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The association of neighborhood characteristics with sleep duration and daytime sleepiness

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Abstract

Background—Neighborhood characteristics have been linked to health outcomes. Various mechanisms link neighborhoods and health outcomes; sleep patterns may be 1 contributor; however, little is known about the social determinants of disordered sleep. We examined the association of neighborhood characteristics with sleep duration and daytime sleepiness.

Methods—Participants (n = 801) enrolled as pairs (55 without pair), from 10 churches in the Stroke Health and Risk Education project; 760 were included for analysis (41 withdrew). Sleep duration (hours of sleep at night) and daytime sleepiness (adaptation of Berlin questionnaire; range, 0–3 [more daytime sleepiness]) were self-reported. Neighborhood characteristics included disadvantage, per capita violent crime (census tract level), and safety (self-reported and individual level). We fit generalized linear mixed models and multinomial and binomial logistic regression models to examine the associations between neighborhood characteristics and sleep outcomes while accounting for the clustering within churches and pairs, before and after adjustment for self-reported confounders (age, gender, income, education, body mass index, depressive symptoms, hypertension, and diabetes).

Results—The mean hours of sleep duration is 6.7 ± 1.2 , and the mean daytime sleepiness is 0.8 ± 0.9 . Neighborhood characteristics were not associated with sleep duration. Higher perceived

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neighborhood safety was associated with an 18.4% lower odds of daytime sleepiness in the unadjusted model (odds ratio, 0.82 [95% confidence interval, 0.69–0.96]). The association was attenuated in the fully adjusted model. Neighborhood disadvantage and violent crime were related to lower daytime sleepiness; however, associations were not statistically significant.

Conclusion—Self-reported neighborhood safety was associated with lower daytime sleepiness. Future exploration of the pathways linking neighborhood characteristics and sleep is warranted.

Keywords

Sleep duration; Daytime sleepiness; Neighborhood; Ethnicity

Introduction

Neighborhood characteristics, including social, economic, and physical features, have been linked to mental health (depressive symptoms) and general health status as well as to specific outcomes including cardiovascular-related end points.^{1–5} Several pathways have been proposed to explain the associations between neighborhoods and cardiovascular outcomes, including pathways involving traditional behavioral risk factors as well as traditional medical cardiovascular disease (CVD) risk factors.⁶ However, the association of neighborhood features with cardiovascular risks often persists after adjustment for traditional behavioral risk factors and chronic conditions, suggesting that other mediating mechanisms could be involved.⁴

Sleep disorders are a common phenomenon. A survey conducted by the National Sleep Foundation showed that at least 40 million Americans have at least 1 of more than 70 different sleep disorders.⁷ Sleep duration is important for several reasons—primarily, it allows various processes to occur that strengthen or improve cardiovascular function, immune system function, memory, mood, and daily function to name a few.⁸ Studies have shown that short sleep duration and daytime sleepiness are associated with high blood pressure, diabetes, coronary artery disease, obesity, and heart failure.^{9,10} Most Americans do not receive the recommended 7–9 hours per night¹¹ and, thus, explorations of the reasons for the high prevalence of inadequate sleep are warranted in an effort to potentially reduce the cardiovascular effects of poor sleep quantity. Sleep may be a novel mediating mechanism between neighborhoods and cardiovascular risk, if sleep is patterned by neighborhoods.

Neighborhood characteristics may plausibly affect sleep. There is evidence supporting that neighborhood environments are associated with adverse sleep outcomes in adult populations.^{12–23} Low socioeconomic status (SES) neighborhoods are often exposed to more neighborhood problems, which could impact residents sleep patterns.²⁴ Specific features of the neighborhood, such as crime and violence, have been shown to affect sleep.^{13,22,25} Feelings of fear and being unsafe as a result of neighborhood crime could induce chronic stress and potentially poor sleep habits.²² Many of the existing studies have measured violence by self-report, which measures the perception of proximate aspects of the neighborhood. Weden et al²⁶ found that subjective neighborhood measures mediate the association between objective neighborhood characteristics and health. Therefore, solely examining subjective measures may not fully capture the contribution of the objective

neighborhood characteristics on sleep outcomes.²⁶ Research should examine both subjective and objective measures of crime or disorder to more thoroughly characterize the contribution of the neighborhood environments to sleep.

Research on sleep in Hispanic populations is extremely limited. Most sleep research has been conducted among cohorts of non-Hispanic white populations, thus limiting the generalizability of the results to other populations including Hispanics.²⁷ It is likely that Hispanics have poor sleep based on the high prevalence of risk factors, such as obesity, diabetes, and living in inner cities, which are linked to poor sleep.^{27,23} For example, evidence suggests that poor sleep may adversely affect glucose regulation and increase the risk of diabetes, and leptin levels (an appetite-stimulating hormones) are lower among those with poor sleep, which promotes appetite and calorie intake leading to obesity.^{28,29} In particular, Mexican Americans have a high burden of CVD risk factors and could have poorer sleep health; thus, it is important to assess the sleep of this subpopulation. A study conducted by Hale and Do²³ on the ethnic differences in self-report of sleep duration found differences for Mexican Americans and other Hispanic populations. Non-Mexican Hispanics had an increased risk of short sleep compared with non-Hispanic whites,²³ whereas Mexican Americans had a higher odds of long sleep compared to non-Hispanic whites (not significant after adjustments for socioeconomic characteristics).²³ Conversely, data from the 2007–2008 National Health and Nutrition Examination Survey (NHANES) survey showed that Mexican Americans were less likely than non-Hispanic whites to report long sleep.³⁰ There are many within-group differences among Hispanics; therefore, sleep health could vary among Hispanic subpopulations as evidenced by the results of Hale and Do and thus should be considered. In addition, emerging evidence suggests that the neighborhood environment (safety and disorder) may contribute to sleep health among Hispanic populations and should be further studied.^{17,19,31}

Examining predictors of sleep in the Mexican American population may inform novel intervention targets to improve sleep quality and subsequently reduce the burden of chronic conditions in this population. Using baseline data from the Stroke Health and Risk Education (SHARE) project, a biethnic behavioral intervention study, we examined the cross-sectional associations of neighborhood characteristics including disadvantage, safety, and crime with sleep duration and daytime sleepiness.

Participants and methods

SHARE is a cluster-randomized, parallel-group, church-based behavioral intervention trial designed to reduce stroke risk in Mexican American and non-Hispanic white parishioners in the Corpus Christi, Texas area.³² Participants in SHARE (n = 801) were recruited from 1 of 10 catholic churches selected among those in the Diocese of Corpus Christi. Advertisements were placed in church bulletins, and parish liaisons identified potentially eligible participants for enrollment.³² At some churches, participation was encouraged by the priests. Participants were encouraged to enroll in friend or family member pairs. A few participants withdrew before baseline, yielding a sample of 760 participants. Of the 760 participants, 738 individuals were enrolled as pairs. The recruitment and enrollment of family or friendship pairs³² allowed the study to exploit the natural social support system to promote behavior

change. A baseline assessment was completed during home visits by trained study coordinators in either English or Spanish.³² Baseline data included behavioral stroke risk factors as well as biological outcome measures collected between May 2011 and November 2012.

Neighborhood measures

Census tract-level and self-reported measures of the neighborhood were assessed. Each participant's address was geocoded to 2010 US Census tracts, which were used as proxies for neighborhood of residence. If a participant's address could not be identified for geocoding, the zip code was used (11%). Census tracts were then assigned based on where the zip code centroid was located. SHARE participants resided in a total of 79 census tracts. Census tract-level measures included neighborhood disadvantage and per capita violent crime. Neighborhood disadvantage was assessed by an index of objective neighborhood disadvantage using data from the American Community Survey 2011 5-year estimates. This composite measure, developed by Ross and Mirowsky,³³ is derived to characterize the neighborhood socioeconomic environment. The index consisted of the percentage of female-headed households with children, the percentage of households with incomes below the federal poverty threshold in the last 12 months, the percentage of college-educated adults, and the percentage of housing units that are owner occupied.³³ Higher scores indicate more disadvantage. Per capita violent crime was assessed as the number of violent crimes (murder, manslaughter, forcible rape, robbery, and aggravated assault) in 2009 per census tract with data provided by the Corpus Christi Police Department. Crime data were only available for participants that resided in Corpus Christi, Texas; those outside of the city (22% of sample) were excluded from these analyses.

Self-reported neighborhood safety was assessed by asking each participant his or her level of agreement with the following statement: "I feel safe walking in my neighborhood day or night." Responses were collected using a Likert scale: 1=strongly disagree; 2=disagree; 3=neutral (neither agree nor disagree); 4=agree; 5=strongly agree.

Sleep measures

We examined sleep duration and daytime sleepiness measured at baseline. Sleep duration in hours was assessed by the question: "How many hours of sleep do you usually get a night (or when you usually sleep)?" Participant responses were recorded in hours and transformed to minutes for the analyses. Sleep duration was also categorized as short (< 6 hours), normal (7 or 8 hours), and long (≥ 9 hours) for the analyses. Daytime sleepiness was measured using the daytime fatigue and sleepiness category of the Berlin Questionnaire³⁴: (1) How often do you feel tired or fatigued after your sleep? (2) During your wake time, how often do you feel tired, fatigued, or not up to par? (3) Have you ever nodded off or fallen asleep while driving a vehicle? If yes, how often does this occur? The responses were scored as follows: 1=nearly every day; 1=3–4 times a week; 0=1–2 times a week; 0=1–2 times a month; 0=never/nearly never. Scores for questions were summed for a total daytime sleepiness score per participant ranging from 0 to 3 with higher scores representing greater daytime sleepiness. We also operationalized daytime sleepiness as a dichotomous variable according to the scoring of the Berlin; high daytime sleepiness was defined as a score of greater than or equal to 2 points.³⁵

Demographic factors and covariates

Participants self-identified as either Mexican American or non-Hispanic white/European American at enrollment. Education was measured as years of education and ranged from 1 to 19 (no formal education to graduate education). Income was categorized into 5 groups (< \$10,000, \$10,000–\$19,999, \$20,000–\$29,999, \$30,000–\$49,999, and >\$50,000). Employment status was categorized as not employed (no current employment) or employed (part time or full time). Date of birth and gender were self-reported.

Analyses were adjusted for risk factors for sleep outcomes (body mass index [BMI], hypertension, diabetes, and depressive symptoms). These risk factors may operate as both confounders and mediators of the neighborhood and sleep association. Study staff measured height and weight for each participant, and BMI was later calculated. While in a seated position, using standard techniques, 3 consecutive readings of blood pressure were measured in the right arm, and the average of the last 2 was taken.³² Self-reported hypertension was determined by a response to the following question: “Have you ever been told by a doctor, nurse or other health professional that you have high blood pressure or hypertension?” *Hypertension* was defined as a having a mean systolic blood pressure greater than or equal to 140 mm Hg, a mean diastolic blood pressure greater than or equal to 90 mm Hg, or a self-reported diagnosis of hypertension. Diabetes was defined by a fasting glucose measurement of greater than or equal to 126 mg/dL or a self-reported diagnosis of diabetes. Diabetes was also self-reported similarly to the hypertension question. The Patient Health Questionnaire (PHQ-2) was used to measure depressive symptoms.³⁶ The PHQ-2 assesses the frequency of lost interest in doing things and frequency of feeling depressed: 0=not at all; 1=several days; 2=more than half the days; 3=nearly every day. Responses were summed for a total depressive symptom score (range, 0–6).

Statistical analysis

Descriptive statistics were calculated for demographics and risk factors stratified by tertiles of neighborhood disadvantage. χ^2 and analysis of variance tests were used to compare categorical and continuous variables across tertiles of neighborhood disadvantage, respectively. Pearson correlations were calculated to examine the correlations between neighborhood variables and between sleep outcomes. Differences in mean sleep duration and mean daytime sleepiness across tertiles of neighborhood disadvantage, safety, and per capita violent crime were assessed by fitting linear models with adjustment for age and sex. We also compared the distribution of sleep outcomes between Mexican American and non-Hispanic white participants.

We fit generalized linear (continuous sleep duration) and multinomial logistic (categories of sleep duration) regression models to examine the associations between each neighborhood characteristic and sleep duration.³⁷ For models with daytime sleepiness as the outcome, we fit generalized linear models with a multinomial distribution and binomial logistic regression models due to the ordinal and dichotomous structures of the daytime sleepiness outcomes. Intraclass correlation coefficients (ICCs) were calculated to determine clustering within church, pair, and census tract. If the responses were clustered within church, pair, and/or census tract, a random intercept was included in the model to account for the clustering. The

ICC with respect to census tract was 0; therefore, a random effect for census tract was not included in any model. We estimated mean differences in the minutes of sleep duration accounting for clustering within churches (ICC=0.06) and pairs (ICC=0.04). Similarly, we estimated mean differences in daytime sleepiness scores accounting for clustering of pair only (ICC=0.07). Each neighborhood characteristic was examined for its relation to each outcome in separate sequential models: model 1 adjusted for age and sex; model 2 adjusted for education, income, and employment status, in addition to the factors in model 1; model 3 further adjusted for depressive symptoms, BMI, diabetes, and hypertension. Neighborhood characteristics were standardized and modeled continuously for comparisons across the neighborhood measures. All analyses were conducted using SAS software version 9.3 (SAS Institute, Cary, NC). The institutional review board at the University of Michigan approved the study, and all participants gave written informed consent.

Results

The average age of the study population was 52.9 years, and the population was mostly female (64%); the sample was predominately Mexican American (84%). Approximately 65.5% of the study population lived in the same home as their pair. A total of 751 participants self-reported sleep duration (reports of <4 hours of sleep at night [$n = 7$] and missing values [$n = 2$] were excluded). No exclusions for daytime sleepiness were made; 756 (99%) had complete data. Daytime sleepiness and sleep duration were associated; for a 1-unit increase in daytime sleepiness, sleep duration decreased by 16 minutes. Neighborhood disadvantage and crime were positively correlated (0.70). Neighborhood safety was weakly correlated with neighborhood disadvantage (−0.29) and crime (−0.28).

There were no differences in age, BMI, sex, smoking status, sleep apnea, and history of CVD across tertiles of neighborhood disadvantage (Table 1). Persons in the high neighborhood disadvantage tertile were more likely to have a higher mean of depressive symptoms and violent crime per capita, report hypertension and diabetes, be unemployed, and have a lower income and lower perceived neighborhood safety score than those in the other neighborhood disadvantage tertiles. Mean hours of sleep duration ranged from 6.5 hours (SD=1.1) in the lowest tertile to 6.8 hours (SD=1.1) in the highest tertile of neighborhood disadvantage ($P = .01$). There was no difference in the daytime sleepiness scores across the tertiles of neighborhood disadvantage.

Forty-four percent of the population had a short sleep duration (< 6 hours), whereas 4.3% had a long sleep duration (> 9 hours) (Table 2). The mean daytime sleepiness score was 0.8 (SD=0.9). Approximately 45% of the Mexican American participants slept 6 hours or less each night. The mean sleep duration was similar between Mexican Americans and non-Hispanic whites, 6.7 (SD=1.2) and 6.7 (SD=1.1), respectively. There was no difference in the prevalence of short sleep duration between Mexican American and non-Hispanic white participants, 45% and 43%, respectively ($P = .84$). The mean daytime sleepiness score was similar between the 2 ethnic groups, (0.70 (SD=0.8) for Mexican Americans and 0.67 (SD=0.8) for non-Hispanic whites ($P = .70$)).

Table 3 shows mean hours of sleep and mean daytime sleepiness across the tertiles of neighborhood disadvantage, self-reported safety, and crime after adjustment for age and sex. Participants in the high neighborhood disadvantage and high neighborhood violent crime groups had a higher mean sleep duration and lower daytime sleepiness score compared to the other categories of neighborhood disadvantage and crime ($P < .01$). Higher self-reported neighborhood safety was associated with a higher mean sleep duration and lower mean daytime sleepiness score ($P < .01$).

Neighborhood characteristics were not associated with sleep duration in the unadjusted or adjusted multinomial and linear models (Table 4 and Supplementary Table 1). Odds of daytime sleepiness associated with each neighborhood characteristic are displayed in Table 5. Greater neighborhood disadvantage was related to lower odds of daytime sleepiness, although not statistically significant in either of the models (Table 5). Neighborhood violent crime was also not associated with daytime sleepiness. A 1-unit change in self-reported neighborhood safety (ie, higher safety) resulted in an 18% (95% confidence interval [CI]=0.69–0.96) lower odds of daytime sleepiness in the model with daytime sleepiness modeled dichotomously. The results were attenuated and marginally significant in the fully adjusted model (odds ratio [OR]=0.85; 95% CI=0.70–1.02). The findings modeling daytime sleepiness as an ordinal variable were similar to the results as a dichotomous variable (Table 5); however, the association remained statistically significant in the fully adjusted model (Supplementary Table 1).

Discussion

Higher perceived neighborhood safety was associated with a lower odds of daytime sleepiness. Higher levels of neighborhood disadvantage and crime were also related to lower daytime sleepiness, although not statistically significant. In this study population, perceived neighborhood safety was weakly associated with neighborhood disadvantage and crime. In examining categories of neighborhood characteristics based on tertiles of the distributions with continuous sleep duration, we found that participants in the highest categories of disadvantage, self-reported safety, and crime had higher mean sleep duration than those in other neighborhood categories with adjustment for demographics. In contrast, we did not observe an association between neighborhood characteristics and sleep duration measured categorically and continuously after adjustment for demographics, socioeconomic position, and risk factors. However, our study population had a high prevalence of short sleep duration particularly among those in the lowest neighborhood disadvantage category. These findings are important given that short sleep duration and daytime sleepiness are a significant public health problem that is associated with total mortality and incident cardiovascular disease morbidity and mortality.^{9,10} Understanding factors that may increase the risk of daytime sleepiness is important, particularly in a population such as Mexican Americans that is at increased risk for many cardiovascular risk factors.

These results of this work are significant for several reasons. Most neighborhood and sleep literature has focused on the association of 1 aspect of the neighborhood environment with sleep^{16,17,22,38}; this study expands the literature by the inclusion of multiple dimensions of the social environment. Our study is also unique in examining both self-reported and

objectively measured neighborhood characteristics with sleep. Furthermore, our study was conducted among a diverse population that included Mexican Americans who are often not included in studies of sleep. To our knowledge, there are only 3 studies that have examined the association of neighborhoods and sleep in Hispanic populations,^{17,19,31} and of those, 2 were conducted outside of the United States.^{17,31} Despite the limited literature, our results were consistent with prior work in suggesting that the neighborhood environment may contribute to sleep health among Hispanics and specifically Mexican Americans.

To our knowledge, only 2 studies have examined the association of neighborhood safety with daytime sleepiness, and the results varied.^{13,17} Hill et al¹⁷ examined perceived neighborhood safety and daytime sleepiness in 6 countries including Mexico. The authors found that greater perceived neighborhood safety was associated with a lower odds of sleepiness in the past 24 hours, which is consistent with our results among Mexican Americans.¹⁷ However, our results differed from those in a multiethnic sample of 1406 adults aged 45–84 years that found greater neighborhood safety (census tract level) was associated with greater sleepiness.¹³ This finding was unexpected and contrary to the authors' hypothesis that lower levels of neighborhood safety would be associated with increased daytime sleepiness.¹³ There are a few plausible explanations for the differences in findings. First, neighborhood safety was measured differently in the different studies. Measurement varied from a census tract-level measure of safety,¹³ to individual measures that referenced safety from crime/violence when walking and at home alone.¹⁷ Our study used an individual-level measure of perceived neighborhood safety defined as feeling safe when walking. Perhaps individual perception of safety has more of an impact on sleep outcomes than an objective measure of safety, which is consistent with our findings and those of Hill et al.¹⁷ Second, our study measured daytime sleepiness according to the sleepiness category of the Berlin Questionnaire, whereas the prior studies included daytime sleepiness measured by either the Epworth Sleepiness Scale¹³ or a single item of sleepiness in the last 24 hours. These are different measures of daytime sleepiness and, therefore, could have a different meaning in regard to sleep health, which may explain the different findings.

The observed association between greater perceived neighborhood safety and less daytime sleepiness leads one to consider possible explanations. There could be mediating pathways by other neighborhood factors, such as unpleasant walking environments and limited access to healthy foods that lead to decreased physical activity and higher BMI,³⁹ which are associated with poor sleep outcomes.⁴⁰ Physical activity data were not available; however, we adjusted for BMI. In our study, after adjustment for BMI, the magnitude of the association between perceived neighborhood safety and daytime sleepiness was attenuated but still statistically significant; in addition, higher BMI was positively associated with daytime sleepiness providing some support for this pathway. It is also important to note that sleep apnea may also confound or mediate the association, given that untreated sleep apnea is associated with sleepiness.⁴¹ Stress is another possible pathway by which neighborhood safety may be associated with sleepiness. Residents who perceive their neighborhoods as unsafe may have increased levels of perceived psychological stress.⁴² Evidence suggests that elevated stress is related to increased sleepiness.⁴³ Stress is known to activate the defense system of the central nervous system including the hypothalamic-pituitary-adrenal axis.⁴⁴ The hypothalamic-pituitary-adrenal axis is involved in regulating the onset and wake time of

sleep,⁴⁴ potentially disrupting sleep quantity and thus leading to daytime sleepiness.⁴⁵ The role of stress as a possible mediator of perceived neighborhood safety and daytime sleepiness association may be a promising direction to explore in future research. In addition, the cross-sectional design of this work leads us to consider the possibility that people with more sleep may have a better attitude about their neighborhood; future research should try to tease out temporality.

Contrary to our hypothesis, crime was not related to daytime sleepiness. Neighborhood violent crime was measured as a census tract-level variable (a police reported count of violent crimes), which may not relate to individual perceptions, evidenced by the weak correlation between crime and perceived safety. Residents may not be aware of the frequency of violent crimes in their neighborhood or feel personally susceptible to violent crime and, therefore, are not vulnerable to the potential negative effects on sleep health. Moreover, researchers have hypothesized that neighborhoods high in crime may interrupt the ability of residents to initiate/maintain sleep²³; however, if these residents exhibit certain stress reducing health behaviors or have social support that combats the feelings of fear, restful sleep may occur. For example, a participant with a high level of social support may feel protected in their neighborhood and, therefore, has a better sleep quality. In this example, social support could potentially modify the association between neighborhood crime and daytime sleepiness, and this is particularly relevant in our study population of Mexican Americans who tend to have a high level of social support.⁴⁶ As a result of this high social support, we may not observe an association between neighborhood crime and daytime sleepiness.

Surprisingly, higher levels of neighborhood disadvantage were associated with lower daytime sleepiness, although this finding was not statistically significant. This unexpected finding was not consistent with our hypothesis or with findings of prior research. Desantis et al¹³ reported that higher neighborhood SES (more advantage) was associated with less daytime sleepiness after adjustment for age and sex. In our study, neighborhood SES was discordant with perceived neighborhood safety; approximately 47% of study participants with higher neighborhood disadvantage perceived their neighborhood as safe. Perceptions of safety may have more of an impact on the sleep of study participants than the SES of the neighborhood.

Neighborhood characteristics were not associated with sleep duration; however, we did find that persons in the lower neighborhood disadvantage group had a higher prevalence of short sleep duration compared to those in the higher neighborhood disadvantage group. Prior research has shown inconsistent reports of associations between neighborhood characteristics and sleep duration.^{13,22} Our results were consistent with the findings of Johnson et al²² who reported no association between perceived neighborhood safety measured at the individual level and sleep duration. Conversely, Desantis et al¹³ found an association with group-level neighborhood safety and sleep duration and also found that the association between neighborhood SES and sleep duration did not become significant until adjustment for sociodemographic variables.

In addition to exploring the associations between neighborhood characteristics and sleep, we described the sleep of Mexican Americans in our study sample. This description contributes to the literature by quantifying the prevalence of short sleep duration among a nonimmigrant population of Mexican Americans. In our study, the prevalence of short sleep duration among Mexican Americans (44.5%) was comparable to that of non-Hispanic whites but higher than recent reports (data from the National Interview Survey) of short sleep duration for blacks (37%) and whites (28%).⁴⁷ Identifying determinants of poor sleep among Mexican Americans may potentially inform interventions to reduce the burden of poor mental and physical health outcomes in this population.

Our study has a few limitations. We included self-reported subjective measures of sleep, which can be unreliable; however, studies have found errors in objective measures also, as well as a moderate correlation between objective and subjective measures.⁴⁸ Sleep duration and daytime sleepiness were self-reported. Therefore, recall bias or measurement error is probable; however, we do not expect that recall differed based on neighborhood status. A reference period was not included in the measurement of the sleep variables, which may increase susceptibility to error. Our measure of daytime sleepiness was based on the validated Berlin Sleep Questionnaire, which is typically used to assess sleep apnea risk rather than an assessment of the individual sleep dimensions such as daytime sleepiness. Our self-reported neighborhood safety variable not only may indeed reflect neighborhood safety but also could represent other factors in the neighborhood such as sidewalks or street lights because Corpus Christi is a car-dependent community.⁴⁹ The inclusion of factors that may operate as both confounders and mediators in our multivariable models may have resulted in overadjustment. We used a sequential modeling approach to understand the potential impact of adjusting for these possible mediators. Our study population was a nonprobability sample of predominantly a nonimmigrant population of Catholic Mexican American churchgoers who had an existing support system (they enrolled in pairs) and were interested in a CVD risk reduction intervention; therefore, these results are not representative of the general population with a different ethnic distribution, SES, or risk factor profile for sleep outcomes. Lastly, our study examined cross-sectional associations and thus is affected by temporal ambiguity, meaning that it is unclear if neighborhoods determine sleep health, if sleep health determines neighborhood environment, or if there is a causal relation between the two.

Future studies should consider the possible pathways linking neighborhood safety with daytime sleepiness. This predominantly Mexican American study population had a high prevalence of short sleep duration, which may have implications for CVD and other health outcomes in this population. Further research should examine factors related to poor sleep among Mexican Americans.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Distribution of selected study population characteristics across tertiles of neighborhood disadvantage categories.

	Neighborhood disadvantage			<i>P</i>
	Lowest 1/3, n = 250	Middle 1/3, n = 258	Upper 1/3, n = 250	
Age (y)	53.6 ± 13.8	52.7 ± 13.8	52.5 ± 14.6	.65
BMI (kg/m ²)	32.2 ± 7.6	32.6 ± 7.9	33.0 ± 7.2	.42
Mexican American	73.1%	91.1%	88.6%	<.01
Male	37.6%	37.6%	33.2%	.50
Smoke	6.0%	8.9%	10.0%	.24
Some college	66.8%	55.8%	39.2%	<.01
>\$50,000	37.9%	28.9%	20.2%	<.01
Employed	67.2%	64.3%	54.6%	<.01
Short sleep duration ^a	50.0%	45.3%	38.1%	.01
Sleep duration	6.5 ± 1.1	6.7 ± 1.2	6.8 ± 1.2	.01
Daytime sleepiness	0.7 ± 0.9	0.7 ± 0.8	0.7 ± 0.8	.75
Depressive symptoms	0.7 ± 1.1	0.9 ± 1.4	1.2 ± 1.6	<.01
Sleep apnea	11.6%	11.7%	9.2%	.60
Hypertension	56.4%	52.7%	58.4%	.42
Diabetes	24.8%	21.7%	28.4%	.22
History of CVD ^b	10.0%	11.0%	11.7%	.83
Violent crime per capita* 100,000 ^c	280.5 ± 199.9	588.2 ± 200.1	998.3 ± 575.8	<.01
Self-reported neighborhood safety				<.01
Strongly agree	27.2%	13.2%	10.0%	
Agree	50.0%	45.0%	37.2%	
Neutral	9.2%	15.9%	16.0%	
Disagree	11.2%	19.8%	27.6%	
Strongly disagree	2.4%	6.2%	9.2%	

Data are mean ± SD or n (%).

^aShort sleep duration less than 7 hours of sleep per night.

^bHistory of CVD includes heart attack, stroke, coronary artery disease, and congestive heart failure.

^cCrime includes murder, manslaughter, forcible rape, robbery, and aggravated assault.

Table 2

Distribution of selected study population characteristics across categories of sleep duration and daytime sleepiness.

	<7 h per night, n = 334	7 h per night, n = 417	Low daytime sleepiness, n = 574	High daytime sleepiness, n = 186	P
Age (y)	51.2 ± 13.6	54.3 ± 14.4	54.5 ± 13.9	48.1 ± 13.3	<.01
BMI (kg/m ²)	33.0 ± 7.6	32.3 ± 7.6	32.2 ± 7.4	34.0 ± 7.9	<.01
Mexican American	84.3%	83.2%	83.8%	85.5%	.59
Male	38.6%	34.0%	37.6%	31.7%	.14
Smoke	7.5%	8.6%	6.3%	14.5%	<.01
Some college	59.9%	49.4%	53.3%	55.9%	.53
>\$50,000	35.5%	23.6%	29.4%	27.8%	.67
Employed	54.3%	71.9	60.1%	63.5%	.33
Depressive symptoms	1.1 ± 1.5	0.8 ± 1.3	0.7 ± 1.2	1.6 ± 1.7	<.01
Sleep apnea	12.0%	9.95	8.2%	18.8%	<.01
Hypertension	54.2%	57.1%	57.7%	50.5%	.09
Diabetes	24.5%	25.9%	25.4%	23.7%	.63
History of CVD ^a	9.0%	12.3%	11.0%	10.4%	.83
Neighborhood disadvantage	-1.4 ± 0.9	-1.4 ± 0.8	-1.4 ± 0.9	-1.4 ± 0.9	.52
Violent crime per capita* 100,000 ^b	602.2 ± 516.1	614.5 ± 448.0	612.2 ± 486.6	589.8 ± 450.7	.62
Self-reported neighborhood safety					.05
Strongly agree	13.5%	19.2%	18.8%	10.2%	
Agree	49.4%	39.3%	43.5%	45.2%	
Neutral	14.1%	13.9%	14.3%	12.9%	
Disagree	17.7%	21.1%	17.4%	25.8%	
Strongly disagree	5.4%	6.5%	5.9%	5.9%	

Data are mean ± SD or n (%).

^aHistory of CVD includes heart attack, stroke, coronary artery disease, congestive heart failure.

^bCrime includes murder, manslaughter, forcible rape, robbery, and aggravated assault.

Table 3

Age and sex-adjusted sleep outcomes by levels of neighborhood disadvantage, self-reported safety, and crime.

	Hours of sleep range: 4–10 (mean)	Daytime sleepiness range: 0–3 (mean)
Disadvantage		
Low	6.54	0.72
Middle	6.68	0.66
High	6.85	0.70
<i>P</i>	<.01	<.01
Safety		
Low	6.73	0.79
Middle	6.60	0.69
High	6.84	0.48
<i>P</i>	<.01	<.01
Crime		
Low	6.58	0.74
Middle	6.67	0.63
High	6.85	0.72
<i>P</i>	<.01	<.01

Safety was not correlated with crime or disadvantage.

Table 4

Association of neighborhood characteristics (in separate models) with categories of sleep duration (referent, normal).

	Model 1		Model 2		Model 3		Model 4	
	OR short sleep (95% CI)	OR long sleep (95% CI)	OR short sleep (95% CI)	OR long sleep (95% CI)	OR short sleep (95% CI)	OR long sleep (95% CI)	OR short sleep (95% CI)	OR long sleep (95% CI)
Neighborhood disadvantage	0.92 (0.79–1.07)	1.05 (0.74–1.51)	0.92 (0.79–1.07)	1.04 (0.73–1.49)	1.01 (0.86–1.19)	0.89 (0.60–1.33)	0.98 (0.83–1.16)	0.90 (0.60–1.37)
Self-reported safety	1.01 (0.88–1.17)	0.76 (0.54–1.07)	0.98 (0.84–1.14)	0.80 (0.56–1.13)	0.89 (0.75–1.04)	0.84 (0.57–1.24)	0.91 (0.77–1.07)	0.89 (0.59–1.33)
Crime	1.00 (0.84–1.18)	1.25 (0.92–1.70)	0.99 (0.84–1.17)	1.25 (0.92–1.71)	1.06 (0.88–1.28)	1.10 (0.72–1.68)	1.02 (0.84–1.24)	1.09 (0.71–1.69)

Model 1 is unadjusted. Model 2 is adjusted for age and sex. Model 3 is adjusted for education, income, and employment status, in addition to the factors in adjusted for in model 2. Model 4 is adjusted for depressive symptoms, BMI, diabetes, and hypertension, in addition to the factors adjusted for in model 3.

Table 5

Associations of neighborhood characteristics (in separate models) with dichotomous daytime sleepiness (high vs low).

	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
Neighborhood disadvantage	0.95 (0.80–1.12)	0.93 (0.79–1.11)	0.93 (0.77–1.12)	0.85 (0.70–1.04)
Self-reported Safety	0.82 (0.69–0.96) *	0.80 (0.67–0.95) *	0.81 (0.68–0.97) *	0.85 (0.70–1.02) **
Crime	0.95 (0.79–1.15)	0.93 (0.76–1.13)	0.98 (0.79–1.23)	0.90 (0.71–1.14)

Model 1 is unadjusted. Model 2 is adjusted for age and sex. Model 3 is adjusted for education, income, and employment status, in addition to the factors in adjusted for in model 2. Model 4 is adjusted for depressive symptoms, BMI, diabetes, and hypertension, in addition to the factors adjusted for in model 3.

* $P < .05$.

** $P < .10$.