Neighborhood Factors as Predictors of Poor Sleep in the Sueño Ancillary Study of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

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Statement of Significance: Prior studies have demonstrated an association between adverse neighborhood and sleep but have been limited by utilizing unvalidated measures of sleep. We used actigraphy and the Insomnia Severity Index to assess the relationship of neighborhood exposures and sleep in a large cohort of Hispanic Americans who are at high risk for living in at risk neighborhoods as well as poor sleep. We found the prevalence of objective short sleep duration was higher in neighborhoods perceived as unsafe, while insomnia prevalence was higher in neighborhoods where noise is considered a problem. These findings confirm the relationship between adverse neighborhood exposures and poor sleep using validated sleep measures in a high risk population and suggest that disturbances in sleep may represent an important pathway by which the neighborhood environment influences health.

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Abstract

Study objectives: To evaluate whether an adverse neighborhood environment has higher prevalence of poor sleep in a US Hispanic/Latino population.

Methods: A cross-sectional analysis was performed in 2156 US Hispanic/Latino participants aged 18-64 years from the Sueño ancillary study of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). Participants completed surveys of neighborhood environment including perceived safety, violence and noise, the Insomnia Severity Index (ISI), and 7 days of wrist actigraphy.

Results: In age and sex-adjusted analyses, short sleep, low sleep efficiency and late sleep midpoint were all more prevalent among those living in an unsafe neighborhood. After adjustment for background, site, nativity, income, employment, depressive symptoms, and sleep apnea, the absolute risk of sleeping < 6 hrs was 7.7 (95% CI [0.9, 14.6]) percentage points greater in those living in an unsafe compared to a safe neighborhood. There were no differences in the prevalence of insomnia by level of safety or violence. Insomnia was more prevalent among those living in a noisy neighborhood. In adjusted analysis, the absolute risk of insomnia was 4.4 (95% CI [0.4, 8.4]) percentage points greater in those living in noisy compared to non-noisy neighborhoods.

Conclusion: Using validated measures of sleep duration and insomnia, we have demonstrated the existence of a higher prevalence of short sleep and insomnia by adverse neighborhood factors. An adverse neighborhood environment is an established risk factor for a variety of poor health outcomes. Our findings suggest negative effects on sleep may represent one pathway by which neighborhood environment influences health.

Keywords: sleep, insomnia, neighborhood, safety, noise, actigraphy

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Introduction:

The association between disadvantaged residential environment (defined as an area with a population with low human, social and/or fiscal capital) and poor health has been widely documented [1]. Those living in disadvantaged neighborhoods are at increased risk of cardiovascular disease and negative mental health outcomes [2-9]. More recently, studies suggest that residents of disadvantaged neighborhoods may also be at greater risk of disturbed sleep [10]. This suggests that effects of neighborhood characteristics on sleep may represent one pathway by which neighborhood environment has an impact on health outcomes. Exposure to violence and crime and feeling unsafe in one's neighborhood have been associated with reductions in both sleep duration [11-13] and sleep quality [10, 12-14], and worse insomnia symptoms [15]. Similarly, increased noise in the neighborhood has been associated with higher prevalence of self-reported sleep disturbances [11, 15-19]. However, a major limitation of the existing literature linking adverse neighborhood features such as crime and violence with sleep has been the reliance on unvalidated measures of sleep[10-14, 20-22]. While studies using actigraphy have evaluated the relationship between sleep and noise, these studies have been limited by small sample size, in-laboratory testing or low levels of noise that may limit generalizability of findings[23, 24]. Our goal was to evaluate the relationship between neighborhood environment and validated measures of sleep in a large cohort of US Hispanics/Latinos, the largest racial/ethnic minority group in the US and a group with a high prevalence of cardiovascular disease risk factors such as diabetes, obesity and hypertension[25]. Further, US Hispanic/Latinos have a high prevalence of deficient sleep[26] and are more likely to live in adverse neighborhood contexts compared to non-Hispanic white adults[27]. We hypothesized that short sleep, poor sleep efficiency, late sleep

midpoint and insomnia will be more prevalent in Hispanic/Latino living in unsafe, violent and nosy neighborhoods.

Methods:

The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a community based prospective cohort study of 16,415 self-identified Hispanic/Latino adults recruited from randomly selected households in four U.S. field centers (Chicago, IL; Miami, FL; Bronx, NY; San Diego, CA) with baseline examination occurring between 2008 and 2011. Full details of the recruitment procedures have been previously reported [28]. As part of the baseline examination, participants provided information on demographics (including self-identified Hispanic/Latino background, place of birth and length of time in the U.S.) and socioeconomic status (including household income). Participants were given questionnaires in their language of preference: English or Spanish. In addition, participants underwent home sleep testing (ARES Unicorder 5.2; B-Alert, Carlsbad, CA) to assess sleep apnea severity. Details regarding the sleep apnea assessment have been previously reported [29]. In brief, respiratory events were defined as a ≥ 50% reduction in airflow for at least 10 seconds with associated desaturations of ≥ 3%. The sum of all such events divided by recording time was used to calculate the apnea hypopnea index (AHI).

The Sueño ancillary study recruited a subset of HCHS/SOL participants across all four sites from 2010 to 2013 aged 18-64 years and free of severe sleep disorders (AHI < 50/hr, no treatment for sleep apnea, and no diagnosis of narcolepsy) to undergo more detailed sleep assessment [30, 31]. The study protocols used for both the parent HCHS/SOL

baseline exam and the Sueño exam were approved by the Institutional Review Boards at each of the participating sites and all participants provided written informed consent.

Participants completed a questionnaire on neighborhood stress that included the following questions: "How safe from crime do you consider your neighborhood to be?" (response options ranged on a 5-point scale) and "Think about your neighborhood as a whole, then please choose the response for each of the following to show how much of a problem each one is in your neighborhood" (one question each for excessive noise and violence, with response options ranged on a 4-point scale). Questions similar to these had acceptable test-retest reliability in other urban populations [32, 33]. The 10-item Center for Epidemiologic Studies Depression Scale (CES-D10) was used to assess depressive symptoms and self-reported information was obtained on employment status [34]. Insomnia was assessed using the Insomnia Severity Index (ISI), a seven item instrument designed to assess the nature, severity, and impact of insomnia in community-based populations and validated in both English and Spanish [35, 36]. Insomnia was defined as an ISI score ≥ 15. This threshold has an 86.1% sensitivity and 87.7% specificity for detecting insomnia cases in community samples [35, 37]. Participants were asked to wear an Actiwatch Spectrum (Philips Respironics, Murrysville, PA) wrist actigraph on their non-dominant wrist and to keep the device on the wrist continuously for 7 days with activity data collected in 30-second epochs. A sleep diary was completed upon awakening each morning.

Actigraphy Scoring:

All actigraphy records were scored at a centralized reading center at Brigham and Women's Hospital. We used a standardized protocol using event markers, sleep diaries and

activity levels to identify rest periods where the participant was trying to sleep [30]. Sleep-wake status for each 30 second epoch was computed using the Actiware 5.59 scoring algorithm. Sleep onset was defined as 5 immobile minutes, 0 immobile minutes for sleep offset, and a wake threshold of 40 counts. This actigraphy scoring algorithm has been validated against polysomnography on an epoch-by-epoch basis [38, 39]. Participants with a minimum of 5 days of valid actigraphy data were included for analysis. All sleep measures were reported as the mean averaged across all valid days in the recording. Sleep duration was then dichotomized as < 6 hours (short sleep) or ≥ 6 hours. Sleep efficiency was defined as the proportion of time from sleep onset to sleep offset that was scored as sleep, and dichotomized as < 85% or ≥ 85% [40]. Sleep midpoint was calculated as the point halfway between sleep onset and sleep offset and late sleep midpoint was defined as a midpoint > 4:00 AM.

Statistical Analysis:

Univariate analyses showed a relationship between neighborhood measures and sleep. As a result, responses to the question on safety were dichotomized as either safe (≥ 3) or unsafe (< 3) based on a 1-5 rating scale and neighborhood noise and violence responses were dichotomized as either representing a problem (very serious problem, somewhat a serious problem, minor problem) or not really a problem. Hispanic/Latino background was categorized in six ethnic groups (Central American, Cuban, Dominican, Mexican, Puerto Rican, or South American). Nativity status was categorized as mainland US born, foreign born with ≥10 years in US, or foreign born with < 10 years in US. Using the median as cut-point, annual household income was categorized as: < $20,000 versus ≥ $20,000. Employment status was dichotomized as any employment versus none.

Depressive symptoms were defined as a CES-D10 score ≥ 10 as this threshold has been identified as predictive of a clinical depression diagnosis [34, 41]. Sleep apnea severity was categorized based on clinical severity criteria as none (AHI < 5/hr), mild (AHI 5-14.9/hr), and moderate to severe (AHI 15-49.9/hr).

The prevalence of dichotomous sleep outcomes (short sleep duration, low sleep efficiency, late sleep midpoint, and insomnia) were calculated using survey linear regression modeling the prevalence as a continuous outcome while accounting for the sampling design and sampling weights adjusted to reflect age and sex distributions based on the 2010 US Census[42]. Similarly, multivariable survey linear regression was used to estimate adjusted prevalence differences in sleep outcomes by perceived neighborhood characteristics. This prevalence difference between those exposed and unexposed to each neighborhood feature represents the absolute risk of the neighborhood exposure. Initial models adjusted for continuous age, sex, site, Hispanic/Latino background and nativity status. Subsequent models additionally included household income, employment status, depressive symptoms, and sleep apnea severity. In addition, the presence of effect modification by sex, age, nativity status and neighborhood factors were tested including an interaction term. In sensitivity analyses, sleep duration, efficiency, midpoint, and insomnia (ISI score) were modeled as continuous variables. All analyses were conducted using SAS version 9.3 and survey commands to account for the complex survey design and sampling weights (SAS Institute, Cary NC).

Results:

A total of 2,189 participants were enrolled in the Sueño ancillary to HCHS/SOL. Of these, 33 were excluded due to less than five days of valid actigraphy data. Data from the remaining 2,156 participants were included in this analysis. Sample characteristics of the study population are displayed in Table 1. Mean age was 47 years and approximately two thirds were women. There was a high prevalence of financial hardship. About half of participants had an annual household income lower than $20,000, and more than 40% were not employed.

The estimated prevalence of adverse neighborhood factors for the underlying Hispanic population studied are shown in Table 2 along with distributions for the key sleep measures assessed. Nearly half of individuals reported violence and/or noise as neighborhood problems and almost a quarter considered their neighborhood unsafe, with greater concerns for safety and violence expressed by women. Table 3 shows the age and sex-adjusted prevalence of short sleep, poor sleep efficiency, late sleep midpoint and insomnia symptoms by neighborhood exposure. Neighborhoods perceived as violent had a higher prevalence of short sleep compared to neighborhoods where violence was not a problem (25.8±2.1% vs. 20.1±1.5%, p=0.03). Neighborhoods perceived as unsafe also had a higher prevalence of short sleep compared to safe neighborhoods (29.9±3.0% vs. 20.5±1.4%, p=0.004). Similarly, the prevalence of low sleep efficiency was higher in neighborhoods perceived as violent (42.9±2.4% vs. 35.7±1.8%, p=0.02) and neighborhoods perceived as unsafe (46.6±3.3% vs. 36.7±1.6%, p=0.007). Neighborhoods perceived as unsafe had a higher prevalence of late sleep midpoint compared to safe neighborhoods (52.1±3.2% vs. 43.4±1.7% p=0.01). In contrast, participants living in violent or unsafe

neighborhoods did not have a significantly higher prevalence of insomnia. While participants living in a noisy neighborhood did not have a significantly higher prevalence of short sleep duration, low sleep efficiency, or late sleep midpoint, insomnia was substantially more frequent among participants living in neighborhoods where noise was a problem as compared to those where noise was not a concern (18.9±1.7% vs. 11.9±1.3%, p=0.001).

The results of multivariable modeling are shown in Tables 4 and 5. A higher prevalence of short sleep duration in unsafe neighborhoods compared to safe neighborhoods persisted after further adjustments for site, Hispanic/Latino background and nativity status. In adjusted analysis, the prevalence of short sleep duration was 8.0 (95% CI [1.5-14.6%]) percentage points higher in unsafe neighborhood compared to safe neighborhoods. This increase in absolute risk persisted after further adjustments for sleep apnea severity, depressive symptoms, employment and household income. When sleep duration was modeled continuously (Table 5), in the fully adjusted model, individuals that perceived their neighborhood as unsafe slept on average 10.2 minutes (95% CI [0.5-19.8 minutes]) less than individuals that perceived their neighborhood as safe. In contrast, the prevalence difference of short sleep duration between neighborhoods perceived as violent and non-violent was attenuated substantially and was no longer statistically significant in adjusted analyses, whether considered dichotomously or continuously. Similarly, in adjusted analyses, no significant differences were found in the prevalence of poor sleep efficiency nor late sleep midpoint across neighborhood measures.

Our results show that the prevalence of insomnia varied by neighborhood factors in a different pattern compared to actigraphic sleep. Insomnia was more prevalent among those living in noisy neighborhoods. After adjusting for age, sex, Hispanic/Latino background, site, nativity status, the prevalence of an ISI score ≥ 15 was 6.2 (95% CI [1.8-10.6%]) percentage points higher in noisy neighborhood compared to non-noisy neighborhoods. After additional adjustment for sleep apnea severity, depressive symptoms, employment and household income, a difference of 4.4 percentage points (95% CI [0.4-8.4%]) in prevalence persisted. When ISI was modeled continuously (Table 5), in the adjusted model, individuals who perceived their neighborhood as noisy had on average a 0.9 (95% CI [0.1, 1.6]) point greater ISI score compared to those who perceived their neighborhood as not noisy. In the fully adjusted model, individuals that perceived their neighborhood as noisy had on average a 0.5 (95% CI [-0.1, 1.2] point greater in ISI score, although this was no longer statistically significant (p=0.12).

Further analyses revealed no modification of the association between neighborhood safety and sleep duration by age, sex, nativity, neighborhood violence or noise or the association between neighborhood noise and insomnia by age, sex, nativity, neighborhood safety or violence ($p > 0.25$ for interaction).

Discussion

This study demonstrates for the first time the potential importance of the neighborhood environment on objective measurements of sleep among US Hispanics/Latinos, the largest minority population in the US. Our results demonstrate that neighborhoods perceived as unsafe have a higher prevalence of objective short sleep

duration. Even after adjustment for differences in socioeconomic measures as well as depressive symptoms, the prevalence of short sleep is approximately 8 percentage points greater in those living in unsafe neighborhoods. Similarly, individuals who perceive their neighborhood as unsafe, sleep on average 10 minutes less per night than individuals who perceive their neighborhood as safe. These findings are consistent with previous studies that reported an association between short sleep duration and low neighborhood safety [10-15, 20-22]. These prior studies however, relied on self-reported sleep duration, raising concern that the associations might reflect known systematic biases in the accuracy of self-report, rather than an actual effect on sleep per se. Our results demonstrate that the perception that one lives in an unsafe neighborhood is associated with an objective measure of short sleep. Of note, the prevalence difference of short sleep between unsafe and safe neighborhoods was not significantly different by sex. In contrast, a prior study found perceived safety had a larger effect on self-reported sleep in women [13]. This difference may reflect the fact that the accuracy of self-report varies by sex [31, 43]. Similarly, we found no evidence of heterogeneity in effect across other important subgroups such as age and nativity.

In terms of neighborhood safety, the prevalence difference in poor sleep efficiency and late sleep midpoint and their counterparts diminished after accounting for differences in nativity status and socioeconomic differences. This may reflect previously demonstrated differences in safety perception between first and second-generation immigrants [44-46]. We also found no differences in the prevalence of insomnia in safe vs. unsafe neighborhoods. This finding is similar to results from the Multi-Ethnic Study of Atherosclerosis (MESA) cohort that found independent assessment of perceived neighborhood safety was associated with sleep duration but not sleep quality [11]. In contrast, a number of studies have reported

associations between unsafe or crime-ridden neighborhoods and poor sleep quality [10-12, 20, 21]. However, the questions used to assess sleep quality in these studies have never been validated and so the relevance to clinical insomnia symptoms is uncertain.

The underlying mechanism by which perceived unsafe neighborhoods affects sleep remains unclear. Short sleep however, is not synonymous of insomnia[47], and results from our study show a distinctive pattern of prevalence of short sleep and insomnia across unsafe neighborhoods. It has been hypothesized that an adverse social environment may create feelings of insecurity, which may impair the ability of residents to initiate and/or maintain sleep [2, 48]. Taking into consideration our results, it is plausible that an unsafe neighborhood may lead to restricting the time in bed, as a way of prolonging the time spent vigilant at night. This in turn may lead to a reduction in sleep duration without adversely impacting sleep efficiency or insomnia symptoms. In longitudinal studies, an increase in the local crime rate predicted psychological distress[49]. Stress may enhance vigilance and adversely impact sleep through activation of the hypothalamo-pituitary-adrenal axis[50], which initiates physiological and behavioral changes in order to face (real or perceived) threats [50-52].

Our results, using a validated insomnia measure, show a higher prevalence of insomnia in neighborhoods where noise is perceived as a problem. These findings are consistent with previous studies that found associations between noise and single unvalidated questions about insomnia symptoms [11, 15, 18, 19, 53]. In contrast, we found no association between noise and actigraphic measures of sleep. These null results are consistent with recent findings from a study carried out in Canada that showed no association between objectively measured noise (from wind turbines) and sleep measured

with actigraphy[24]. In that study however noise levels were relatively low[24]. One potential explanation for the differential effects on insomnia but not actigraphy with low levels of noise might be that the effects (e.g., changes in sleep architecture) may be too subtle to be detected by actigraphy[54]. Another study focusing on neighborhoods with high levels of noise pollution did identify an association between actigraphic sleep measures and objective noise measures[55]. Thus, the relative importance of noise on sleep may be impacted by the baseline level of neighborhood noise.

Lack of perceived neighborhood safety has been linked to cardiovascular risk factors such as diabetes, hypertension and obesity as well as negative mental health outcomes [2, 4-7, 9]. Similarly epidemiological studies have shown that noise exposure is associated with self-reported health [56], depression [56, 57], cardiovascular disease [58-62], and mortality [62, 63]. These associations often persist after adjustment for classic behavioral and biomedical risk factors, suggesting that other factors may partly explain these associations. Conversely, psychological distress is hypothesized as one of the mechanisms by which crime safety and noise exposure might affect health. Both short sleep duration and insomnia have been associated with psychological distress, [64-66] and are known independent risk factors for cardiovascular disease and mental health well-being [67-72]. Thus, these aspects of poor sleep might represent pathways by which neighborhood environment affects health.

Our study has several limitations. Even though our analyses accounted for potential differences in sleep disordered breathing and depression, two of the most common medical conditions that contribute to poor sleep and that may be associated with neighborhood [6, 73], there are other determinants of sleep such as quality of housing or attitudes toward

bedsharing that could not be accounted for in our analyses[74-76]. Similarly, air pollution which varies by neighborhood and walking environment have been suggested as other neighborhood factors that can impact sleep quality [77, 78]. Another neighborhood factor that was not assessed was neighborhood was light at night, which may be an important predictor for sleep[79]. Because of the cross-sectional nature of our data, it is not possible to establish a causal relationship between perceived neighborhood environment and sleep. For example, the associations may reflect the impact of an unmeasured confounder such as social support and cohesion which might influence both sleep and perceptions of one's neighborhood. In addition, the identified association between neighborhood noise and insomnia could be explained by reverse causation, in that those suffering from insomnia may be more aware and sensitive to environmental noise. The nature of our data also prevents us from ruling out systematic self-selection into disadvantaged neighborhoods by the participants. Another limitation of our study is that we did not include objective measures of neighborhood factors such as noise levels or official crime statistics. Using official crime statistics however has limitations with evidence of underreporting of crime in minority and lower income neighborhoods[80]. Finally, our sample was drawn from urban areas and therefore our findings may not apply to other populations.

Our study has a number of strengths as well. The Sueño study is one of the largest studies of objective sleep patterns in a working age population and the first to focus on Hispanic/Latinos. In our analysis, at least 5 days of actigraphy were included (weekend/non-work days), increasing the likelihood that sleep patterns observed were representative of habitual sleep. A formalized algorithm was implemented to minimize

variability in actigraphy scoring [30]. Another strength of our study is the use of the ISI, a validated and widely used tool for insomnia assessment [35].

In summary, in a large and diverse population of US Hispanics/Latinos, the prevalence of objectively measured short sleep duration was significantly higher in unsafe neighborhoods compared to safe neighborhoods, while the prevalence of insomnia was higher in noisy neighborhoods. These findings suggest that sleep may represent an important pathway by which the perceived neighborhood environment may influence health.

Acknowledgements

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Table 1: Sample characteristics by sex, Sueño Ancillary Study to HCHS/SOL (2010-2013)

	Overall (N=2156)	**Women** (N=1396)	**Men** (N=760)
Age, years	47.0 (11.6)	47.4 (11.1)	46.3 (12.2)
Hispanic/Latino background			
Central American	291 (13.5%)	194 (13.8%)	97 (12.7%)
Cuban	389 (18.0%)	226 (16.1%)	163 (21.4%)
Dominican	270 (12.5%)	194 (13.8%)	76 (10.0%)
Mexican	576 (26.7%)	376 (26.9%)	200 (26.3%)
Puerto Rican	452 (21.0%)	286 (20.4%)	166 (21.8%)
South American	178 (8.3%)	120 (8.5%)	58 (7.6%)
Nativity			
Mainland US born	357 (16.6%)	214 (15.3%)	143 (18.8%)
Foreign born with ≥ 10 years in US	1239 (57.7%)	817 (58.7%)	422 (55.5%)
Foreign born with < 10 years in US	553 (25.7%)	359 (25.8%)	194 (25.5%)
Sleep apnea severity			
AHI < 5 events/hr	1530 (72.1%)	1053 (76.7%)	477 (63.6%)
AHI 5-14.9 events/hr	404 (19.0%)	229 (16.6%)	175 (23.3%)
AHI 15-49.9 events/hr	188 (8.9%)	90 (6.5%)	98 (13.0%)
Depressive symptoms	675 (31.3%)	505 (36.1%)	170 (22.3%)
Income ≤ $20,000	985 (49.4%)	667 (52.3%)	318 (44.2%)
Unemployed	902 (41.8%)	635 (45.4%)	267 (35.1%)

All values provided as mean (standard deviation) or N (percentage). Depressive symptoms defined as a score on the 10-item Center for Epidemiologic Studies Depression Scale greater than or equal to 10. AHI: apnea hypopnea index.

Table 2: Perceived neighborhood characteristics and poor sleep measures by sex, Sueño Ancillary Study to HCHS/SOL (2010-2013)

	Overall (N=2156)	**Women** (N=1396)	**Men** (N=760)
Perceived Neighborhood, Prevalence (SE)			
Violent	45.3% (1.9%)	48.0% (2.2%)	42.8% (2.5%)
Unsafe	23.5% (1.5%)	26.8% (1.9%)	20.3% (2.0%)
Noisy	50.8% (1.9%)	51.5% (2.3%)	50.0% (2.6%)
Sleep measures, mean (SE)			
Sleep duration, min	401.7 (2.0)	413.5 (2.4)	389.5 (3.1)
Sleep efficiency, %	85.2 (0.2)	86.5 (0.2)	84.0 (0.4)
Sleep midpoint, HH:MM	4:02 (0:03)	3:54 (0:03)	4:11 (0:05)
ISI score	7.0 (0.2)	7.6 (0.4)	6.4 (0.3)

ISI: Insomnia Severity Index. The prevalences and means reported account for sampling strategy and have been age and sex adjusted to reflect the age and sex distributions of the US population aged 18-64 based on the 2010 US Census data.

Table 3: Prevalence of short sleep, poor sleep efficiency, late sleep midpoint and insomnia symptoms by perceived neighborhood factors

	Short Sleep Duration (<6 hours)		Poor Sleep Efficiency (<85%)		Late Sleep Midpoint (> 4:00 AM)		Insomnia (ISI ≥ 15)	
	Prevalence (Standard Error)	p	Prevalence (Standard Error)	p	Prevalence (Standard Error)	p	Prevalence (Standard Error)	p
Overall	22.7% (1.3)		39.0% (1.4)		45.4% (1.6)		15.5% (1.1)	
Violent Neighborhood	25.8% (2.1)		42.9% (2.4)		47.9% (2.5)		16.4% (1.6)	
		0.03		0.02		0.12		0.41
Non-violent Neighborhood	20.1% (1.5)		35.7% (1.8)		43.4% (1.8)		14.7% (1.4)	
Unsafe Neighborhood	29.9% (3.0)		46.6% (3.3)		52.1% (3.2)		19.0% (2.4)	
		0.004		0.007		0.01		0.09
Safe Neighborhood	20.5% (1.4)		36.7% (1.6)		43.4% (1.7)		14.4% (1.2)	
Noisy Neighborhood	24.6% (1.3)		42.0% (2.2)		46.5% (2.3)		18.9% (1.7)	
		0.13		0.06		0.46		0.001
Not Noisy Neighborhood	20.7% (1.8)		35.9% (2.0)		44.4% (1.9)		11.9%(1.3)	

ISI: Insomnia Severity Index. The prevalences reported account for sampling strategy and have been age and sex adjusted to reflect the age and sex distributions of the US population aged 18-64 based on the 2010 US Census data (N=2,156)

Table 4. Adjusted prevalence differences in short sleep duration, poor sleep efficiency, late sleep midpoint and insomnia by adverse perceived neighborhood factors.

	Short Sleep Duration (<6 hours)		Poor Sleep Efficiency (<85%)		Sleep Midpoint (> 4:00 AM)		Insomnia (ISI ≥ 15)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Violent Neighborhood	4.3% (-1.3, 9.9)	3.8% (-1.9, 9.6)	2.0% (-4.8, 9.0)	1.8% (-5.1, 8.7)	1.1% (-5.8, 8.1)	1.8% (-5.1, 8.8)	1.5% (-3.2, 6.3)	1.7% (-2.4, 5.9)
Unsafe Neighborhood	**8.0% (1.5, 14.6)**	**7.7% (0.9, 14.6)**	5.2% (-2.1, 12.6)	3.2% (-4.2, 10.7)	-3.6% (-10.2, 3.1)	-1.7 (-8.5, 5.0)	3.7% (-1.8, 9.3)	-0.1% (-5.6, 4.6)
Noisy Neighborhood	2.7% (-2.7, 8.1)	3.0% (-2.5, 8.6)	2.5% (-3.8, 8.8)	2.4% (-3.9, 8.8)	2.9% (-3.0, 8.8)	3.2% (-2.9, 9.3)	**6.2% (1.8, 10.6)**	**4.4% (0.4, 8.4)**

Prevalence differences with 95% confidence intervals are presented comparing the prevalence in those with and without each neighborhood factor accounting for sampling design and adjusting for covariates.
Model 1 (n=2149) is adjusted for age, site, sex, ethnic background and nativity status.
Model 2 (n= 2114) is adjusted for covariates in Model 1 as well as employment status, household income, sleep apnea severity and depressive symptoms.

Table 5. Adjusted mean differences in sleep duration, sleep efficiency and insomnia by adverse perceived neighborhood factors.

	Sleep Duration (Minutes)		Sleep Efficiency (%)		Insomnia (ISI)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Violent Neighborhood	-1.9 (-10.6, 6.7)	-1.6 (-10.3, 7.1)	-0.5 % (-1.4, 04)	-0.4% (-1.3, 0.4)	0.4 (-0.4, 1.3)	0.5 (-0.2, 1.2)
Unsafe Neighborhood	**-9.8 (-19.5, -0.2)**	**-10.2 (-19.8, -0.5)**	**-1.0 % (-2.0, -0.1)**	-0.6% (-1.6, 0.2)	0.8 (-0.1, 1.8)	-0.1 (-0.8, 0.7)
Noisy Neighborhood	3.4 (-4.4, 11.2)	3.5 (-4.7, 11.9)	-0.3% (-1.1, 0.5)	-0.3% (-1.1, 0.5)	**0.8 (0.1, 1.6)**	0.5 (-0.1, 1.1)

Mean differences with 95% confidence intervals are presented comparing the prevalence in those with and without each neighborhood factor accounting for sampling design and adjusting for covariates.
Model 1 (n=2149) is adjusted for age, site, sex, ethnic background and nativity status.
Model 2 (n= 2114) is adjusted for covariates in Model 1 as well as employment status, household income, sleep apnea severity and depressive symptoms.

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