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## Neighborhood and Household Environment as Contributors to Racial Disparities in Sleep Duration among U.S. Adolescents

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### Abstract

**Objective:** Racial disparities in adolescent sleep duration have been documented, but pathways driving these disparities are not well understood. This study examined whether neighborhood and household environments explained racial disparities in adolescent sleep duration.

**Methods:** Participants came from Waves I and II of Add Health (n=13,019). Self-reported short sleep duration was defined as less than the recommended amount for age (<9 hours for 6-12 years, <8 hours for 13-18 years, and <7 hours for 18-64 years). Neighborhood factors included neighborhood socioeconomic disadvantage, perceived safety and social cohesion. Household factors included living in a single parent household and household socioeconomic status (HSES). Structural equation modeling was used to assess mediation of the neighborhood and household environment in the association between race/ethnicity and short sleep duration.

**Results:** Only HSES mediated racial disparities, explaining non-Hispanic (NH) African American-NH White (11.6%), NH American Indian-NH White (9.9%), and Latinx-NH White (42.4%) differences. Unexpectedly, higher HSES was positively associated with short sleep duration.

**Conclusion:** Household SES may be an important pathway explaining racial disparities in adolescent sleep duration. Future studies should examine mechanisms linking household SES to sleep and identify buffers for racial/ethnic minority adolescents against the detrimental impacts that living in a higher household SES may have on sleep.

### Keywords

Sleep; Race; Ethnicity; Sex; Gender; Health status disparities; Life span

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## 1. Introduction

A large body of literature has linked short sleep duration (ranging from < 6 hours to < 8 hours) to obesity, type-2 diabetes, poorer mental health, and engagement in injury related behaviors such as tobacco use and drunk driving among adolescents [1-4]. Short sleep duration is highly prevalent among U.S. adolescents with as high as 60% of middle school and 70% of high school students reporting sleeping less than the recommended amount by age based on guidelines set by the American Academy of Sleep Medicine (<9 hours for age 6-12 years and <8 hours for age 13-18 years) [5]. Furthermore, racial disparities in short sleep duration among adolescents has been well documented with racial/ethnic minority adolescents generally reporting shorter sleep duration than non-Hispanic White adolescents [6-8]. The reasons for these disparities are unclear. Understanding the mechanisms driving these disparities among adolescents can help to inform interventions to reduce these disparities in sleep duration and consequently health outcomes among adolescents.

The neighborhood context may play an important role in explaining racial differences in sleep duration among adolescents. Previous studies suggests that living in neighborhoods of higher socioeconomic disadvantage is associated with shorter sleep duration among children and adolescents [9-12]. Socioeconomically disadvantaged neighborhoods often have fewer health promoting resources (e.g. recreational facilities, sidewalks, and healthy food stores) that could help encourage healthy sleep behaviors (e.g., physical activity, reduced sedentary behaviors such as screen time, and healthy diets) subsequently resulting in more sleep [13,14]. In addition, disadvantaged neighborhoods are more likely to have greater noise (e.g., traffic, police sirens, and construction work) and air pollution (e.g., PM<sub>2.5</sub> and nitrogen oxides) that may contribute to less sleep through arousals, inflammatory pathways, and stress responses [15-17]. Moreover, neighborhood socioeconomic disadvantage is correlated with poorer social environments such as greater neighborhood disorder (i.e., lack of order and social control within a community characterized by indicators including but not limited to vandalism, littering and/or loitering, and high-risk substance use), less safety, and lower social cohesion (i.e., strength of relationships and the sense of solidarity among residents in a neighborhood) [18-20] which are associated with shorter sleep duration among adolescents [21-24]. Living in these stressful neighborhood social conditions may result in hypervigilance and psychological distress that lead to physiologic hormones that interfere with sleep [25,26]. Furthermore, these neighborhood environments are patterned by race/ethnicity with racial/ethnic minorities being more likely to live in neighborhoods of lower SES and poorer social environments [27]. However, studies examining whether racial differences in neighborhood environments exacerbate or mitigate racial disparities in sleep duration among adolescents are lacking.

In addition to the neighborhood SES, household-level factors such as household SES may be an important contributor to racial disparities in sleep among adolescents. Living in households of lower SES is associated with shorter sleep duration among adolescents [28]. Parents with lower SES are more likely to be shift workers, work multiple jobs, and live in more noisy and crowded spaces interfering with the ability to establish healthy sleep habits for their children such as consistent bedtimes that are beneficial for sleep [29-31].

Additionally, adolescents of lower SES have less access to health care to prevent and/or treat medical conditions (e.g., asthma and obesity) that can negatively influence sleep. Household SES varies by race/ethnicity with racial/ethnic minority adolescents being more likely to have lower household SES than their non-Hispanic White peers [32]. Thus, household SES may be a contributor to the documented adolescent sleep disparities. However, research examining whether household SES explains racial disparities in adolescent sleep duration remain sparse.

Another household factor that may contribute to racial disparities in adolescent sleep is living in a single parent household. There is evidence to suggest that living in a single parent household is associated with shorter sleep duration [33,34]. One component of living in a single parent household that may explain shorter sleep duration is that it could reflect household SES as those living in a single parent household may have lower income than a two-parent household. Furthermore, living in a single parent household may reflect instability of the home environment that could inhibit sleep [33]. For instance, previous literature have found greater parent-child conflict among single parent families and an association between parent-child conflict and sleep problems among adolescents [35-37]. One explanation for this association is that optimal sleep is best facilitated in an environment perceived as safe and free of threat, thus repeated exposure to feelings of instability in the home environment may increase vigilance and interfere with sleep [38]. Research suggests that racial/ethnic minority adolescents may be more likely to live in single parent households in comparison to non-Hispanic White adolescents [39]. Studies have not investigated whether living in a single parent household contributes to racial differences in adolescent sleep duration.

The primary purpose of this study is to simultaneously examine whether neighborhood (e.g. neighborhood socioeconomic disadvantage, safety, and social cohesion) and household environments (e.g. household SES and single parent household) explain racial disparities in sleep duration among U.S. adolescents. Using structural equation modeling, the hypotheses being tested are: 1) racial/ethnic minority adolescents are more likely to have shorter sleep duration than White adolescents, 2) living in adverse neighborhood and household environments will be positively associated with short sleep duration, and 3) racial/ethnic minority adolescents will be more likely to live in these stressful neighborhood and household environments which will lead to greater reports of short sleep duration compared to White adolescents.

## 2. Materials and Methods

### 2.1. Study Population

The data for this study are from Waves I and II of the National Longitudinal Study of Adolescent to Adult Health (Add Health). Add Health is an ongoing longitudinal, nationally representative, school-based study of adolescent health behaviors and their outcomes during adulthood. Details about the study design and procedures have been published elsewhere [40]. In brief, a school-based study design was used in which 80 high schools and 52 middle schools from the US were sampled and stratified by region of country, urbanicity, school size, school type, and ethnicity. In 1994-1995, an in-school questionnaire on topics such as

school extracurricular activities, friendships, and health status were administered to 90,118 students between grades 7-12 with parental and student consent. A subset of those that completed the in-school questionnaire and those that did not complete the questionnaire but were on the school roster (n=20,745) were interviewed in their homes from 1994-1995 which formed Wave I (mean age: 16 years) of the study. Wave II (1996; mean age: 16 years) was conducted a year later and consists of a subset of Wave I participants (n=14,738). Sampling weights were constructed by the Add Health study team to be applied in analyses allowing for nationally representative estimates. Weights were unable to be constructed for participants selected out of the sampling frame for Add Health sub studies [41]. This study included only those who participated in both Waves of data collection and had complete sample weights (n=13,568). Those who did not identify as African American, American Indian, Asian, Hispanic, or White (n=124) and were long sleepers defined as sleep duration greater than the American Academy of Sleep Medicine's (AASM) recommended amount of sleep by age (>12 hours for 6-12 years, >10 hours for 13-18 year, and >9 hours for 18-64 years) (n=405) were excluded due to their small sample sizes providing a final analytic sample of 13,019. Add Health was approved by the institutional review board of the University of North Carolina, Chapel Hill and written consent forms were obtained from adolescents and their parents.

## 2.2. Neighborhood Environment

Data on neighborhood environmental factors were obtained from Wave I. Participant home addresses at Wave I were geocoded using the following sources in order of priority: 1) street-segment matches from commercial geographic information system (GIS) databases; 2) global positioning system (GPS) units, when street segments were not available; 3) a ZIP+4/ZIP+2 or a 5 digit zip centroid match when neither GIS or GPS data were available; and 4) respondent's geocoded school location [42]. The home addresses were then linked to block, group, tract, and county information from the 1990 US Census and the National Archive of Criminal Justice Data for crime information [43]. Those with missing geocoded data, missing source data, and unstable estimates due to small sample sizes were coded as missing (n=306). In addition, in-home interviews with adolescent participants were conducted in Wave I to collect information on neighborhood characteristics such as perceived safety and social cohesion and are further described below. Neighborhood socioeconomic disadvantage was assessed with a summary score constructed by standardizing and summing the following five census tract measures that have been used in prior Add Health research: proportions of female-headed households, individuals living below the poverty threshold, individuals receiving public assistance, adults with less than a high school education, and adults who were unemployed [44,45]. A higher summary score represented greater disadvantage and was modeled continuously. Perceived neighborhood safety was assessed based on adolescent report of yes or no to the question "Do you usually feel safe in your neighborhood?" and modeled as a binary variable. Neighborhood social cohesion was evaluated using a summary score from a prior Add Health studies based on adolescent report of yes or no to the following three items: 1) "You know most of the people in your neighborhood in the past month"; 2) "You have stopped on the street to talk with someone who lives in your neighborhood"; and 3) "People in this neighborhood look out for each other" [46,47]. Responses (yes=1, no=0) were summed to generate a score ranging from

0 to 3. The summary score was modeled as a continuous variable with a higher score representing greater social cohesion.

### 2.3. Household Environment

Information on household environment measures were obtained from Wave I. During Wave I, an in-home interview was conducted with the adolescent and their parent to ascertain information on household sociodemographic characteristics. For this study, household environment measures included living in a single parent household and household SES. Living in a single parent household was determined by adolescent report of family structure and was modeled as a dichotomous variable [48]. Household SES was assessed by a summary measure including parental education, parental occupation, and household income. The highest parental education level was used and categorized in three groups: 1) less than high school, or high school graduate or vocational school, 2) some college, or 3) college graduate or graduate education. The highest parental occupational level was selected and classified as: 1) service industry, transportation, construction or military; 2) technical, office worker, sales; or 3) professional or manager. Household income was categorized into tertiles as low, medium, and high. A summary score was created using a weighted average of the sum of the parental education, parental occupation, and household income resulting in a score ranging from 0 to 2 with a higher score representing higher household SES.

### 2.4. Sleep Duration

Sleep duration data was obtained from Wave II and ascertained from adolescent participants by asking “How many hours of sleep do you usually get?” in which they were only allowed to respond in whole hours per day. Responses were categorized based on the recommended amount of sleep for age by the American Academy of Sleep Medicine (AASM): 9-12 hours for 6-12 years of age, 8-10 hours for 13-18 years of age, and 7-9 hours for 18-64 years of age [49,50]. Sleep was dichotomized as either short sleep duration (less than the amount recommended by age) or recommended sleep duration (within the recommended range by age).

### 2.5. Race/ethnicity

Participants were asked to provide a yes or no response to the question “Are you of Hispanic or Latino origin?” Following that question, participants were asked “What is your race?” with White, Black or African American, American Indian or Native American, Asian or Pacific Islander, or Other as possible choices and the ability to indicate more than one race. Based on recommendations by Add Health researchers [51], those that responded with yes to being of Hispanic or Latino origin were designated as Hispanic for their race/ethnicity and excluded from any race category that was selected. If participants selected “black or African American” and any other race, they were designated as African American for their race/ethnicity, and eliminated from the other selected race categories. The process was repeated for the remaining race categories in the following order: Asian, American Indian, and White. The race/ethnicity variable consisted of non-Hispanic African American, non-Hispanic American Indian, non-Hispanic Asian, Hispanic, and non-Hispanic White. Henceforth, the race/ethnicity groups will be referred to as African American, American Indian, Asian, Latinx, and White.

## 2.6. Statistical Analysis

Study sample characteristics were examined by race/ethnicity using PROC SURVEY procedures in SAS 9.4 to account for complex sampling weights [52]. Structural equation modeling (SEM) was used to examine neighborhood and household environmental factors as mediators in the association between race/ethnicity and short sleep duration adjusting for self-reported sex (male vs. female) and age. An attempt was made to model the neighborhood and household environment as latent constructs mediating the association between race/ethnicity and short sleep, but did not meet the guidelines for identifiability [53]. Therefore, each individual neighborhood and household measure was modeled as a mediator in the SEM. White adolescents were the reference group in all pathways involving comparisons between racial/ethnic groups. The SEMs accounted for complex sampling weights and were conducted with MPlus v8.4 using the weighted least squares means and variance estimator (WLSMV) to obtain the standardized probit coefficients and standard errors (SE) for the total effect (TE), direct effect (DE), and indirect effect (IDE) of each pathway [54]. Missing data was addressed using the default missing data procedure implemented for WLSMV in MPlus [54]. Covariance of error terms between each neighborhood measure and separately each household variable were included to account for potential collinearity. Modification indices were examined and covariance of error terms between the neighborhood and household characteristics with indices greater than 10 were included to improve model fit. Model fit was assessed with root mean square error of approximation (RMSEA), comparative fit index (CFI) and standardized root mean square residual (SRMR). Acceptable model fit is indicated by  $RMSEA < 0.06$ ,  $CFI > 0.95$ , and  $SRMR < 0.08$  [55].

## 3. Results

### 3.1. Descriptive Analyses

Study sample characteristics by race/ethnicity are shown in Table 1. Overall, the mean age was 15.0 years ( $SE=0.11$ ), 49.8% were female, 41.6% reported short sleep duration, and 15.6%, 2.1%, 4.0%, 12.3%, and 66.1% were African American, American Indian, Asian, Latinx, and White respectively. All characteristics significantly differed by race/ethnicity ( $p < .001$ ) except sex and age. African American, American Indian and Latinx adolescents were more likely to live in neighborhoods with greater socioeconomic disadvantage compared to Asian and White adolescents. A smaller percentage of African American and Latinx adolescents reported living in a safe neighborhood compared to their American Indian, Asian, and White peers. On average, African Americans and White adolescents reported greater neighborhood social cohesion compared to all other racial/ethnic groups. In terms of household factors, a higher proportion of African American, American Indian, and Latinx adolescents reported lower household SES than Asian and White adolescents. A higher proportion of African American and Hispanic adolescents reported living in a single parent household compared with their peers of other racial/ethnic groups. Furthermore, African American adolescents had the highest prevalence of short sleep duration (47.1%), followed by Asian (46.5%), American Indian (45.1%), Latinx (40.7%), and White (40.1%) adolescents.

### 3.2. Structural Equation Models

The simplified version of the results for each pathway without the SE and exact p-values are shown in Fig. 1. The estimates, SE, and p-values for the total, direct, and indirect effects of the SEM comparing short sleep duration for African American, Asian, American Indian, and Latinx to White adolescents are shown in Table 2. Model fit statistics suggested acceptable model fit (RMSEA= .014, CFI= .996, and SRMR=.025).

**Racial/Ethnic Differences in Short Sleep Duration**—African American (TE:  $\beta=.055$ , SE=.014,  $p<.001$ ) and Asian (TE:  $\beta=.026$ , SE=.013,  $p=.047$ ) adolescents were more likely to have short sleep duration than White adolescents. There were no statistically significant Latinx-White and American Indian-White differences.

#### 3.2.1. Racial/Ethnic Differences in Neighborhood and Household

**Environments**—African American adolescents were more likely to live in neighborhoods with greater socioeconomic disadvantage (DE:  $\beta=.455$ , SE=.028,  $p<.001$ ), less safety (DE:  $\beta=-.186$ , SE=.023,  $p<.001$ ), and more social cohesion (DE:  $\beta=.031$ , SE=.015,  $p=.042$ ) than White adolescents. American Indian adolescents were more likely to live in greater neighborhood socioeconomic disadvantage (DE:  $\beta=.066$ , SE=.021,  $p=.002$ ) and less safety (DE:  $\beta=-.039$ , SE=.020,  $p=.049$ ) compared with White adolescents, but there were no statistically significant differences in social cohesion. Asian adolescents were more likely to live in neighborhoods with less social cohesion than White adolescents (DE:  $\beta=-.084$ , SE=.012,  $p<.001$ ), but there were no other statistically significant neighborhood differences. Compared to White adolescents, Latinx adolescents reported living in neighborhoods of greater socioeconomic disadvantage (DE:  $\beta=.193$ , SE=.035,  $p<.001$ ), lower safety (DE:  $\beta=-.167$ , SE=.021,  $p<.001$ ), and less social cohesion (DE:  $\beta=-.067$ , SE=.012,  $p<.001$ ).

African American adolescents were more likely to live in lower household SES (DE:  $\beta=-.180$ , SE=.028,  $p<.001$ ) and to live in a single parent household (DE:  $\beta=.287$ , SE=.020,  $p<.001$ ) than their White peers. American Indian adolescents were more likely to have lower household SES compared to White adolescents (DE:  $\beta=-.054$ , SE=.014,  $p<.001$ ), but no significant differences of living in a single parent household between these two groups. There were no significant differences in household characteristics between Asian and White adolescents. Latinx adolescents lived in lower household SES (DE:  $\beta=-.222$ , SE=.021,  $p<.001$ ) and were more likely to live in a single parent household (DE:  $\beta=.071$ , SE=.021,  $p=.001$ ) than White adolescents.

#### 3.2.2. Neighborhood and Household Characteristics on Short Sleep Duration

—Higher household SES (DE:  $\beta=.069$ , SE=.020,  $p=.001$ ) was significantly associated with greater likelihood of short sleep. There was no statistically significant association between living in a single parent household and short sleep duration or between any of the neighborhood characteristics and short sleep duration.

**3.2.3. Mediation of Neighborhood and Household Environment**—There were no significant mediation by the neighborhood environment in the association between race/ethnicity and short sleep duration (IDE:  $p's>.05$ ). Household SES mediated 11.6%

of African American-White (IDE:  $\beta=-.011$ ,  $SE=.004$ ,  $p=.007$ ), 9.9% of American Indian-White (IDE:  $\beta=-.003$ ,  $SE=.001$ ,  $p=.017$ ), and 42.4% of Latinx-White short sleep duration differences (IDE:  $\beta=-.014$ ,  $SE=.005$ ,  $p=.007$ ). That is, the difference in short sleep duration between each racial/ethnic group compared to White adolescents is increased by having higher household SES. However, there were no indirect effects for living in a single parent household. Furthermore, differences in short sleep duration between Asian and White adolescents were not significantly mediated by any of the household characteristics.

#### 4. Discussion

To our knowledge, this is one of first studies to examine contributors to racial disparities in sleep duration among adolescents. This study comprised of racial groups beyond African American, Latinx, and White adolescents and included Asian and American Indian adolescents. In this study, African American, American Indian, and Asian adolescents were more likely to have short sleep duration than White their peers. Racial/ethnic minority adolescents were more likely to live in adverse neighborhood environments than White adolescents. Contrary to our hypotheses, these neighborhood characteristics were not related to short sleep duration and did not explain the racial differences in sleep duration between racial/ethnic minority groups and White adolescents. Furthermore, results from this study show that African American, Latinx, and American Indian adolescents were more likely to live in adverse household environments than Asian and White adolescents. Living in a single parent household was not related to sleep duration and unexpectedly living in lower SES households was related to a lower likelihood of short sleep duration. Results further suggest that household SES partially contributed to African American-White, American Indian-White, and Latinx-White differences. That is, living in a lower household SES for these racial/ethnic minority groups decreased differences in sleep duration compared to White adolescents

Consistent with prior studies, our study found a higher proportion of short sleep duration among African American, American Indian, and Asian compared to White adolescents [5,6]. However, our results did not indicate sleep duration differences between Latinx and White adolescents. Findings from prior studies comparing sleep duration between Latinx and White adolescents have been mixed with Latinx reporting shorter or longer sleep duration than Whites [56-61]. These contradictory results could be due to differences in the study population. Latinx ethnicity in some studies, including the current study, were comprised of various Hispanic subgroups (e.g., Puerto Ricans, Mexican Americans, and Cuban Americans) whereas other studies assessed individual ethnic groups (e.g. Mexican Americans) [7,56,58,62]. The diverse sociocultural context of Hispanic subgroups (e.g., migration histories and levels of acculturation) may differentially influence their sleep and may explain the various Latinx-White disparity findings [63-65]. Furthermore, the differences in the definition of short sleep duration may explain the contrasting results across studies. For instance, a study from the Youth Risk Behavioral Surveillance Survey that uses a one-item question to assess sleep found no significant Hispanic-White differences in short sleep duration that was defined similar to this study using the AASM guidelines [5]. Whereas another study using data from a nationally representative sample of 8<sup>th</sup>, 10<sup>th</sup> and 12<sup>th</sup> graders with a one-item question assessment of sleep, found that Hispanics were



more likely than White adolescents to have inadequate sleep which was defined as less than 7 hours [61]. Additionally, there are variations in the measurement of sleep across studies in which some studies used objective measures of sleep duration (e.g. actigraphy and polysomnography), while others use self-reported subjective measures such as parent report or time diaries. Studies conducted with actigraphy and polysomnography generally have found no significant Hispanic-White differences in sleep duration among adolescents [7,57,66,67]. Inconsistent results were more common among studies with self-reported sleep measures. For instance, a study of children in Tucson, Arizona [57] using parent report found that Hispanic adolescents reported shorter sleep duration; while a study from the Child Development Supplement of the Panel Study of Income Dynamics using a time diary survey found greater sleep duration among Hispanic compared to White adolescents [60].

Similar to our findings, some studies among adolescents found null associations between neighborhood factors and sleep duration [21,68]. However, other studies among adolescents have found associations between neighborhood socioeconomic deprivation, lack of perceived safety and social fragmentation with shorter sleep duration [10-12,21-24]. The discrepancies between study results could be due to the differences in measurement of the neighborhood characteristics such as the use of different census measures for assessment of neighborhood socioeconomic disadvantage and varying scales to measure safety and social cohesion. Furthermore, the differences in results across studies could be the measurement of sleep duration in which some studies assessed sleep duration with actigraphy and/or self-reported sleep duration based on the sleep and wake time whereas our study used a one-item question with responses in whole hours.

Contrary to our hypothesis, living in a single parent household was not significantly associated with short sleep duration. A prior study among Black and White high school students by Troxel et al., found that living in a single parent household was associated with shorter actigraphy-assessed weekend sleep duration [33]. In the Add Health study, sleep duration was self-reported and not reported separately for weekday and weekend in Waves I and II, which precluded us from examining whether the results may have differed based on weekday and weekend sleep and comparing the results between studies.

A few studies conducted outside of the U.S. (e.g., China, India, and Turkey) [69-74] have found shorter sleep duration among higher household SES adolescents citing heavier homework demands, academic pressures, and greater access to participation in extracurricular activities (e.g., sports and private tutoring) as some of the factors explaining shorter sleep duration [75-77]. This may be the case for this study since Add Health is a school-based sample where academic pressures and participation in extracurricular activities may be more salient factors for adolescents in school compared to those not enrolled. Furthermore, these results are aligned with prior literature indicating that racial/ethnic minority adolescents may benefit less from being of higher household SES when compared to White adolescents [78-80]. Prior studies suggest that racial/ethnic minority adolescents of higher SES may be more likely to live in areas and attend schools that have predominantly White students where they experience heightened discrimination [81-84]. These experiences of discrimination may result in shorter sleep duration [85-87].

Other studies conducted among U.S. adolescents contradict our findings in which lower household SES was associated with shorter sleep duration [88-90]. The differences in results could be due to the use of actigraphy assessed sleep in these studies [88-90] whereas our study was limited to self-reported sleep in whole hours. In addition, there were variations in the measurement of household SES in which some of these studies included indicators of SES individually [88,89] instead of a composite measure. Furthermore, the discrepancy in findings may be explained by the differences in the age of the study samples in which previous studies included mainly younger adolescents in middle school [88-90] whereas our study consisted of mostly high school students. This may have led to differences in results because of the greater academic and social pressures among high school compared to middle school students.

There are at least three strengths to this study. First, this is one of the first studies to formally test neighborhood and household characteristics as contributors to racial disparities in sleep duration comparing African American, Asian, Latinx, and American Indian to White adolescents. Second, the analyses simultaneously modeled both household and neighborhood characteristics, which allowed for the decomposition of specific direct and indirect effects and accounted for the potential correlation between these variables. Finally, the study cohort was large, racially/ethnically diverse, and nationally representative which allows for greater generalizability.

Despite the strengths of this study, the results should be considered in the context of the potential limitations. Although the study attempted to include comprehensive measures of the neighborhood context, aggregate data may not represent individual level data and there may be other factors at the neighborhood level not captured in this study, such as measures of neighborhood disorder, crime data, and physical environment (e.g. noise, walkability, air pollution) that may contribute to racial disparities in sleep among adolescents [13]. Similarly, there are other household level factors such as parental sleeping habits, traumatic life events (e.g. death in family), and caregiver stress that may explain racial differences in sleep [91-95]. In addition, studies comparing self-report to actigraphy assessed sleep duration among adolescents have found that they tend to overestimate their sleep with moderate correlations between measures, suggesting that there may be random misclassification of sleep duration that resulted in the null findings [96,97]. Although there were null results in the association between neighborhood environmental measures with short sleep duration and mediation by these variables, there were numerous significant pathways detected between race/ethnicity and household environmental factors with short sleep duration and mediation by household SES. This indicates that the null findings in this study may not have been primarily due to the measurement error of self-reported sleep duration. Moreover, the adult literature has found that measurement error of self-reported sleep may vary by race/ethnicity [98,99]. Evidence of this bias in the adolescent literature is lacking, but may exist as studies have found racial differences in norms and attitudes about sleep that could influence the reporting of sleep duration [12,100]. Finally, the Add Health data used for this study was collected nearly three decades ago and cannot account for the historic changes (e.g., recessions and COVID-19 pandemic) and technological advancements (e.g., smartphones) that could affect the saliency of household and neighborhood factors on sleep duration for adolescents. However, racial/ethnic disparities in adolescent sleep and

inequalities in these household and neighborhood factors that could differentially impact adolescent sleep across racial/ethnic groups persists. Thus, our findings are still relevant in providing insights to potential factors driving the current racial/ethnic disparities in adolescent sleep duration.

Given the large body of literature documenting significant racial disparities in adolescent sleep [6], understanding the contributors to these disparities is crucial for developing targeted interventions to mitigate these disparities. This study contributes to the early stages of trying to understand these pathways driving racial disparities in adolescent sleep duration and serve as a starting point for future research. Since household SES was found to be a potential pathway, it is important for future work to examine mechanisms linking varying levels of household SES to short sleep duration. In particular, future studies should be conducted within racial/ethnic groups to identify buffers that can reduce the harmful impacts that differing levels of household SES has on sleep. Knowledge on these mechanisms and buffers can be used to develop policies and intervention at the school level to improve sleep and reduce racial disparities in sleep.

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## Data Availability Statement

Information on how to obtain the Add Health data files is available on the Add Health website (<https://addhealth.cpc.unc.edu>).

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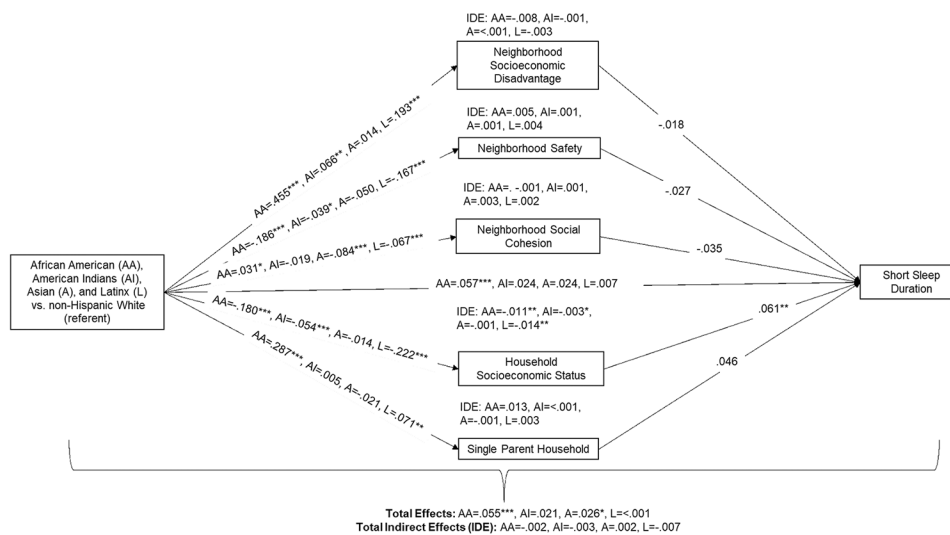
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**Fig. 1.** Structural Equation Model of the Association between Race/ethnicity and Short Sleep Duration as Mediated by Neighborhood and Household Environmental Factors. **Note:** Paths emanating from race/ethnicity represent a comparison of each minority group (African American, Asian, American Indian and Latinx) to non-Hispanic White. All variables were modeled simultaneously and adjusted for sex and age. Total effects, indirect effects, and direct effects were estimated for all pathways. Standardized estimates are shown in each pathway. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

Sample Characteristics by Race/Ethnicity from Waves I and II of the National Longitudinal Study of Adolescent to Adult Health, United States, 1994-96

**Table 1**

Characteristics	Total (N=13,019)	African American (N= 2,790; 15.6%)	American Indian (N=240; 2.1%)	Asian (N=928; 4.0%)	Latinx (N=2,210; 12.3%)	White (N=6,851; 66.1%)
Age, mean (SE)	15.04 (0.11)	15.19 (0.19)	14.89 (0.17)	15.23 (0.27)	15.14 (0.21)	14.98 (0.13)
Sex, Female	49.8%	51.3%	43.1%	47.6%	48.8%	50.0%
Household Socioeconomic Status, mean (SE)	0.88 (0.03)	0.66 (0.04)	0.74 (.05)	0.94 (0.06)	0.55 (0.03)	0.99 (0.03)
Single parent household	23.6%	47.0%	19.4%	15.5%	24.9%	18.4%
Neighborhood Socioeconomic Disadvantage, mean (SE)	21.65 (0.92)	32.5 (0.96)	23.7 (2.26)	19.07 (1.34)	26.19 (1.29)	18.34 (0.98)
Neighborhood Perceived as Safe	89.8%	82.7%	88.3%	88.7%	82.8%	92.8%
Neighborhood Social Cohesion, mean (SE)	2.28 (0.02)	2.38 (0.03)	2.20 (0.07)	1.90 (0.07)	2.11 (0.03)	2.31 (0.03)
Short sleep duration	41.6%	47.1%	45.1%	46.5%	40.7%	40.0%

Abbreviations: SE=Standard Error

Note: Results accounted for Add Health sampling weights; p<0.001 for comparison of all characteristics except for age and sex (p' s>0.05)

**Table 2**

Results from Structural Equation Model of the Association between Race/ethnicity and Short Sleep Duration as Mediated by Neighborhood and Household Environmental Factors

Pathways (n=13,019)	$\beta$	SE	p-value
<b>Total Effects:</b>			
Race/ethnicity → Short Sleep Duration			
African American	.055	.014	<.001
American Indian/Alaska Native	.021	.013	.095
Asian	.026	.013	.047
Latinx	<.001	.015	.994
<b>Direct Effects:</b>			
Race/ethnicity → Short Sleep Duration			
African American	.057	.016	<.001
American Indian/Alaska Native	.024	.013	.058
Asian	.024	.013	.074
Latinx	.007	.015	.648
Race/ethnicity → Neighborhood Socioeconomic Disadvantage			
African American	.455	.028	<.001
American Indian/Alaska Native	.066	.021	.002
Asian	.014	.026	.583
Latinx	.193	.035	<.001
Race/ethnicity → Neighborhood Safety			
African American	-.186	.023	<.001
American Indian/Alaska Native	-.039	.020	.049
Asian	-.050	.026	.051
Latinx	-.167	.021	<.001
Race/ethnicity → Neighborhood Social Cohesion			
African American	.031	.015	.042
American Indian/Alaska Native	-.019	.010	.062
Asian	-.084	.012	<.001
Latinx	-.067	.012	<.001
Race/ethnicity → Household Socioeconomic Status			
African American	-.180	.028	<.001
American Indian/Alaska Native	-.054	.014	<.001
Asian	-.014	.016	.397
Latinx	-.222	.021	<.001
Race/ethnicity → Single Parent Household			
African American	.287	.020	<.001
American Indian/Alaska Native	.005	.020	.819
Asian	-.021	.016	.195
Latinx	.071	.021	.001
Neighborhood Socioeconomic Disadvantage → Short Sleep Duration	-.018	.020	.373

<b>Pathways (n=13,019)</b>	<b><math>\beta</math></b>	<b>SE</b>	<b>p-value</b>
Neighborhood Safety → Short Sleep Duration	-.027	.029	.359
Neighborhood Social Cohesion → Short Sleep Duration	-.035	.018	.058
Household Socioeconomic Status → Short Sleep Duration	.061	.021	.004
Single Parent Household → Short Sleep Duration	.046	.026	.078
<b>Indirect Effects:</b>			
<i>Total:</i>			
Race/ethnicity → Short Sleep Duration			
African American	-.002	.011	.863
American Indian/Alaska Native	-.003	.002	.181
Asian	.002	.002	.337
Latinx	-.007	.006	.227
<i>Specific:</i>			
Race/ethnicity → Neighborhood Socioeconomic Disadvantage → Short Sleep Duration			
African American	-.008	.009	.375
American Indian/Alaska Native	-.001	.001	.397
Asian	<.001	<.001	.610
Latinx	-.003	.004	.378
Race/ethnicity → Neighborhood Safety → Short Sleep Duration			
African American	.005	.006	.371
American Indian/Alaska Native	.001	.001	.405
Asian	.001	.002	.423
Latinx	.004	.005	.366
Race/ethnicity → Neighborhood Social Cohesion → Short Sleep Duration			
African American	-.001	.001	.163
American Indian/Alaska Native	.001	.001	.236
Asian	.003	.002	.085
Latinx	.002	.001	.084
Race/ethnicity → Household Socioeconomic Status → Short Sleep Duration			
African American	-.011	.004	.007
American Indian/Alaska Native	-.003	.001	.017
Asian	-.001	.001	.427
Latinx	-.014	.005	.007
Race/ethnicity → Single Parent Household → Short Sleep Duration			
African American	.013	.007	.071
American Indian/Alaska Native	<.001	.001	.818
Asian	-.001	.001	.327
Latinx	.003	.002	.081