The relationship between social fragmentation and sleep among adolescents living in Boston, Massachusetts

Journal of Public Health | Vol. 36, No. 4, pp. 587–598 | doi:10.1093/pubmed/fdu001 | Advance Access Publication 3 February 2014

The relationship between social fragmentation and sleep among adolescents living in Boston, Massachusetts

Roman Pabayo[1], Beth E. Molnar[2], Nancy Street[3], Ichiro Kawachi[1]

[1]Department of Social and Behavioral Sciences, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115, USA
[2]Bouvé College of Health Sciences, Northeastern University, Boston, MA 02115, USA
[3]School of Nursing, Science and Health Professions, Regis College, Weston, MA 02493, USA
Address correspondence to Roman Pabayo, E-mail: rpabayo@hsph.harvard.edu

ABSTRACT

Background Sufficient sleep is needed for the healthy development of youth. However, only a small minority of adolescents obtain adequate amounts of sleep. Although individual-level correlates of sleep have been identified, studies investigating the influence of the environment on sleep are warranted.

Methods By using cross-sectional data collected from 1878 urban adolescents living in 38 neighborhoods participating in the 2008 Boston Youth Survey (BYS), we determined the association between neighborhood social fragmentation and sleep. Social fragmentation of each participant's residential neighborhood was composed using 2010 US Census data. Multilevel regression models were used to determine the association between social fragmentation and meeting the recommended hours of sleep (>8.5 h) and sleep duration while controlling for individual-level sex, race, age and nativity.

Results Moderate (OR = 0.51, 95% CI = 0.27, 0.97) and high (OR = 0.33, 95% CI = 0.18, 0.61) social fragmentation within the residential neighborhood was associated with a decreased likelihood of obtaining adequate sleep. Those in moderate ($\beta = -23.9$, 95% CI = −43.1, −4.8) and high ($\beta = -22.1$, 95% CI = −43.3, −0.9) socially fragmented neighborhoods obtained fewer minutes of sleep per night.

Conclusions Social fragmentation may be an important determinant of sleep among youth living in urban settings.

Keywords environment, public health, social determinants

Introduction

The Centers for Disease Control and Prevention (CDC) recommends adolescents obtain a minimum of 8.5 h of sleep per night (http://www.cdc.gov/sleep/about_sleep/how_much_sleep) for healthy growth and development. However, a majority of American adolescents do not meet this recommendation.[1,2] For example, among US adolescents, an estimated 63–87% of adolescents report needing more sleep than they obtain.[1,2] Some researchers estimated that 15 million American children do not obtain adequate sleep.[3] Further investigation of the predictors of sleep as well as the mechanisms involved, is needed to understand the phenomenon of lack of adequate sleep among adolescents.

Obtaining adequate sleep is important for the growth and development of children and adolescents.[4] Sleep plays a key role in the many metabolic, immune, thermoregulatory, cardiovascular and respiratory functions.[5–8] Inadequate sleep has also been identified as a risk factor for overweight and obesity.[9] According to a recent review, children aged 6 to 12 sleep ∼10 h per night.[10] As children age into adolescence, total sleep demands are unchanged, but adolescents obtain substantially less sleep than school-aged children.[10] For example, the amount of sleep obtained decreases from 10 h during childhood to 7.5–8.0 h by age 16.[10–13]

Roman Pabayo, Postdoctoral Fellow
Beth E. Molnar, Associate Professor
Nancy Street, Associate Professor
Ichiro Kawachi, Professor

Certain demographic sub-groups are at risk for inadequate sleep. In general, older youth obtain significantly fewer minutes of total sleep time in comparison with younger children.[10,14–16] Minority boys slept significantly less than non-minority boys and girls and minority girls.[17] Also, the oldest minority boys, on average, obtained significantly fewer minutes of sleep in comparison with students in other age, sex and ethnic sub-groups.[17] Lower socioeconomic status was associated with fewer minutes of sleep.[18,19] Also, nativity has shown to be associated with sleep duration. For example, foreign-born adolescents accumulate more minutes of sleep in comparison with those who were born in the USA.[20] Depressive symptoms of the parents and the child are also associated with inadequate sleep.[3] Among Mexican-Americans, researchers identified lower parental acculturation and the fathers' familial values as predictors of more healthful sleep, whereas higher levels of family income, parental education and parental perception of neighborhood crime were predictive of less healthful sleep.[21]

On top of individual characteristics, the social determinants of health framework posit that the conditions in which 'people are born, grow, live, work, and age, play an important role in health and well being (http://www.who.int/social_determinants/en/).' Therefore, although not thoroughly examined in their role in sleep, the environmental factors of the residential neighborhood might influence this behavior. For example, the social environment, which incorporates the physical surroundings, social relationships and cultural settings within which groups of individuals and families reside and interact, might influence sleep behavior.[22] Youth who live in economically deprived urban settings are more likely to be exposed to social disorder,[23] such as violence, which may have a detrimental impact on their mental health[24] and therefore disrupt their sleep.[25] Another example is noise within a neighborhood, such as ambulance sirens and vehicular traffic, which can potentially disturb or disrupt sleep.[26–28] Similar to exposure to social disorder, in comparison with those from higher socioeconomic status, individuals from lower socioeconomic status are more likely to live off of busy roads and through roads and are therefore more likely to be affected by noise.[29] Also, neighborhood social cohesion has been identified as a correlate for shorter sleep duration.[30] Therefore, the social and physical environment can make a substantial impact on sleep among youth.

In the present study, we determine whether social fragmentation, a social environmental exposure, relates to sleep among adolescents. Social fragmentation is linked to the concept of anomie, which Emile Durkheim defined as a state of normlessness,[31] or the breakdown of social bonds between individuals and their communities. Social fragmentation is thought to be a representation of greater residential instability. These communities are characterized by fragmentation of residents' social identity, and by rejection of self-regulatory values.[31]

For example, researchers have used US Census variables to describe specific social conditions, such as proportion of residents moving out of residential area within the last 5 years, to describe stability. Instead of being a proxy for poverty, these relate to rapid turnover, lone person households and rented tenancy.

Contextual characteristics might influence sleep through several plausible mechanisms.

The residential environment might affect sleep directly, i.e. makes an impact on how adolescents sleep, or indirectly, i.e. through mediators. These mediators could be behavioral, such as physical activity, or psychological, such as poor mental health. For example, neighborhood social fragmentation has been investigated to be associated with physical activity.[32] In turn, recent evidence suggests that those who get at least 150 min of exercise a week were significantly more likely to sleep better than those who do not.[33] Among adolescents, those who achieved $\geq$5 bouts of Moderate-to-Vigorous-Physical Activity per week were more likely to sleep $\geq$8 h of sleep.[34] Similarly, increased sedentary behavior was associated with an increased likelihood of having sleep problems.[35]

Another potential mediator is adverse mental health, such as depressive symptoms. Social fragmentation has shown to be associated with poor mental health.[36–39] Furthermore, experiencing depressive symptoms has been shown to be a determinant of poor sleep.[40] Also, other behaviors, such as smoking and alcohol consumption, might lie along the causal pathway between social fragmentation and sleep. Cigarette smoking[41,42] and alcohol consumption[42,43] have been shown to be associated with sleep problems and shorter sleep duration among adolescents, as well as to social fragmentation.[44,45] Finally, another potential mediator is perception of neighborhood safety. Social fragmentation has been shown to be related to perception of neighborhood safety and in turn, perception of neighborhood safety has been identified as a correlate of poor quality of sleep[46] and inadequate sleep.[3]

In this study, we investigated the relationship between area-level social fragmentation and sleep among adolescents in Boston, Massachusetts. We tested the hypothesis that high social fragmentation is associated with a decreased likelihood of obtaining the minimum recommended hours of sleep and sleep duration. We also tested several possible mechanisms that may account for why social fragmentation is associated with sleep.

Methods

We used data from the 2008 *Boston Youth Survey* (BYS), a biennial survey of high school students (grades 9–12) in Boston

Public Schools. Sampling has been described elsewhere.[47,48] The research team sought to administer the BYS in all eligible Boston Public high schools ($n = 31$).[48] Schools that were excluded were those that serve adults, short-term schools and those that serve students with severe disabilities.[48] Twenty-two of the eligible schools participated in the survey (71%). The final sample of schools was representative of all schools in the Boston area in terms of race/ethnicity of the students, school drop-out rates and other variables.[48]

A unique list of classrooms was obtained from each school, and classrooms stratified by grade were randomly selected for participation in the survey until ~100–120 students were identified. All students in randomly selected classrooms were invited to participate.[48] We used passive consent, and students were free to decline to participate at any time before or during the survey administration. The response rate was 69%, yielding a sample size of 1878 students. Since complete data were available for 1148/1878 = 61.1% students, we used multiple imputations to replace missing behavioral data. As a result, complete data, within the imputed data set, were available for 1375 (1375/1878 = 73.2%) students. Briefly, we imputed missing values within five copies of the data set. We then used multilevel regression analyses to fit the model of interest to each of the imputed data sets. Next, we averaged estimates to obtain overall estimated associations.[49] Those with missing data were more likely to be male, black and older in age and to have immigrated to the USA within the last 4 years.

Data collection

The BYS staff developed the questionnaire, utilizing multiple reliable and valid scales, to measure behaviors, with a particular emphasis on violence exposure. During the spring of 2008, a paper-and-pencil survey was administered in classrooms by trained staff (youth workers, researchers, graduate students and city workers). The Office of Human Research Administration at the Harvard School of Public Health approved data collection procedures for the BYS.

Study variables

To measure usual sleep duration, students were asked, 'How many hours and minutes of sleep do you usually get on a school night?' Based on the CDC's recommendation (http://www.cdc.gov/sleep/about_sleep/how_much_sleep), responses were dichotomized to ≥8.5 h and <8.5 h per night. Also, the number of hours of sleep was converted to the number of minutes to obtain a continuous measure of sleep duration.

Exhibiting depressive symptoms was measured using five indicators from the modified depression scale, which has been shown to have acceptable reliability and validity psychometrics.[50] Students were asked 'In the past month, how often . . .(a) "Were you very sad?"; (b) "Were you grouchy or irritable, or in a bad mood?"; (c) "Did you sleep a lot more or less than usual?"; and (e) "Did you have difficulty concentrating on your work?"'. Response options included: (i) never, (ii) rarely, (iii) sometimes, (iv) often and (v) always. The internal consistency had a value of Cronbach's $\alpha = 0.79$. We derived total scores by summing items among youth who had complete responses for all five items (range: 5–25).[50] We categorized students with scores of >20 as having depressive symptoms.

To assess student perception of social cohesion of their neighborhood, five statements, which have been used previously,[51] were administered in the BYS. The average social cohesion score was 12.0 (SD = 2.9), and the range was 5 to 20. Tertile cutoffs were used to categorize social cohesion into low, moderate and high.

To assess student perception of neighborhood safety, they were asked '*Do you feel safe in your neighborhood?*' Response options were *never/rarely, sometimes* and *mostly/always*. For current smoking and alcohol consumption, students were asked, 'In the past 30 days, on how many days did you?' participate in the behavior. Response options included none, 1–2, 3–9 or 10 or more and were dichotomized into none versus yes. To measure physical inactivity, students were asked, 'In the past 7 days, on how many days did you exercise or participate in physical activity for at least 20 min that made you sweat and breathe hard?' Participants were categorized into inactive (0 days) or active (1–7 days).

We used 2010 US Census data, a representative survey of adult neighborhood residents, and crime data from the Boston Police Department to characterize each participant's residential neighborhood. Each participant in the BYS was asked to name the nearest cross streets to their residence. Useable residential information was obtained from 88% of the sample, and these respondents were assigned to US Census tracts for geocoding. Principal Components Analysis (PCA) was used to develop neighborhood-level indices for Social Fragmentation, Economic Deprivation and Danger each of which was geocoded to US Census tracts, described later. For each construct, tertiles of the PCA derived scores were used to categorize the constructs into low, moderate and high.

Social fragmentation, which is a measure of the stability within the neighborhood, was composed of the indicators proportion of residents who have lived in the same house for <5 years, proportion of vacant house units and proportion of owner-occupied housing (reverse coded). Social fragmentation ranged from −2.13 to 1.71, and the average score was 0 (SD = 1.0) (Cronbach $\alpha = 0.87$).

Economic deprivation was composed of the following indicators: proportion of residents below poverty level, proportion of households on public assistance, proportion of households with 2009 income of <25 000 USD, proportion of households with 2009 income of >100 000 USD (reverse coded) and proportion of residents with a college degree (reverse coded). Principal Components Analysis indicated that the variables loaded onto the same factor (Cronbach $\alpha =$ 0.87). Economic Deprivation scores ranged from −1.79 to 2.42, and the average score was 0 (SD = 1.0). A higher score reflects greater economic deprivation of the student's residential neighborhood.

To assess neighborhood danger, the counts of criminal homicide, robbery, aggravated assault, burglary, larceny theft, vehicle theft and arson were added using data obtained from the Boston Police Department, geocoded to US Census tracts.

The Boston Neighborhood Survey (BNS) was used to measure neighborhood disorder. The BNS is a biennial random-digit-dial telephone survey of ∼1710 adults, aged 18 and older between January and September 2008 in Boston.[52] The BNS was used to supplement BYS data with contextual information about neighborhood-level conditions and social processes as perceived by adult residents.[48,52] Disorder is a neighborhood exposure that is composed of both social (five items) and physical (four items) disorder. A combined score was created; a greater score is indicative of greater neighborhood disorder.

Other covariates included sex, age, nativity (US-born, foreign-born ≤4 years and foreign-born arrived >4 years) and race/ethnicity (white, black, Asian, Hispanic and other).

Statistical analysis

Because respondents were nested within neighborhoods, we used multilevel modeling to determine whether area-level social fragmentation was significantly associated with sleep ($P < 0.05$). Multilevel models are a generalization of the linear model used in traditional regression analysis.[53,54] Multilevel linear regression was used for the continuous sleep duration outcome, whereas multilevel logistic regression was used for the dichotomous (<8.5 and ≥8.5 h) outcome. We tested a threshold for adequate sleep of 8.0, which yielded similar findings (results not reported). In addition, since obtaining excessive amounts of sleep is associated with adverse health outcomes, students who sleep >10 h were excluded and analyses were repeated. Again, this sensitivity analysis yielded similar findings to the main analysis (results not shown).

To investigate the potential effect of social fragmentation on sleep, we adopted a step-up approach and conducted different sets of analyses.[53,54] A first set of analyses involved estimating the null model. For the continuous outcome model, the null model allows for the decomposition of variance in sleep duration to determine whether it was attributable to area-level and between-person variation. For the dichotomous outcome, the null model is used so that the 95% plausible value range could be computed, which is an indication of the degree of variability of the likelihood of meeting the 8.5 h of recommended sleep. Next, a set of analyses included social fragmentation and the other neighborhood-level characteristics. Then, individual-level characteristics were added to the models. Finally, smoking, alcohol consumption, physical inactivity, depressive symptoms and social cohesion were included in the models to test for mediation.

To determine whether smoking, alcohol consumption, physical inactivity, depressive symptoms, perception of neighborhood safety and social cohesion acted as mediators between social fragmentation and sleep, we applied the Baron and Kenny[55] method to test mediation. In order to identify whether these behavioral variables mediate the relationship between social fragmentation and sleep, the following relationships were checked: (1) whether Social Fragmentation is significantly associated with each of the potential mediators, (2) whether each of the mediators is significantly associated with sleep and (3) whether the relationship between social fragmentation and sleep is attenuated, once the potential mediators have been included.

Results

Characteristics of the 1375 students attending secondary schools in the Boston area are presented in Table 1. Overall, the sample had slightly more females (55.4%). Approximately 46% were black, and 71.6% were US-born. The average number of minutes of sleep per night achieved by the students was 397.8 (SD = 85.9) and $n = 129$ or 9.4% of the sample reporting sleeping 8.5 h or more. Also, for each demographic group, the average sleep duration and proportion meeting the 8.5 of sleep were indicated (Table 1). Students in younger age groups had more minutes of sleep duration in comparison with the older age groups. Also, white students in comparison with all the other racial groups and students without depressive symptoms in comparison with those with depressive symptoms had higher average sleep durations. Foreign-born students who have arrived ≤4 years ago had greater sleep duration in comparison with those born in the USA and those who were foreign-born and arrived >4 years ago.

Table 1 Characteristics of adolescents and the residential neighborhoods participating in the Boston Youth Study, 2008 ($n = 1375$)

Individual-level covariate	n	%	*Sleep duration mean (SD)*	*≥8.5 h of sleep (%)*
Sex				
Female	761	55.4	396.3 (83.3)	10.4
Male	614	44.7	399.0 (88.0)	8.1
Age				
14	114	8.3	416.7 (87.8)	14.9
15	281	20.4	404.1 (89.1)	11.0
16	374	27.2	406.0 (85.2)	9.6
17	361	26.3	392.5 (81.3)	7.5
18	188	13.7	381.9 (84.1)	7.5
19	57	4.2	362.1 (87.5)	7.0
Race				
White	156	11.4	406.7 (77.7)	6.4
Black	632	46.0	401.4 (87.9)	10.9
Asian	116	8.4	380.2 (89.5)	6.9
Hispanic	372	27.1	397.4 (82.5)	9.4
Other	99	7.2	383.5 (90.6)	7.1
Nativity				
US-born	984	71.6	396.0 (84.8)	8.7
Foreign-born arrived	117	8.5	413.1 (94.3)	16.2
≤4 years				
Foreign-born arrived	274	19.9	397.8 (85.8)	8.8
>4 years				
Depressive symptoms				
No	1263	91.9	401.9 (84.8)	9.7
Yes	112	8.2	361.1 (90.2)	6.3
Social cohesion				
Low	542	39.4	390.9 (85.2)	7.9
Moderate	407	29.6	402.7 (85.5)	10.3
High	426	31.0	402.0 (86.9)	10.3
Perception of neighborhood safety				
Never/rarely	164	11.9	394.8 (94.8)	11.0
Sometimes safe	190	16.6	395.9 (84.8)	8.4
Mostly/always safe	583	42.4	400.7 (84.6)	10.0
Smoked in the last 30 days				
No	1205	87.6	400.3 (85.1)	10.1
Yes	170	12.4	380.3 (89.9)	4.1
Consumed alcohol in the last 30 days				
No	842	61.2	382.7 (84.2)	11.5
Yes	533	38.8	407.4 (85.7)	6.0
Physically inactive				
No	1056	76.8	402.2 (83.9)	9.3
Yes	319	23.2	383.3 (91.0)	9.7
Neighborhood-level characteristic ($n = 38$)	Median	SD	Range	
Social fragmentation	−0.27	1.0	−1.17, 3.46	
Economic deprivation	−0.05	1.0	−1.79, 2.42	
Danger	0.16	1.0	−2.13, 1.71	
Disorder	2.84	0.49	2.06, 4.00	

The 95% plausible value range determined from the null multilevel model showed that the proportion of adolescents reporting sleeping 8.5 h or more ranged from 5 to 16% across neighborhoods. The null multilevel model for the continuous outcome showed that 98% and 2% of the variance in number of minutes sleeping were attributable to within-person and between-neighborhood variation, respectively.

The addition of the neighborhood-level characteristics revealed that those living in moderately (OR = 0.50, 95% CI = 0.27, 0.93) and highly (OR = 0.35, 95% CI = 0.19, 0.65) socially fragmented neighborhoods were less likely to meet the 8.5 h of sleep (Table 2). Also, those from moderately ($\beta = -25.0$, 95% CI = −44.5, −5.5) socially fragmented neighborhoods obtained fewer minutes of sleep in comparison with those from students living in low socially fragmented neighborhoods. Although not significant, those from highly socially fragmented neighborhoods ($\beta = -20.4$, 95% CI = −42.4, 1.6) obtained fewer minutes of sleep (Table 3).

The multilevel models that included only socio-demographic covariates identified older age groups as being less likely to obtain 8.5 h of sleep or more and accumulated significantly fewer minutes of sleep in comparison with their younger counterparts (Table 2). Conversely, immigrants who arrived within the previous 4 years were more likely to obtain the 8.5 h of sleep or more and on average accumulated >25 min of sleep in comparison with US-born students (Table 3).

When individual-level and neighborhood-level covariates were included (Model 2) in the analysis, findings were similar in that those in moderately (OR = 0.51, 95% CI = 0.27, 0.97) and highly (OR = 0.33, 95% CI = 0.18, 0.61) socially fragmented neighborhoods were less likely to obtain the recommended 8.5 h of sleep (Table 2). Similarly, students who lived in moderately ($\beta = -23.9$, 95% CI = −41.1, −4.8) and highly ($\beta = -22.1$, 95% CI = −43.3, −0.9)

Table 2 Multilevel analyses investigating the association between covariates and the likelihood of sleeping ≥8.5 h of sleep per night ($n = 1375$)

	Model 1		*Model 2*		*Model 3*	
	OR	*95% CI*	*OR*	*95% CI*	*OR*	*95% CI*
Individual covariates						
Intercept	0.29	0.15, 0.54	0.30	0.09, 0.95	0.34	0.10, 1.12
Sex (ref: male)						
Female			1.35	0.87, 2.09	1.37	0.88, 2.14
Age (ref: 14) (year)						
15			0.77	0.42, 1.40	0.77	0.41, 1.43
16			0.71	0.36, 1.38	0.69	0.35, 1.39
17			0.49	0.25, 0.97	0.49	0.25, 0.98
18			0.45	0.22, 0.91	0.50	0.24, 1.05
19			0.36	0.10, 1.33	0.45	0.11, 1.79
Race (ref: white)						
Black			1.35	0.73, 2.44	1.30	0.68, 2.49
Asian			1.02	0.51, 2.06	0.87	0.43, 1.78
Hispanic			1.29	0.63, 2.63	1.32	0.64, 2.76
Other			0.81	0.32, 2.08	0.79	0.31, 2.02
Nativity (ref: US-born)						
Immigrant (>4 years)			1.07	0.63, 1.81	1.10	0.65, 1.84
Immigrant (≤4 years)			2.38	1.36, 4.16	2.30	1.30, 4.08
Mediators						
Depression (ref: no symptoms)						
Depressive symptoms					0.76	0.37, 1.61
Social cohesion (ref: low)						
Moderate					1.51	1.03, 2.24
High					1.57	0.98, 2.52
Perception of neighborhood safety (ref: never safe)						
Sometimes safe					0.68	0.39, 1.19
Always safe					0.84	0.51, 1.40
Alcohol consumption last 30 days (ref: no.)						
Yes					0.56	0.36, 0.89
Tobacco smoking last 30 days (ref: no.)						
Yes					0.61	0.27, 1.36
Physical activity (ref: active)						
Physically inactive					1.06	0.70, 1.60
Neighborhood characteristics						
Economic deprivation (ref: low)						
Moderate	1.12	0.64, 1.98	1.04	0.09, 0.95	1.02	0.60, 1.74
High	1.12	0.55, 2.26	1.02	0.48, 2.18	1.02	0.50, 2.07
Social fragmentation (ref: low)						
Moderate	0.50	0.27, 0.93	0.51	0.27, 0.97	0.55	0.30, 1.00
High	0.35	0.19, 0.65	0.33	0.18, 0.61	0.35	0.19, 0.62
Danger (ref: low)						
Moderate	1.16	0.70, 1.92	1.16	0.68, 1.97	1.17	0.69, 1.97
High	1.84	1.23, 2.77	1.92	1.24, 2.96	1.94	1.25, 3.01
Disorder (ref: low)						
Moderate	0.70	0.46, 1.06	0.68	0.44, 1.07	0.73	0.49, 1.10
High	0.65	0.36, 1.18	0.63	0.32, 1.25	0.66	0.35, 1.25

Model 1: neighborhood-level factors added.

Model 2: neighborhood-level factors and demographic characteristics added.

Model 3: demographic, neighborhood-level factors and mediators added.

Table 3 Multilevel analyses investigating the association between characteristics and sleep duration in minutes ($n = 1375$)

	Model 1		*Model 2*		*Model 3*	
	β	*95% CI*	*β*	*95% CI*	*β*	*95% CI*
Individual covariates						
Intercept	401.2	378.0, 424.4	425.4	395.0, 455.8	426.1	393.8, 458.3
Sex (ref: male)						
Female			3.6	−5.2, 32.6	9.0	0.5, 17.5
Age (ref: 14) (year)						
15			−11.5	−33.2, 10.3	−8.7	−29.0, 11.6
16			−8.2	−26.0, 9.6	−5.2	−22.0, 11.7
17			−22.8	−41.9, −3.8	−19.5	−37.3, −1.7
18			−36.2	−52.5, −19.9	−29.1	−45.1, −13.1
19			−57.2	−86.0, −28.4	−44.0	−71.7, −16.2
Race (ref: white)						
Black			−8.8	−24.8, 7.2	−9.8	−26.4, 6.8
Asian			−23.2	−40.6, −5.8	−25.9	−42.9, −8.8
Hispanic			−12.0	−27.0, 3.1	−10.9	−26.7, 5.0
Other			−26.8	−49.1, −4.5	−29.4	−52.2, −6.6
Nativity (ref: US-born)						
Immigrant (>4 years)			5.3	−5.5, 16.1	6.0	−4.3, 16.3
Immigrant (≤4 years)			25.0	4.2, 45.8	24.3	3.1, 45.5
Depressive symptoms (ref: no.)						
Yes					−32.5	−48.7, −16.4
Social cohesion (ref: low)						
Moderate					9.8	0.5, 19.1
High					7.8	−2.1, 17.7
Perception of neighborhood safety (ref: never safe)						
Sometimes safe					−2.6	−16.4, 11.3
Always safe					1.6	−9.9, 13.0
Alcohol consumption last 30 days (ref: no.)						
Yes					−21.0	−30.2, −11.8
Tobacco smoking last 30 days (ref: no.)						
Yes					−3.3	−18.2, 11.6
Physical activity (ref: active)						
Physically inactive					−18.5	−27.2, −9.8
Neighborhood characteristics						
Economic deprivation (ref: low)						
Moderate	18.8	3.2, 34.4	18.0	2.4, 33.7	17.0	3.0, 31.1
High	14.5	−4.4, 33.4	13.7	−5.2, 32.6	13.9	−2.9, 30.7
Social fragmentation (ref: low)						
Moderate	−25.0	−44.5, −5.5	−23.9	−43.1, −4.8	−23.4	−41.7, −5.2
High	−20.4	−42.4, 1.6	−22.1	−43.3, −0.9	−19.6	−40.5, 1.2
Danger (ref: low)						
Moderate	−7.0	−22.8, 8.7	−4.1	−19.6, 11.3	−2.2	−17.0, 12.5
High	8.9	−5.6, 23.4	11.0	−3.8, 25.8	11.7	−3.0, 26.4
Disorder (ref: low)						
Moderate	4.3	−22.8, 8.7	3.9	−7.5, 15.3	6.9	−3.1, 16.8
High	11.5	−5.6, 23.4	10.3	−6.0, 26.6	12.2	−2.4, 26.8

Model 1: neighborhood-level factors added.

Model 2: demographic characteristics added.

Model 3: neighborhood-level factors and demographic characteristics added.

Model 4: demographic, neighborhood-level factors and mediators added.

socially fragmented neighborhoods obtained significantly fewer minutes of sleep in comparison with low socially fragmented neighborhoods (Table 3). When the analyses included the potential mediators (Model 3), the effect of social fragmentation on sleep remained. This is an indication that depression, social cohesion, perception of neighborhood safety, alcohol consumption, tobacco smoking and physical activity did not mediate the relationship between social fragmentation and sleep. The inclusion of these potential mediators would have eliminated or abated the relationship.

Results of testing whether alcohol consumption, smoking, physical inactivity, social cohesion, perception of neighborhood safety and depressive symptoms acted as possible mediators between area-level social fragmentation and sleep are presented in Table 4. High social fragmentation was associated with a significant increase in odds of alcohol consumption and being physically inactive, but associated with a significant decrease in odds of reporting moderate and high social cohesion. Moderate and high social cohesions were significantly associated with greater minutes of sleep duration. Those who consumed alcohol and smoked cigarettes were significantly less likely to sleep 8.5 h or more. Although these results indicate that the behaviors could potentially act as mediators between social fragmentation and sleep, results from the adjusted model (models 3, Tables 2 and 3) indicate otherwise.

Discussion

Main finding of this study

In this cross-sectional study in Boston, Massachusetts, we found that moderate and high social fragmentation was associated with a decreased likelihood of meeting the recommended number of hours of sleep and fewer minutes of sleep duration in comparison with those students living in low social fragmentation neighborhoods. The effect of social fragmentation on sleep was not abated when potential mediators were included in the model. The oldest children in comparison with the youngest were significantly less like to obtain 8.5 h of sleep and obtain fewer minutes of sleep. Whites in comparison with other racial groups, and immigrants who arrived in the USA <4 years ago in comparison with US-born students were more likely to obtain 8.5 h of sleep and obtain more minutes of sleep.

Among students participating in the BYS, the average number of minutes of sleep obtained was 6.61 h and 6.65 h among females and males, respectively. Also, sleep duration was highest among the youngest age group, 6.96 h, and lowest among the 19-year-olds, 6.04 h. In comparison with findings from other studies, these estimates are lower. For example, among adolescents aged 12–16 years, participating in a US Nationally representative study, average duration of sleep was 8.31 h among males and 8.15 h among females at baseline and then declined.[56] Among students followed from 14 to 18 years of age, attending high schools in Philadelphia, the average sleep duration at age 14 was 8.13 and 8.16 h among males and females, respectively.[57] By the end of the study, the average sleep duration was 7.54 and 7.52 h, among males and females, respectively.[57]

What is already known on the topic?

Sleep in itself is an important predictor of health. For example, researchers have identified sleep duration inversely associated with BMI.[58] A recent systematic review presented results that indicated shorter sleep duration was associated with subsequent weight gain among children.[9] Other researchers have identified sleep as a partial mediator between neighborhood disorder and self-rated health.[59] For example, they found that among adults living in a neighborhood that is perceived to be noisy, unclean and crime-ridden, they were more likely to report poorer self-rated physical health, which was mediated by lower sleep quality.[59]

Although we found no evidence of mediation between social fragmentation and sleep among this study population, these behaviors and depressive symptoms might lie along the causal pathway among other groups. Social fragmentation has already been identified as a risk factors for mental health,[38,60,61] suicide[62] and physical inactivity.[32] It is therefore reasonable to conceptualize behavioral factors as being partial mediators that are along the causal pathway between area-level social fragmentation and sleep. Other possible psychological conditions not measured in this study might also be risk factors for sleep problems. For example, anxiety has been shown to be associated with sleep problems, such as nightmares and difficulty sleeping alone, which may disrupt sleep duration and sleep quality.[63]

What this study adds

This study adds to the literature because it identifies how a socioeconomic characteristic of the residential neighborhood might interfere with the ability of children to obtain adequate sleep. Findings are consistent with the social determinants of health framework that emphasized that the conditions in which individual and families reside influence their health. These conditions are shaped by the distribution of money, power and resources, which leads to social and health inequalities.[64] Certain populations might be disproportionately more likely to live in neighborhoods that are socially fragmented. People from lower socioeconomic backgrounds have been shown to move

Table 4 Bivariate analyses of social fragmentation and physical inactivity with the potential mediators social cohesion, perception of neighborhood safety, depressive symptoms, alcohol consumption, cigarette smoking and physical inactivity: Boston Youth Study; Boston; 2008

	Depressive symptoms (ref: no.) 95% CI	*Social cohesion (ref: low/moderate) high 95% CI*	*Perception of neighborhood safety (ref: never/sometimes) always safe 95% CI*	*Alcohol consumption last 30 days 95% CI*	*Tobacco smoking last 30 days 95% CI*	*Physically inactive 95% CI*	*Likelihood of sleeping ≥8.5 h 95% CI*	*Sleep duration β 95% CI*
Social fragmentation (ref: low)								
Moderate	0.75 (0.44, 1.27)	**0.52 (0.32, 0.85)**	0.53 (0.33, 0.86)	1.27 (0.90, 1.81)	0.84 (0.48, 1.46)	1.18 (0.81, 1.72)	0.87 (0.51, 1.48)	−6.7 (−20.1, 6.8)
High	0.99 (0.70, 1.41)	**0.54 (0.34, 0.88)**	0.58 (0.34, 0.99)	**1.27 (1.02, 1.59)**	0.90 (0.58, 1.40)	**1.43 (1.05, 1.96)**	0.94 (0.59, 1.48)	−1.6 (−13.0, 9.9)
Social cohesion (ref: low)								
Moderate							1.35 (0.95, 1.92)	**12.1 (2.8, 21.4)**
High							1.37 (0.91, 2.06)	**11.4 (2.3, 20.6)**
Perception of neighborhood safety (ref: never safe)								
Sometimes safe							0.91 (0.57, 1.48)	6.2 (−5.0, 17.5)
Always safe							0.75 (0.44, 1.27)	1.0 (−13.6, 15.6)
Depressive symptoms (ref: no.)								
Yes							0.63 (0.30, 1.32)	−39.7 (−56.8, −22.7)
Alcohol consumption (ref: no.)								
Yes							**0.52 (0.33, 0.81)**	−24.1 (−34.0, −14.2)
Smoking cigarettes (ref: no.) yes							**0.34 (0.14, 0.86)**	**−17.0 (−32.1, −1.9)**
Physical inactivity (ref: no.)								
Yes							1.22 (0.77, 1.93)	**−15.4 (−26.9, −3.9)**

Significant findings are in bold.

frequently,[65] which may result in greater social fragmentation within a neighborhood.

Limitations of this study

We need to interpret these findings with caution due to limitations of this study. We used cross-sectional data, and therefore, we cannot infer causality since temporality was not observed. However, the hypotheses and directionality have intuitive appeal. Additionally, we relied on self-report for sleep duration. Furthermore, the question utilized to measure sleep duration can be interpreted as time spent in bed, and not the time spent sleeping. However, the use of the question has been used in other population-based surveys.[43] Residual confounding might also be a limitation since important covariates such as individual-level SES variables (i.e. household income) were not asked in the BYS questionnaire. Also, although the BYS sample was originally representative of youth attending public high schools in the city of Boston, the demographic distribution of our analytic sample changed due to missing data. However, we may be able to generalize these findings to adolescents in comparable urban centers. Another limitation is that we had no measures of sleep quality. Researchers have identified sleep quality rather sleep duration as a better predictor of health and well-being.[66] Furthermore, social cohesion, perception of neighborhood safety, depressive symptoms, alcohol consumption, cigarette smoking and physical inactivity might actually mediate the relation between social fragmentation and sleep quality. Finally, another limitation is that we did not measure weekend sleep duration.

Strengths of this investigation include the large sample size representative of students attending public schools in an urban setting, our ability to control for neighborhood-level characteristics in the multiple regression analyses and our use of multilevel modeling to account for the clustering of the participants within neighborhoods.

In conclusion our study suggests that neighborhood-level social fragmentation may act as an independent variable that influences sleep duration among adolescents while controlling for confounders. Creating a stable social environment that is supportive may be needed to help children obtain adequate sleep for growth and development. Research has indicated that as social housing decreases, the rate of mobility increases.[67] Possible interventions may not only include decreasing turnover rates through such policies as funding social housing, but also by providing social support for residents and families living in socially fragmented neighborhoods. Future work that utilizes longitudinal data may help determine temporality and to further gain a better understanding of the causal mechanisms.

Acknowledgements

The Boston Youth Survey (BYS) was conducted in collaboration with the Boston Public Health Commission (Barbara Ferrer, Director), Boston's Office of Human Services (Larry Mayes, Chief), Boston Public Schools (Carol Johnson, Superintendent) and the Office of The Honorable Mayor Thomas M. Menino. The survey would not have been possible without the participation of the faculty, staff, administrators and students of Boston Public Schools.

Funding

This work was supported by a grant from the Center for Disease Control and Prevention (CDC) National Center for Injury Prevention and Control (NCIPC) (U49CE00740) to the Harvard Youth Violence Prevention Center (David Hemenway, Principal Investigator). Roman Pabayo is a Canadian Institutes of Health Research postdoctoral fellowship recipient.

References

1 Mercer PW, Merritt SL, Cowell JM. Differences in reported sleep need among adolescents. *J Adolesc Health* 1998;**23(5)**:259–63.

2 Wolfson AR, Carskadon MA. Sleep schedules and daytime functioning in adolescents. *Child Dev* 1998;**69(4)**:875–87.

3 Smaldone A, Honig JC, Byrne MW. Sleepless in America: inadequate sleep and relationships to health and well-being of our nation's children. *Pediatrics* 2007;**119(Suppl 1)**:S29–37.

4 Brand S, Kirov R. Sleep and its importance in adolescence and in common adolescent somatic and psychiatric conditions. *Int J Gen Med* 2011;**4**:425–42.

5 Siegel JM. Clues to the functions of mammalian sleep. *Nature* 2005;**437(7063)**:1264–71.

6 Krueger JM, Rector DM, Roy S *et al*. Sleep as a fundamental property of neuronal assemblies. *Nat Rev Neurosci* 2008;**9(12)**:910–9.

7 Siegel JM. Sleep viewed as a state of adaptive inactivity. *Nat Rev Neurosci* 2009;**10(10)**:747–53.

8 Tononi G, Cirelli C. Sleep function and synaptic homeostasis. *Sleep Med Rev* 2006;**10(1)**:49–62.

9 Magee L, Hale L. Longitudinal associations between sleep duration and subsequent weight gain: a systematic review. *Sleep Med Rev* 2012;**16(3)**:231–41.

10 McLaughlin Crabtree V, Williams NA. Normal sleep in children and adolescents. *Child Adolesc Psychiatr Clin N Am* 2009;**18(4)**:799–811.

11 Wolfson AR, Carskadon MA, Acebo C *et al*. Evidence for the validity of a sleep habits survey for adolescents. *Sleep* 2003;**26(2)**:213–6.

12 Iglowstein I, Jenni OG, Molinari L *et al*. Sleep duration from infancy to adolescence: reference values and generational trends. *Pediatrics* 2003;**111(2)**:302–7.

13 Leger D, Beck F, Richard JB *et al*. Total sleep time severely drops during adolescence. *PLoS One* 2012;**7(10)**:e45204.

14 Coble PA, Kupfer DJ, Taska LS *et al*. EEG sleep of normal healthy children. Part I: findings using standard measurement methods. *Sleep* 1984;**7(4)**:289–303.

15 Mason TB 2nd, Teoh L, Calabro K *et al*. Rapid eye movement latency in children and adolescents. *Pediatr Neurol* 2008;**39(3)**:162–9.

16 Stores G, Crawford C, Selman J *et al*. Home polysomnography norms for children. *Technol Health Care* 1998;**6(4)**:231–6.

17 Spilsbury JC, Storfer-Isser A, Drotar D *et al*. Sleep behavior in an urban US sample of school-aged children. *Arch Pediatr Adolesc Med* 2004;**158(10)**:988–94.

18 Marco CA. Family socioeconomic status and sleep patterns of young adolescents. *Behav Sleep Med* 2012;**10**(**10**):70–80.

19 Jarrin DC, McGrath JJ, Quon EC. Objective and subjective socioeconomic gradients exist for sleep in children and adolescents. *Health psychol* 2013;(**2**):144–58.

20 Singh GK, Kenney MK. Rising prevalence and neighborhood, social, and behavioral determinants of sleep problems in US children and adolescents, 2003–2012. *Sleep Disord* 2013;**2013**:394320.

21 McHale SM, Kim JY, Kan M *et al*. Sleep in Mexican-American adolescents: social ecological and well-being correlates. *J youth adolesc* 2011;**40(6)**:666–79.

22 Barnett E, Casper M. A definition of 'social environment'. *Am J Public Health* 2001;**91(3)**:465–500.

23 Ross CE, Mirowsky J. Neighborhood disadvantage, disorder, and health. *J Health Soc Behav* 2001;**42(3)**:258–76.

24 Leventhal T, Brooks-Gunn J. Moving to opportunity: an experimental study of neighborhood effects on mental health. *Am J Public Health* 2003;**93(9)**:1576–82.

25 McEwen BS. Brain on stress: how the social environment gets under the skin. *Proc Natl Acad Sci USA* 2012;**109(Suppl 2)**:17180–5.

26 Nivison ME, Endresen IM. An analysis of relationships among environmental noise, annoyance and sensitivity to noise, and the consequences for health and sleep. *J Behav Med* 1993;**16(3)**:257–76.

27 Goines L, Hagler L. Noise pollution: a modem plague. *South Med J* 2007;**100(3)**:287–94.

28 Moudon AV. Real noise from the urban environment: how ambient community noise affects health and what can be done about it. *Am J Prev Med* 2009;**37(2)**:167–71.

29 Hoffmann B, Robra BP, Swart E. Social inequality and noise pollution by traffic in the living environment--an analysis by the German Federal Health Survey (Bundesgesundheitssurvey). *Gesundheitswesen* 2003;**65(6)**:393–401.

30 Desantis AS, Diez Roux AV, Moore K *et al*. Associations of neighborhood characteristics with sleep timing and quality: the multi-ethnic study of atherosclerosis. *Sleep* 2013;**36(10)**:1543–51.

31 Mestrovic SG. *Emile Durkheim and the Reformation of Sociology*. Lanham, MD: Rowan & Littlefield, 1988.

32 Pabayo R, Barnett TA, Datta GD *et al*. Area-level social fragmentation and walking for exercise: cross-sectional findings from the Quebec Adipose and Lifestyle Investigation in Youth Study. *Am J Public Health* 2012;**102(9)**:e30–37.

33 Loprinzi PD, Cardinal BJ. Association between objectively-measured physical activity and sleep, NHANES 2005–2006. *Mental Health Phys Act* 2011;**4(2)**:65–9.

34 Nelson MC, Gordon-Larsen P. Physical activity and sedentary behavior patterns are associated with selected adolescent health risk behaviors. *Pediatrics* 2006;**117(4)**:1281–90.

35 Costigan SA, Barnett L, Plotnikoff RC *et al*. The health indicators associated with screen-based sedentary behavior among adolescent girls: a systematic review. *J Adolesc Health* 2012;(**4**):382–92.

36 Evans J, Middleton N, Gunnell D. Social fragmentation, severe mental illness and suicide. *Soc Psychiatry Psychiatr Epidemiol* 2004;**39(3)**:165–70.

37 Allardyce J, Gilmour H, Atkinson J *et al*. Social fragmentation, deprivation and urbanicity: relation to first-admission rates for psychoses. *Br J Psychiatry* 2005;**187**:401–6.

38 Ivory VC, Collings SC, Blakely T *et al*. When does neighbourhood matter? Multilevel relationships between neighbourhood social fragmentation and mental health. *Soc Sci Med* 2011;**72(12)**: 1993–2002.

39 Zammit S, Lewis G, Rasbash J *et al*. Individuals, schools, and neighborhood: a multilevel longitudinal study of variation in incidence of psychotic disorders. *Arch Gen Psychiatry* 2010;**67(9)**: 914–22.

40 Roberts RE, Duong HT. Depression and insomnia among adolescents: a prospective perspective. *J Affect Disord* 2012;(**1**):66–71.

41 Patten CA, Choi WS, Gillin JC *et al*. Depressive symptoms and cigarette smoking predict development and persistence of sleep problems in US adolescents. *Pediatrics* 2000;**106(2)**:E23.

42 Ohida T, Osaki Y, Doi Y *et al*. An epidemiologic study of self-reported sleep problems among Japanese adolescents. *Sleep* 2004;**27(5)**: 978–85.

43 Krueger PM, Friedman EM. Sleep duration in the United States: a cross-sectional population-based study. *Am J Epidemiol* 2009;**169(9)**: 1052–63.

44 Stjarne MK, Ponce de Leon A, Hallqvist J. Contextual effects of social fragmentation and material deprivation on risk of myocardial infarction--results from the Stockholm Heart Epidemiology Program (SHEEP). *Int J Epidemiol* 2004;**33(4)**:732–41.

45 Smith GD, Whitley E, Dorling D *et al*. Area based measures of social and economic circumstances: cause specific mortality patterns depend on the choice of index. *J Epidemiol Community Health* 2001;**55(2)**: 149–50.

46 Hill TD, Burdette AM, Hale L. Neighborhood disorder, sleep quality, and psychological distress: testing a model of structural amplification. *Health Place* 2009;**15(4)**:1006–13.

47 Hemenway D, Barber CW, Gallagher SS *et al*. Creating a National Violent Death Reporting System: a successful beginning. *Am J Prev Med* 2009;**37(1)**:68–71.

48 Azrael D, Johnson RM, Molnar BE *et al*. Creating a youth violence data system for Boston, Massachusetts. *Aust N Z J Criminol* 2009;**42(3)**:406–21.

49 Sterne JA, White IR, Carlin JB *et al*. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. *BMJ* 2009;**338**:b2393.

50 Dunn EC, Johnson RM, Green JG. The Modified Depression Scale (MDS): a brief, no-cost assessment tool to estimate the level of depressive symptoms in students and schools. *School Ment Health* 2012;**4(1)**:34–45.

51 Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science* 1997;**277(5328)**:918–24.

52 Rothman EF, Johnson RM, Young R *et al*. Neighborhood-level factors associated with physical dating violence perpetration: results of a representative survey conducted in Boston, MA. *J Urban Health* 2011;**88(2)**:201–13.

53 Diez-Roux AV. Multilevel analysis in public health research. *Annu Rev Public Health* 2000;**21**:171–92.

54 Raudenbush SW. Comparing personal trajectories and drawing causal inferences from longitudinal data. *Annu Rev Psychol* 2001;**52**: 501–25.

55 Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 1986;**51(6)**:1173–82.

56 Knutson KL. The association between pubertal status and sleep duration and quality among a nationally representative sample of U. S. adolescents. *Am J Hum Biol* 2005;**17(4)**:418–24.

57 Mitchell JA, Rodriguez D, Schmitz KH *et al*. Sleep duration and adolescent obesity. *Pediatrics* 2013;**131(5)**:e1428–1434.

58 Storfer-Isser A, Patel SR, Babineau DC *et al*. Relation between sleep duration and BMI varies by age and sex in youth age 8–19. *Pediatr Obes* 2012;**7(1)**:53–64.

59 Hale L, Hill TD, Burdette AM. Does sleep quality mediate the association between neighborhood disorder and self-rated physical health? *Prev Med* 2010;**51(3–4)**:275–8.

60 Congdon P. Spatial path models with multiple indicators and multiple causes: mental health in US counties. *Spat Spatiotemporal Epidemiol* 2011;**2(2)**:103–16.

61 Fagg J, Curtis S, Stansfeld SA *et al*. Area social fragmentation, social support for individuals and psychosocial health in young adults: evidence from a national survey in England. *Soc Sci Med* 2008;**66(2)**: 242–54.

62 Mok PL, Leyland AH, Kapur N *et al*. Why does Scotland have a higher suicide rate than England? An area-level investigation of health and social factors. *J Epidemiol Community Health* 2012;(**1**):63–70.

63 Alfano CA, Ginsburg GS, Kingery JN. Sleep-related problems among children and adolescents with anxiety disorders. *J Am Acad Child Adolesc Psychiatry* 2007;**46(2)**:224–32.

64 Marmot M. Social determinants of health inequalities. *Lancet* 2005;**365(9464)**:1099–104.

65 Valois RF, MacDonald JM, Bretous L *et al*. Risk factors and behaviors associated with adolescent violence and aggression. *Am J Health Behav* 2002;**26(6)**:454–64.

66 Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. *J Psychosom Res* 1997;**42(6)**:583–96.

67 Burrows R. Residential mobility and residualisation in social housing in England. *J Soc Policy* 1999;**28(1)**:27–52.