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ORIGINAL ARTICLE

The Neighborhood Social Environment and Objective Measures of Sleep in the Multi-Ethnic Study of Atherosclerosis

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Study objectives: To investigate cross-sectional associations of neighborhood social environment (social cohesion, safety) with objective measures of sleep duration, timing, and disturbances.

Methods: A racially/ethnically diverse population of men and women (*N* = 1949) aged 54 to 93 years participating in the Multi-Ethnic Study of Atherosclerosis Sleep and Neighborhood Ancillary studies. Participants underwent 1-week actigraphy between 2010 and 2013. Measures of sleep duration, timing, and disruption were averaged over all days. Neighborhood characteristics were assessed via questionnaires administered to participants and an independent sample within the same neighborhood and aggregated at the neighborhood (census tract, *N* = 783) level using empirical Bayes estimation. Multilevel linear regression models were used to assess the association between the neighborhood social environment and each sleep outcome.

Results: Neighborhood social environment characterized by higher levels of social cohesion and safety were associated with longer sleep duration and earlier sleep midpoint. Each 1 standard deviation higher neighborhood social environment score was associated with 6.1 minutes longer [95% confidence interval (CI): 2.0, 10.2] sleep duration and 6.4 minutes earlier (CI: 2.2, 10.6) sleep midpoint after adjustment for age, sex, race, socioeconomic status, and marital status. These associations persisted after adjustment for other risk factors. Neighborhood social factors were not associated with sleep efficiency or sleep fragmentation index.

Conclusions: A more favorable neighborhood social environment is associated with longer objectively measured sleep duration and earlier sleep timing. Intervening on the neighborhood environment may improve sleep and subsequent health outcomes.

Statement of Significance

With the growing prevalence of sleep disturbances in the United States, it is imperative to examine the determinants of poor sleep which may include the neighborhood environment in which we sleep. We investigated associations of neighborhood social cohesion and safety as well as a summary measure of the neighborhood social environment (social cohesion and safety) with objectively measured sleep. Individuals in neighborhoods with higher levels social cohesion and safety slept longer and had an earlier sleep timing. These results demonstrate the significance of the impact of the neighborhood environment on sleep outcomes. Future research should explore the neighborhood environment as a point of intervention to improve sleep.

Keywords: Neighborhoods, sleep duration, sleep timing, actigraphy.

INTRODUCTION

Sleep deficiency has been recognized as an independent risk factor for a host of adverse health outcomes including mood, cardiovascular, and metabolic disorders.[1–3] The social determinants of sleep patterns at a population level continue to be defined but increasing evidence suggests neighborhood factors may play an important role. Ambient noise and light in the neighborhood can have detrimental effects on sleep.[4–9] The neighborhood social environment (including perceptions of levels of trust or safety) could also affect sleep. There is evidence that the neighborhood social environment is linked to mood disorders, obesity, and cardiovascular disease.[10–13] If the social environment is linked to sleep, sleep could represent an important mediator of the links between social environments and these outcomes.

Research regarding the impact of neighborhood social environment on sleep has been limited by a reliance on self-reported assessments of both sleep and neighborhood characteristics.[14–20] Self-reported assessments of sleep duration correlate weakly with objective measures and level of agreement varies by socioeconomic status and race.[21] The use of self-report to measure both sleep and neighborhood conditions also results in the potential for same-source bias. In addition, reliance on reports of sleep duration prevents evaluation of other aspects of sleep such as sleep timing and fragmentation that are increasingly identified as important predictors of health outcomes.[22,23] Similar to sleep duration, sleep timing, and fragmentation could be affected by the neighborhood social environment by increasing stress which leads to a state of arousal which may delay sleep or cause difficulty in maintaining sleep. Additionally, the association between neighborhood social environment and sleep may vary according to race as a result of differential access to resources (i.e. fitness or community centers, parks, etc) that may mitigate the adverse influence of the environment on sleep. However, the extent to which race modifies the relationship between neighborhood and sleep has not yet been explored.

We investigated the relationship between neighborhood social environment and habitual sleep patterns using community ratings of neighborhoods and actigraphic measures of sleep available in the Multi-Ethnic Study of Atherosclerosis (MESA). We further explored for modification of these relationships by race/ethnicity. We hypothesized that a favorable neighborhood social environment (higher social cohesion and safety) would be associated with a longer sleep duration, earlier midpoint, and less fragmented sleep.

METHODS

MESA is a longitudinal multi-ethnic study of adults between 45 and 84 years old at baseline sampled from 6 communities in the United States: Baltimore City and Baltimore County, Maryland; Chicago, Illinois; Forsyth County, North Carolina; Los Angeles County, California; Northern Manhattan and the Bronx, New York; and St. Paul, Minnesota. The study was designed to prospectively investigate risk factors for subclinical cardiovascular disease and progression to clinical disease.[24] Between 2000 and 2012, 5 exams were conducted. The current analyses utilize data on sleep measures and neighborhood characteristics from 2 MESA ancillary studies collected in conjunction with Exam 5. Institutional Review Board approval was obtained at each study site and written informed consent was obtained from all participants.

Neighborhood Social Environment

Survey-based measures of neighborhood characteristics were administered to MESA participants in Exam 5 (2010 to 2012) as part of the MESA Neighborhood ancillary study. In addition, the survey was administered to an independent sample of non-MESA participants recruited via list-based sampling from the same census tracts as MESA participants between 2011 and 2012, referred to as the community survey (CS).[25] This sample consisted of 4212 adult respondents, representing a 33.7% overall response rate for the CS sample. Neighborhoods were defined as census tracts ($N = 783$). The social environment was assessed using scales for social cohesion which was based on four items (e.g., "people in my neighborhood can be trusted")[26] and safety based on 3 items (e.g., "I feel safe walking in my neighborhood, day or night")[27] in which respondents were asked to rate the area within 1-mile or a 20-minute walk of their home. To create the neighborhood measures, responses from MESA and CS surveys were pooled to increase the number of informants per neighborhood and improve precision. Conditional empirical Bayes (CEB) estimates were derived for each census tract from 3-level hierarchical linear models (i.e., scale items nested within individuals nested within census tracts) and were adjusted to the mean gender, age, study site, and study source (MESA or CS) distribution of respondents to account for any systematic differences in these factors. In addition, a summary neighborhood social environment score was created by summing the standardized component measures for social cohesion and safety. In secondary analyses, we used individual-level MESA participant responses to the same items as alternative measures of the neighborhood social environment representing individual perceptions as opposed to neighborhood level measures.

Sleep Measures

Between 2010 and 2013, sleep patterns were assessed using 1 week of wrist actigraphy as part of the MESA Sleep Ancillary study. Participants wore an Actiwatch Spectrum device (Philips Respironics, Murrysville, PA) on the nondominant wrist for 7 consecutive days, while completing a sleep diary over the same period.[28] A centralized reading center at Brigham and Women's Hospital, Boston, MA, scored all records. Details regarding the measurement and scoring of the actigraphic data have been previously published.[29] In brief, sleep–wake status was determined for each 30 second epoch using a validated algorithm in which a weighted average of activity counts for the epoch and surrounding 2-minute time period (i.e., ±2 minute) was computed.[30] Sleep duration was the sum of all epochs scored as sleep in the main sleep period. Sleep midpoint was calculated as the point halfway between sleep onset and sleep offset. Sleep efficiency was the proportion of epochs between sleep onset and sleep offset scored as sleep. The sleep fragmentation index was calculated as the sum of 2 proportions: the proportion of all epochs during the sleep period that were mobile (i.e., the activity count was 2 or greater) and the proportion of all immobile bouts (i.e., consecutive epochs where the activity count was less than 2) during the sleep period that were 1 minute or less in duration. Each sleep variable was computed for each day of recording and then averaged across all recorded days. Only those individuals with at least 5 days of data were included in analyses. Sleep duration was categorized as short (<6 hours), normal (6–8 hours), and long (>8 hours). Scoring reliability was high (intraclass coefficients for sleep duration and efficiency: 0.84 to 0.86.)

Covariates

Socioeconomic status was assessed with highest level of education, household income, and employment status. Education was based on a 9-category scale ranging from 0 to 8 (no schooling to graduate or professional school). Household income was divided into 15 categories ranging from <$5000 to >$150 000. For study sample demographics only we further categorized income into 4 groups (<$25 000, $25 000–$49 000, $50 000–$74 000, and ≥$75 000). Employment was categorized as employed, unemployed, retired, and homemaker. Marital status was categorized as either married/living with a partner or not.

Height and weight were measured at baseline and body mass index (BMI) was calculated as the ratio of weight (in kilograms) to height (in meters) squared. Alcohol use was treated as the average number of drinks consumed per week derived from the food frequency questionnaire designed for the Insulin Resistance and Atherosclerosis Study.[31] Smoking status was categorized as current smoker or not. Depressive symptomology was assessed with the Center for Epidemiologic Studies of Depression (CES-D) scale and modeled continuously.[32] In-home polysomnography was performed as previously described,[29] and the apnea–hypopnea index (AHI) was calculated as the number of apneas plus hypopneas associated with a 4% desaturation per hour of sleep.

Statistical Analysis

Out of 2258 participants, we excluded individuals with missing neighborhood data and those without at least 5 days of actigraphy data, which yielded 1949 individuals as the analytical sample. Based on scatterplots with a fitted smooth line, we found no evidence that the relationship between sleep and neighborhood social environment measures was nonlinear. Multilevel linear models were used to model the associations of neighborhood sleep environment with continuous measures of each sleep measure (sleep duration, sleep midpoint, sleep efficiency, and sleep fragmentation index).

Regression models included a random intercept for the census tract to account for within tract correlation. Neighborhood characteristics were modeled adjusting for age and sex (model 1) and then with further adjustment for race/ethnicity, education, income, marital status, and employment (model 2). A subsequent model additionally adjusted for BMI, alcohol use, smoking status, depressive symptoms, and AHI (model 3) given the potential for these latter factors to be on the causal pathway.

Finally, in an exploratory fashion, we investigated whether the associations of neighborhood social environment and sleep were modified by race/ethnicity. Interaction terms between each neighborhood exposure variable and race/ethnicity were included in the fully adjusted models and a $p < .05$ was considered statistically significant. For models where evidence of effect modification was found, we conducted analyses stratified by race/ethnicity. Associations of neighborhood variables with sleep are reported for a 1 standard deviation (SD) difference in the exposure to facilitate comparisons. All analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

The study population (n = 1949) had a mean age of 68.6 (*SD* 9.1) years and was 45.9% male. The mean nightly sleep duration was 6.5 (1.3) hours with 30.6% of the cohort sleeping less than 6 hours, 58.2% sleeping 6 to 8 hours, and 11.1% sleeping more than 8 hours. The average sleep midpoint time was 03:16 am (01:23).

Table 1 shows demographic characteristics by sleep duration categories. Respondents who reported short sleep were more likely than those who reported long sleep to be African American, have a college degree or higher, and have a lower income. They also had higher BMI, and higher levels of depressive symptoms. Sleep duration was longest among Hispanics and shortest among African Americans (Supplemental Table 1). Neighborhood social cohesion and social environment scores were highest among non-Hispanic whites while safety scores were highest among Asians. In bivariate analyses, higher neighborhood social cohesion and safety were associated with longer sleep duration ($p_{trend} < .05$ for both).

Multivariable Analysis

Table 2 shows mean differences in sleep duration and sleep midpoint associated with 1 SD higher levels of neighborhood characteristics after adjustment for covariates. In age and sex adjusted models, each 1 SD higher neighborhood social cohesion and safety was associated with 8.5 minute (95% confidence interval: 4.5, 12.5) and 9.4 minute (95% CI: 5.3, 13.6) longer sleep duration, respectively. Results were attenuated but remained statistically significant in fully adjusted analyses (adjusted for age, sex, race/ethnicity, education, income, employment, AHI, marital status, BMI, depressive symptoms, alcohol use, and smoking). We conducted similar analyses with self-reported neighborhood characteristics, and in comparison to the results of the census tract-level neighborhood characteristics and sleep duration, the estimates were attenuated and mostly nonsignificant (Supplemental Table 2).

Higher levels of neighborhood social cohesion were also associated with an earlier sleep midpoint. For every 1 *SD* increase in the social environment (higher social cohesion and safety) the sleep midpoint was 5.8 minutes (95% CI: 1.7, 9.9) earlier after adjustment for age and sex. Findings were attenuated but statistically significant in the fully adjusted model. In contrast, there were no associations between neighborhood social environment and either sleep efficiency or sleep fragmentation index (Table 3).

Effect Modification

In exploratory analyses, tests for interaction were not statistically significant. However, the association between neighborhood social cohesion and sleep duration differed somewhat by race/ethnicity, $p_{int} < .10$ (Supplemental Table 3), such that the association of higher neighborhood social cohesion with longer sleep duration was strongest in African Americans, where each *SD* increase in social environment score was associated with an additional 12.0 minutes (95% CI: 5.2, 18.8) of sleep. No significant associations of neighborhood social environment with duration were apparent in other race/ethnic groups although there was an inverse association among Chinese participants that was not statistically significant.

Race did not modify the association between neighborhood characteristics and sleep timing (Supplemental Table 1).

DISCUSSION

Our results show that a more favorable social environment is associated with a longer nightly sleep duration and earlier timing of the sleep period. We enhanced prior research by using objective measures of sleep and by creating improved neighborhood level measures which aggregate the responses of multiple informants (rather than relying only on the report of the study participant). These findings confirm prior studies using self-report on the positive impact of neighborhood social environment on sleep duration while also demonstrating for the first time that a supportive social environment is associated with earlier sleep timing as well. In contrast, we found no association between neighborhood social environment and measures of sleep efficiency or fragmentation.

Reductions in sleep duration have been strongly associated with a host of adverse health outcomes including impacts on mood, metabolic, and cardiovascular disease.[33,34] Similarly, delayed sleep timing has been associated with increased risk of depression and recent data suggest adverse associations with obesity and diabetes risk as well.[23,35–37] For example, delayed sleep timing may lead to depression.[35] Our observed associations may represent important pathways by which a poor neighborhood social environment predisposes to adverse health outcomes.

Prior research suggests residents of neighborhoods with more favorable social environments are more likely to report a longer habitual sleep duration.[17,18] A prior MESA analysis using a similar assessment of the neighborhood social environment (low disorder, high social cohesion and safety) found a more positive social environment was associated with longer self-reported sleep, with a 9-minute increase in sleep duration for each 1 *SD* improvement in neighborhood

Table 1—Distribution of Selected Characteristics Across Categories of Sleep Duration (*N* = 1949).

		Sleep duration			
	Full sample (*n* = 1949)	<6 hours (*n* = 597)	6–8 hours (*n* = 1135)	>8 hours (*n* = 217)	*p*
Age (years)	68.6 (9.1)	68.5 (9.3)	68.0 (8.9)	72.1 (9.1)	<0.001
Male (%)	45.9	16.9	25.1	3.9	<0.001
Race (%)					<0.001
African American	28.1	12.3	14.0	1.8	
Hispanics	22.1	6.8	12.2	3.0	
Asian/Chinese	11.5	4.0	6.6	0.9	
Non-Hispanic white	38.4	7.5	43.8	48.4	
Education (%)					0.02
<High school	14.1	3.9	7.8	2.4	
High school/GED	16.2	5.7	8.9	1.7	
Some college	24.3	6.9	14.8	2.7	
>college	45.3	14.1	26.8	4.4	
Employment (%)					<0.001
Employed	40.5	13.3	24.7	2.5	
Unemployed	4.8	1.9	2.4	0.5	
Retired	45.6	13.3	25.8	6.5	
Homemaker	9.1	2.0	5.4	1.6	
Household income (%)					<0.01
<$25 000	25.5	8.8	13.3	3.5	
$25 000–$49 000	27.9	8.7	16.3	2.8	
$50 000–$74 000	18.1	5.5	10.4	2.2	
$75 000+	28.4	7.6	18.4	2.4	
Married/living as married (%)	60.9	16.7	38.2	6.0	<0.001
BMI (kg/m^2)	28.8 (5.5)	29.6 (5.7)	28.4 (5.4)	28.2 (5.4)	<0.001
Alcohol use (drinks per week)	2.7 (6.7)	2.6 (6.7)	2.7 (6.4)	3.3 (8.5)	0.43
Active smoker (%)	6.7	3.0	2.8	0.9	<0.001
CES-D score	8.2 (7.6)	9.4 (8.0)	7.6 (7.0)	8.4 (8.6)	<0.001
AHI (events/hour)	20.2 (18.9)	23.3 (20.2)	18.7 (18.4)	18.8 (17.2)	<0.001

All values expressed as percentage or mean (*SD*). AHI = apnea–hypopnea index; BMI = body mass index; CES-D = Center for Epidemiologic Studies Depression scale; GED = general educational development.

social environment.[17] The previous study relied upon self-reported sleep which is known to overestimate objective sleep duration.[21] In the current study using a subset of participants with actigraphy data, we confirmed a positive association between neighborhood social environment and objective sleep duration. Additionally, in an analysis of African Americans participating in the Jackson Heart Study, individuals in neighborhoods with lower violence levels had a longer self-reported sleep duration.[18] Another study of adolescents demonstrated that greater neighborhood social fragmentation was associated with reduced self-reported habitual sleep.[8] Our results using actigraphy-based sleep duration are consistent with these previous studies.

We used neighborhood measures aggregated over multiple respondents because this aggregation process is likely to yield a better estimate of the "objective" qualities of the neighborhood.[27,39] The use of these measures also avoids same-source bias and reverse causation effects (sleep disturbance affects perceptions). However, because individuals' perceptions of their environments may be especially important to sleep we repeated analyses using only individual reports. Contrary to expectation we observed weaker associations when these measures were used. It is possible that the aggregate measure is a better reflection of the true exposure that is relevant to sleep, and that imprecise measurement of individual perceptions hampers the ability to detect associations. Alternatively confounding by

Table 2—Adjusted Mean Differences in Sleep Duration and Sleep Midpoint Associated With a 1 *SD* Better Neighborhood Social Environment, *N* = 1949.

	Age and sex adjusted model	Model 2	Model 3
Sleep duration (minutes)			
Social cohesion	8.52 (4.51, 12.52)[a]	5.55 (1.45, 9.64)[a]	6.09 (1.91, 10.27)[a]
Safety	9.44 (5.31, 13.57)[a]	6.18 (2.10, 10.26)[a]	6.07 (1.92, 10.23)[a]
Social environment	9.43 (5.40, 13.46)[a]	6.07 (1.99, 10.16)[a]	6.39 (2.24, 10.54)[a]
Sleep midpoint (minutes)			
Social cohesion	−5.43 (−9.53, −1.33)[a]	−6.88 (−11.06, −2.71)[a]	−7.54 (−11.86, −3.21)[a]
Safety	−4.91 (−9.08, −0.75)[b]	−4.41 (−8.57, −0.26)[b]	−4.13 (−8.43, 0.17)[c]
Social environment	−5.84 (−9.95, −1.73)[a]	−6.40 (−10.58, −2.23)[a]	−6.60 (−10.90, −2.29)[a]

Model 2 adjusted for age, sex, race/ethnicity, education, income, employment status, and marital status. Model 3 adjusted for variables in Model 2 as well as apnea–hypopnea index, body mass index, depressive symptoms, alcohol use, and smoking status. One *SD* = 0.21 (social cohesion); 0.37 (safety); 1.73 (social environment).
[a]$p \leq .01$; [b]$p \leq .05$; [c]$p \leq .10$.

Table 3—Adjusted Mean Differences in Sleep Disruption Associated With a 1 *SD* Better Neighborhood Social Environment, *N* = 1949.

	Age and sex adjusted model	Model 2	Model 3
Sleep efficiency (%)			
Social cohesion	0.27 (0.10, 0.43)[a]	0.10 (−0.08, 0.27)	0.12 (−0.06, 0.30)
Safety	0.16 (−0.01, 0.33)	0.02 (−0.15, 0.19)	0.01 (−0.17, 0.18)
Social environment	0.23 (0.06, 0.40)[a]	0.06 (−0.11, 0.23)	0.07 (−0.11, 0.25)
Sleep fragmentation index (%)			
Social cohesion	−0.13 (−0.44, 0.17)	0.04 (−0.29, 0.36)	−0.08 (−0.42, 0.25)
Safety	−0.11 (−0.42, 0.19)	−0.01 (−0.32, 0.31)	−0.02 (−0.35, 0.30)
Social environment	−0.12 (−0.42, 0.19)	0.03 (−0.29, 0.35)	−0.04 (−0.37, 0.29)

Model 2 adjusted for age, sex, race/ethnicity, education, income, employment status, and marital status. Model 3 adjusted for variables in Model 2 as well as apnea–hypopnea index, body mass index, depressive symptoms, alcohol use, and smoking status. One *SD* = 0.21 (social cohesion); 0.37 (safety); 1.73 (social environment).
[a]$p \leq .01$.

other neighborhood level measures correlated with the aggregate measures could play a role.

Our analyses also describe an association between a more favorable neighborhood social environment and earlier sleep midpoint. It is unclear whether this reflects an impact purely on behavioral factors altering the timing of sleep or differences in circadian rhythms or sleep homeostatic drive. However, prior studies have found social factors such as neighborhood stressors can impact circulating cortisol profiles over the day.[40,41] Our finding is significant because sleep timing, determined by an interaction between the circadian clock and homeostatic sleep pressure,[42] can lead to circadian misalignment and result in adverse cardiometabolic effects.[23,43,44] However, further research on the relationship between neighborhood social environment and circadian biology using validated circadian markers is needed.

In contrast to effects on duration and timing of sleep, we found no association between neighborhood social environment and actigraphic measures of sleep disruption such as sleep efficiency or the sleep fragmentation index. Sleep efficiency and fragmentation were highly correlated, and weakly correlated with sleep duration and timing. These actigraphic measures of sleep disruption record movement, and not true electroencephalogram measures of sleep and thus may not be sensitive enough to detect arousals/awakenings. However, our findings contrast with prior work demonstrating a consistent association between more favorable neighborhood social environments and better self-reported sleep quality.[14,16,45–47] The null finding may be explained by our use of objective sleep measures, as opposed to the subjective measures in prior studies as it is well recognized that objective and subjective assessments of sleep quality differ, particularly in individuals with insomnia.[48]

Studies on driving performance have demonstrated clinically important improvements in performance with a 20-minute increase in habitual sleep duration.[49] Experimental work focused on disrupting sleep indicates that even 10-minutes of uninterrupted sleep can be restorative.[50–52] Thus, the effect sizes for sleep duration observed in this study when accumulated on a long term basis may have important effects on neurocognitive function and performance. However, it should be remembered that the effect sizes reported represent population averages and there are likely subgroups who may be much more susceptible to neighborhood effects. More work is needed to quantify the clinical relevance of the effect sizes observed regarding the impact on adverse metabolic and cardiovascular consequences.

There are a number of potential pathways by which a more favorable neighborhood social environment could impact sleep. Some of these may be through behavioral effects. For example, in the setting of a strong social environment, positive role modeling of sleep hygiene (e.g., not staying up late) from neighborhood peers may be more effectively conveyed. This could be directly through the timing of socializing activities with neighbors or disapproval of loud noises late at night. Alternatively, there may be indirect effects through irregular schedules or chaotic routines which impact sleep patterns as well.

From a biological standpoint, a poor neighborhood social environment activates stress pathways.[53] The social context of the neighborhood is associated with stress biomarkers,[40,54–56] suggesting that a poor neighborhood social environment may elicit chronic activation of the hypothalamic–pituitary–adrenal axis,[57] which in turn limits the ability to sleep.[58] Lack of safety may also activate limbic systems such as the amygdala and medial prefrontal cortex along with the locus coeruleus and dorsal raphe that prevent initiation of sleep.[59]

An exploratory finding of our work was the potential effect modification of neighborhood social cohesion by race. Although findings from secondary analyses need to be interpreted with caution and the tests for effect modification were not statistically significant, our results suggest that the impact of neighborhood social cohesion on sleep duration could be larger among African Americans. In stratified analyses, we found statistically significant associations between neighborhood measures and sleep duration in African Americans; in contrast, there were no statistically significant associations observed in any of the other groups. These findings need to be confirmed in larger samples given the multiple interactions investigated.

There are several strengths of this study. The use of a dense sampling design in combination with the use of empirical Bayes estimates to quantify neighborhood characteristics, likely increases the validity of the neighborhood measures in this study. We also expanded the literature beyond investigating self-reported sleep.[14–17,19,20,45–47] Our study is unique in being the first to show evidence of the association between the social neighborhood environment and sleep duration measured with the use of actigraphy which may be more accurate than self-reported measures of sleep.[60] Furthermore, we have identified for the first time that neighborhood social environment impacts the sleep midpoint, suggesting the possibility of effects on underlying circadian rhythms.

Our study also has limitations. We examined cross-sectional associations and thus causal relationships cannot be determined. There was no information on housing conditions, that have been shown to affect sleep, independent of the neighborhood social environment.[46,61] Our study population only included middle age and older adults; thus, our findings are not generalizable to populations with different demographics. Additionally, residual confounding may be possible if there were unmeasured covariates at the individual (e.g., individual occupation) and/or neighborhood level that were not accounted for in the statistical models. Finally, our study focused on the social neighborhood environment, which excludes effects of the physical environment. Features of the physical neighborhood environment such as noise pollution from traffic, access to healthy foods, walkability (presence of parks and sidewalks), and presence of liquor stores may have both direct and indirect effects on sleep.[62,63]

In summary, we found the neighborhood social environment is related to objectively measured sleep duration and sleep midpoint with a supportive social environment associated with both longer sleep duration and earlier timing of sleep. Future research should evaluate the extent to which sleep represents a clinically relevant mediator of the impact of neighborhood social environment on long-term health outcomes. The neighborhood environment may be a point of intervention to improve sleep health.

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SUPPLEMENTARY MATERIAL

Supplementary Material is available at *SLEEP* online.

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