% were female, 71.1% had a household yearly income of less than \$30,000, and 22.0% were US-born (mainland). Most participants completed the SCAS exam within four (72.3%) or six months (88.3%) of the baseline HCHS/SOL exam. Weighted mean acculturation stress, ethnic discrimination, and chronic moderate/severe stress scores were, 13.39 ($SE = 0.31$), 25.10 ($SE = 0.20$), and 1.23 ($SE = 0.03$), respectively. Weighted mean WHIIRS score ($M = 6.93$, $SE = 0.12$) and weighted ESS score ($M = 5.59$, $SE = 0.10$) were below clinically significant cut-offs for insomnia and excessive daytime sleepiness. Weighted mean sleep duration was 8.01 h ($SE = 0.03$).

Stress and insomnia

In individual models, 1SD increases in acculturation stress ($\exp(b) = 1.14$, 95% CI = 1.11, 1.18) and ethnic discrimination ($\exp(b) = 1.12$, 95% CI = 1.08, 1.15), and a 1 unit increase in chronic moderate/severe stress ($\exp(b) = 1.12$, 95% CI = 1.11, 1.14) were each associated with higher insomnia symptom scores in models adjusting for site, socio-demographics, medical conditions, and health behaviors (Table 2).

Table 1

Weighted Demographic Characteristics, Covariates, Sleep Outcomes, and Psychosocial/Sociocultural Stressors in the Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study (N = 5313).

Variable	All Sites	
	(N = 5313)	
Sample Demographic Characteristics ^a	N	%
Age 45 or older	3278	43.54
Female	3299	54.85
<i>Hispanic Ancestry</i>		
Central American	554	7.60
Cuban	776	20.32
Dominican	534	11.69
Mexican	2080	36.53
Puerto Rican	880	15.75
South American	352	4.80
More than one	137	3.31
<i>Household yearly income</i>		
less than \$30,000	3877	71.14
<i>Nativity</i>		
born in the US mainland	919	21.96
immigrated ≥ 10 years	3143	50.88
immigrated < 10 years	1251	27.16
<i>Educational attainment</i>		
less than high school	1927	32.53
<i>Health Behaviors and Medical Conditions</i>		
Hypertension (yes)	1541	24.26
Cardiovascular Disease (yes)	348	5.60
Diabetes Mellitus (yes)	1079	16.0
Lung Disease (yes)	507	10.73
<i>Alcohol Use</i>		
Never	1106	19.99
Former	1752	30.42
Current	2455	49.59
<i>Cigarette Use</i>		
Never	3244	61.27
Former	1095	18.08
Current	974	20.65
Obstructive Sleep Apnea (AHI ≥ 15)	626	10.31
Insomnia WHIIRS ≥ 10	1718	29.83
Sleepiness ESS > 10	815	15.04
<i>Health Behaviors</i>	M	SE
Body Mass Index (BMI)	29.64	0.15
Depressive Symptoms (CES-D)	7.88	0.13
<i>Sleep Indicators</i>	M	SE
Insomnia symptoms	6.93	0.12
Sleepiness symptoms	5.59	0.10
Sleep duration	8.01	0.03
<i>Stressors</i>	M	SD
Acculturation stress	13.39	0.31
Ethnic discrimination	25.10	0.20
Chronic stress	1.23	0.03

AHI = apnea hypopnea index; WHIIRS = Women's Health Initiative Insomnia Rating Scale; ESS = Epworth Sleepiness Scale; CES-D = Center for Epidemiological Studies Depression Scale

^a Note: unweighted Ns, weighted %, unless otherwise noted.

These estimates were attenuated but remained statistically significant after additional adjustment for depressive symptoms. In aggregate models (all three stress exposures entered simultaneously) adjusting for site, socio-demographics, medical conditions, and health behaviors, each stress exposure continued to be associated with higher insomnia symptom scores, though the estimates were attenuated. After final adjustment for depressive symptoms, only chronic moderate/severe stress remained significantly and independently associated with insomnia symptoms, such that a 1 unit increase in reported chronic/moderate severe stress was independently associated with 7% greater insomnia symptom scores ($\exp(b) = 1.07$, 95% CI = 1.05, 1.09). Similarly, each unit increase in reported chronic moderate/severe stress was associated

Table 2

Results of Multivariable Analysis of Association of Psychosocial/Sociocultural Stressors with Insomnia Symptom Scores: Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study (N = 5313).

	Model 1 ^c Exp (b) (95% CI)	Model 2 ^d Exp (b) (95% CI)	Model 3 ^e Exp (b) (95% CI)
<i>Individual Models^a</i>			
Acculturation stress	1.15 ^{***} (1.11, 1.18)	1.14 ^{***} (1.11, 1.18)	1.07 ^{***} (1.04, 1.11)
Ethnic discrimination	1.12 ^{***} (1.09, 1.16)	1.12 ^{***} (1.08, 1.15)	1.07 ^{***} (1.03, 1.10)
Chronic stress	1.13 ^{***} (1.11, 1.15)	1.12 ^{***} (1.11, 1.14)	1.08 ^{***} (1.06, 1.10)
<i>Aggregate Models^b</i>			
Acculturation stress		1.06 ^{**} (1.03, 1.10)	1.03 (0.99, 1.07)
Ethnic discrimination		1.04 [†] (1.01, 1.08)	1.03 (1.00, 1.07)
Chronic stress		1.10 ^{***} (1.08, 1.12)	1.07 ^{***} (1.05, 1.09)

Note. Acculturation stress and ethnic discrimination were transformed into z-scores. 95% CI = 95% confidence interval.

- * $p < .05$,
- ** $p < .01$,
- *** $p < .001$

^a Stressors tested in individual models.

^b Stressors tested in a single model.

^c Model 1 adjusts for study site, age, gender, and Hispanic/Latino background group, nativity status, income, education

^d Model 2 adjusts for Model 1 + body mass index, hypertension, cardiovascular disease, lung disease, diabetes mellitus, alcohol use, cigarette smoking, apnea-hypopnea index (AHI) > =15

^e Model 3 adjusts for Model 2 + depressive symptoms

with a 22% increase in the odds of insomnia (WHIIRS ≥ 10) in aggregate models that adjusted for all covariates (Supplemental Table 1). In sensitivity analyses using the modified CES-D score, the estimates associated with each of the stress variables and insomnia were modestly attenuated in each of the individual models compared to estimates with the total CES-D score, though the estimates remained statistically significant and in the same direction. In the aggregate models, acculturation stress was now statistically associated with insomnia, (in addition to chronic stress), though again the estimates were of similar magnitude and in the same direction as with the total CES-D score (Supplemental Table 4).

Stress and daytime sleepiness

In individual models, 1SD increases in acculturation stress (exp(b) = 1.07, 95% CI = 1.03, 1.11), ethnic discrimination (exp(b) = 1.07, 95% CI = 1.04, 1.10), and a 1 unit increase in reported chronic moderate/severe stress (exp(b) = 1.03, 95% CI = 1.01, 1.05) were each associated with higher daytime sleepiness symptom scores in the adjusted models (Table 3). Once all three stress exposures were entered simultaneously, the estimates associated with acculturation stress (exp (b) = 1.06, 95% CI = 1.02, 1.10) and ethnic discrimination (exp(b) = 1.05, 95% CI = 1.01, 1.08) remained statistically significant, while the estimate for chronic stress was only marginally significant. These estimates were unchanged after final adjustment for depressive symptoms. Similarly, each 1SD increase in ethnic discrimination was associated with a 14% increase in the odds of the binary outcome, excessive daytime sleepiness (ESS > 10), in final adjusted aggregate models (Supplemental Table 2). In sensitivity analyses using the modified CES-D score, the estimates associated with each of the stress variables and sleepiness remained statistically significant and in the same direction, though modestly attenuated compared to results using the original CES-D score (Supplemental Table 4).

Table 3

Results of Multivariable Analysis of Association of Psychosocial/Sociocultural Stressors with Sleepiness Symptom Scores: Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study (N = 5313).

	Model 1 ^c Exp (b) (95% CI)	Model 2 ^d Exp(b) (95% CI)	Model 4 ^e Exp(b) (95% CI)
<i>Individual Models^a</i>			
Acculturation stress	1.10 ^{***} (1.07, 1.14)	1.10 ^{***} (1.06, 1.13)	1.07 ^{***} (1.03, 1.11)
Ethnic discrimination	1.09 ^{***} (1.06, 1.13)	1.08 ^{***} (1.05, 1.12)	1.07 ^{***} (1.04, 1.10)
Chronic stress	1.05 ^{***} (1.03, 1.08)	1.05 ^{***} (1.02, 1.07)	1.03 [†] (1.01, 1.05)
<i>Aggregate Models^b</i>			
Acculturation stress		1.06 ^{**} (1.02, 1.10)	1.05 [†] (1.01, 1.09)
Ethnic discrimination		1.05 ^{**} (1.01, 1.08)	1.05 ^{**} (1.01, 1.08)
Chronic stress		1.02 (1.00, 1.05)	1.01 (0.99, 1.04)

Note. Acculturation stress and ethnic discrimination were transformed into z-scores. 95% CI = 95% confidence interval.

- * $p < .05$,
- ** $p < .01$,
- *** $p < .001$

^a Stressors tested in individual models.

^b Stressors tested in a single model.

^c Model 1 adjusts for study site, age, gender, and Hispanic/Latino background group, nativity status, income, education

^d Model 2 adjusts for Model 1 + body mass index, hypertension, cardiovascular disease, lung disease, diabetes mellitus, alcohol use, cigarette smoking, apnea-hypopnea index (AHI) > =15

^e Model 3 adjusts for Model 2 + depressive symptoms

Stress and sleep duration

In both individual and aggregate models, only ethnic discrimination was associated with sleep duration (Table 4). In individual models, a 1 SD increase in the total ethnic discrimination score was associated with a 14% increased prevalence of short sleep duration compared to average sleep duration (RRR = 1.14, 95% CI = 1.04, 1.26) after adjustment for site, socio-demographics, medical conditions, and health behaviors. This estimate did not change appreciably after further adjustment for depressive symptoms. In aggregate models including all three stress exposures, ethnic discrimination was associated with both short and long sleep duration. Specifically, a 1 SD increase in total ethnic discrimination score was both associated with a 16% increase in the prevalence of short sleep duration (RRR = 1.16, 95% CI = 1.02, 1.31) and with a 13% increase in the prevalence of long sleep duration (RRR = 1.13, 95% CI = 1.00, 1.27) compared to average sleep duration. The RRRs for the association of discrimination stress with short sleep duration and long sleep duration did not change appreciably with additional adjustment for employment status (Supplemental Table 3). In sensitivity analyses, the short and long sleep duration estimates associated with ethnic discrimination were slightly strengthened in aggregate models using the modified CES-D score compared to the model using the original CES-D score (Supplemental Table 4).

Sex effects

Effect modification by sex was assessed by adding a sex * stress interaction term into each of the above final models. In none of these models did the sex * stress term reach statistical significance at a $p < 0.05$ or $p < .10$ threshold.

Discussion

Overall, our results provide evidence that sociocultural stressors, namely ethnic discrimination and acculturation stress, in addition to

Table 4
Results of Multivariable Analysis of Association of Psychosocial/Sociocultural Stressors with Sleep Duration Categories: Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study (N = 5313).

	Short sleep duration (< 7 h) versus average sleep duration (7–9 h)			Long sleep duration (> 9 h) versus average sleep duration (7–9 h)		
	Model 1 ^c	Model 2 ^d	Model 3 ^e	Model 1 ^c	Model 2 ^d	Model 3 ^e
	RRR (95%CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
<i>Individual Models^a</i>						
Acculturation stress	1.03 (0.92, 1.14)	1.01 (0.91, 1.12)	0.99 (0.88, 1.11)	1.02 (0.91, 1.13)	1.01 (0.91, 1.13)	0.99 (0.88, 1.11)
Ethnic discrimination	1.16 ^{**} (1.05, 1.29)	1.14 ^{**} (1.04, 1.26)	1.13 [*] (1.02, 1.26)	1.11 (0.99, 1.24)	1.12 (1.00, 1.24)	1.11 (0.99, 1.24)
Chronic stress	1.08 [*] (1.01, 1.15)	1.05 (0.99, 1.12)	1.05 (0.97, 1.13)	1.02 (0.95, 1.10)	1.02 (0.95, 1.10)	1.00 (0.92, 1.09)
<i>Aggregate Models^b</i>						
Acculturation stress		0.93 (0.81, 1.06)	0.92 (0.80, 1.06)		0.96 (0.85, 1.08)	0.94 (0.84, 1.07)
Ethnic discrimination		1.16 [*] (1.02, 1.31)	1.16 [*] (1.02, 1.31)		1.14 [*] (1.01, 1.28)	1.13 [*] (1.00, 1.27)
Chronic stress		1.04 (0.97, 1.12)	1.04 (0.96, 1.12)		1.01 (0.93, 1.09)	1.00 (0.92, 1.08)

Note. Acculturation stress and ethnic discrimination were transformed into z-scores. 95% CI = 95% confidence interval. RRR = relative risk ratio.

* $p < .05$,
 ** $p < .01$,
^a Stressors tested in individual models.
^b Stressors tested in a single model.
^c Model 1 adjusts for study site, age, gender, and Hispanic/Latino background group, nativity status, income, education
^d Model 2 adjusts for Model 1 + body mass index, hypertension, cardiovascular disease, lung disease, diabetes mellitus, alcohol use, cigarette smoking, apnea-hypopnea index (AHI) > =15
^e Model 3 adjusts for Model 2 + depressive symptoms

chronic psychosocial stress, are independently and differentially associated with adverse sleep outcomes in a large diverse sample of Hispanics/Latinos. In aggregate models (all three stress exposures entered simultaneously) that adjusted for a wide range of potential confounders including negative affect, only chronic moderate/severe psychosocial stress was associated with insomnia symptoms. In contrast, sociocultural stressors, namely ethnic discrimination and acculturation stress severity were associated with greater daytime sleepiness. Similarly, greater ethnic discrimination scores were associated with a higher prevalence of short (< 7 h) and long sleep duration (> 9 h) in the final adjusted aggregate models. Notably, we did not find evidence that sex moderated the stress-sleep association: the direction and magnitude of these associations were similar in Hispanic/Latino males and females.

Consistent with previous research (Hall et al., 2015; Morin et al., 2003; Slopen et al., 2016; Smagula, Stone, Fabio & Cauley, 2016), we found evidence that all three stressors were associated with insomnia symptoms. However, only the measure of cumulative chronic stress burden, operationalized as the total number of stressors rated as moderately or severely distressing and lasting at least six months, had an independent and consistent adverse association with insomnia symptoms after adjustment for affective bias operationalized as depressive symptoms. The chronic stress burden measure used captured both the duration and intensity of the stressor, whereas the measures of ethnic discrimination and acculturation stress did not assess for the intensity

of these stressors. Thus, affirmative responses of ethnic discrimination and acculturation stress may have reflected experiences that were too transient to engender chronic insomnia symptoms. As such, future research on sociocultural stressors and insomnia should assess the duration and intensity of these stressors vis-à-vis the psychophysiology of insomnia (Riemann et al., 2010). Relatedly, the high co-occurrence of insomnia and depression and demonstrated bidirectional rather than unidirectional relationship (Alvaro, Roberts & Harris, 2013) may also have contributed to the loss of statistical significance observed when depressive symptoms were added to the aggregate models. Indeed, though the sociocultural stressors were no longer statistically associated with insomnia, the direction and magnitude of the parameter estimates for the sociocultural stressors did not change appreciably. It is also possible that the association of sociocultural stress (e.g., ethnic discrimination) with insomnia severity differs by level of depressive symptoms. For example, prior studies have shown that ethnic discrimination is prospectively associated with depressive symptoms among Latinos (Torres & Ong, 2010). Future research adequately powered to explore this three-way interaction would help illuminate these associations.

While the weighted average of self-reported sleep duration in this sample was 8.01 h, which is considered “healthy” or average sleep (Luyster et al., 2012), our results indicated that greater exposure to ethnic discrimination in Hispanics/Latinos was positively associated with a higher prevalence of both self-reported short (< 7 h) and long (> 9 h) sleep duration independent of socio-demographics, concurrent stressors, depressive symptoms, health risk behaviors, and medical confounders—a finding consistent with previous literature (Lewis et al., 2013; Slopen et al., 2016; Slopen & Williams, 2014; Yang & Park, 2015). Importantly, these results did not change after adjustment for employment status. These findings may reflect the consequences of ethnic discrimination on important health decisions such as sleep time and wake time. For example, exposure to ethnic discrimination may facilitate the development and perpetuation of preservative cognitions (worry or rumination) about past or future experiences of ethnic discrimination (Hicken et al., 2013). Worry or rumination about ethnic discrimination while in bed may be a maladaptive coping strategy that promotes excessive time in bed (long sleep duration). Qualitative research to identify explanatory models of short and long sleep duration across racial/ethnic minorities, including its perceived causes and patient-preferred treatment strategies, would further intervention science to reduce racial/ethnic disparities in sleep. Alternatively, the association of ethnic discrimination with sleep duration may reflect a third variable that could also limit the opportunity for sleep such as living in adverse neighborhood structural conditions (e.g., neighborhood noise levels) or exposure to adverse occupational factors such as night shift work or job strain. Additional research with comprehensive assessments of industrial and occupational factors would help illuminate the specific work or job related factors that strengthen or weaken the stress-sleep duration association (Jackson, Redline, Kawachi, Williams & Hu, 2013).

We also found that increases in ethnic discrimination and acculturation stress were both associated with greater daytime sleepiness scores in aggregate models, and that this estimate did not change after final adjustment for socio-demographics, other concurrent stressors, and important medical and behavioral confounders. Of note, in supplemental analyses (not reported) that additionally adjusted for sleep duration, ethnic discrimination (exp(b)=1.05, 95% CI = 1.01, 1.08) and acculturation stress (exp(b) = 1.05, 95% CI = 1.00, 1.09) remained significantly associated with daytime sleepiness. As such, these findings do not reflect inadequate sleep quantity. The relationship among exposure to ethnic discrimination, acculturation stress, and daytime sleepiness may be due to a third variable. For example, exposure to ethnic discrimination and acculturation stress may reflect employment conditions such as nighttime shiftwork or occupations (e.g., professional managerial positions, manufacturing) that may result in inadequate timing of sleep secondary to shiftwork or work stress and

greater napping throughout the day or as a strategy to cope with these sociocultural stressors that would influence the subjective experience of daytime sleepiness. The association of these sociocultural stressors and daytime sleepiness may also reflect disturbed sleep architecture (e.g., lack of stage 3 NREM “restorative” sleep) in the presence of these stressors. Future research using polysomnography to assess sleep architecture, in tandem with multiple assessments of sociocultural stressors, and a comprehensive assessment of occupational and employment conditions would help clarify whether the observed associations with daytime sleepiness are due to abnormalities in sleep architecture in the context of sociocultural stress, and under what employment and occupational conditions.

Previous research on Hispanic/Latino sleep health has used acculturation proxies such as nativity status, language proficiency, and duration in the United States to assess the relationship of acculturation with sleep. To our knowledge, this is the first study to directly test the association of acculturation stress with sleep disturbances in a sample of US- and foreign-born Hispanic/Latinos. These findings provide initial cross-sectional evidence of the potential adverse impact of acute acculturation stress on sleep for Hispanics/Latinos regardless of nativity status. It may be that it is the extent of acute stress experienced by the process—not the level—of acculturation that is most proximally tied to sleep. Future research should continue to unpack the linkages among acculturation, acculturation stress, and sleep through the identification and measurement of specific behavioral acculturation domains that are conceptually and physiologically linked to sleep outcomes.

Although previous research has found sex differences in the prevalence of sleep disturbances and stress appraisals (Hammen, 2005; Kendler et al., 2001; Arber et al., 2009; Armitage & Hoffmann, 2001), our exploratory analyses did not find evidence that sex moderated the association of stress with sleep. It is possible that another variable acting on the same causal pathway is necessary to observe effect modification by sex (i.e., three-way interaction) or that we were not adequately powered to detect a significant interaction.

Limitations

Our study has several limitations. First, this was a cross-sectional study; we are unable to assess causality or directionality. It is possible that sleep disturbances influenced the experience and appraisal of stress; relatedly, these relationships may be bidirectional. Second, assessment of both stress and sleep (other than sleep apnea) were based on self-reported measures and assessed at one time point. Future research should use prospective designs and multi-method assessments of sleep, including actigraphy to assess habitual sleep, and ecological momentary assessments of stress (including type, intensity, and frequency) to better disentangle the moment-to-moment and temporal associations among psychosocial and sociocultural stressors and sleep health in racial/ethnic minority groups. Third, we observed small effect sizes, though these estimates were comparable to other studies on in this area (Akerstedt et al., 2015; Slopen & Williams, 2014). Fourth, these findings may not generalize to Hispanics/Latinos from other ancestry groups and/or rural regions.

Conclusion

Racial/ethnic minorities, such as Hispanics/Latinos, face specific sociocultural stressors associated with their marginalized statuses in the United States. In one of the first studies to examine the cumulative effect of multiple and disparate stressors on sleep in over 5000 Hispanic/Latino adults from diverse background groups and four US cities, we found that both chronic psychosocial stress and understudied sociocultural stressors, namely ethnic discrimination and acculturation stress, were associated with self-reported poor sleep; these associations were consistent across Hispanic males and females. Increases in chronic stress were associated with greater insomnia symptoms, whereas

increases in ethnic discrimination and acculturation stress were most consistently associated with greater daytime sleepiness symptoms, and increases in the prevalence of short sleep duration (< 7 h) as well as long sleep duration (> 9 h) after adjustment for important confounders, including affective bias (i.e., depressive symptoms). If these results are replicated, these findings could be used to inform the development or refinement of psychosocial and behavioral interventions to reduce stress and improve poor sleep among Hispanics, one of the fastest growing segments of the US population. For example, cognitive behavioral interventions for insomnia, the first line of treatment for chronic insomnia, tailored for Hispanics/Latinos may benefit from adjunctive components that target not just coping with nonspecific chronic psychosocial stress, but also adaptive coping with sociocultural stressors such as acculturation stress and ethnic discrimination. Our findings also suggest that psychosocial or behavioral interventions that target the extension or shortening of problematic sleep duration patterns in Hispanic/Latino adults may also benefit from considering components that address adaptive coping with ethnic discrimination and acculturation stress, two timely and important issues given the current sociopolitical climate and the rapidly changing demography of the United States.

Ethics approval

Institutional Review Board (IRB) approvals were obtained from all study sites (San Diego State University, Albert Einstein College of Medicine University of Miami Miller School of Medicine, Northwestern University Feinberg School of Medicine), and all participants provided written informed consent.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.ssmph.2017.08.004>.

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