Racial/Ethnic and Socio-Contextual Correlates of Chronic Sleep Curtailment in Childhood

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Study Objectives: To examine the association between race/ethnicity and sleep curtailment from infancy to mid-childhood, and to determine the extent to which socioeconomic and contextual factors both explain racial/ethnic differences and are independently associated with sleep curtailment.

Methods: We studied 1,288 children longitudinally in Project Viva, a pre-birth cohort study, from 6 months to 7 years of age. The main exposure was the child’s race/ethnicity. The main outcome was a sleep curtailment score from 6 months to 7 years. The score ranged from 0–13, where 0 indicated maximal sleep curtailment and 13 indicated never having curtailed sleep.

Results: The mean (standard deviation) sleep curtailment score was 10.2 (2.7) points. In adjusted models (β [95% CI]), black (−1.92, [−2.39, −1.45] points), Hispanic (−1.58, [−2.43, −0.72] points), and Asian (−1.71, [−2.55, −0.86] points) children had lower sleep scores than white children. Adjustment for sociodemographic covariates attenuated racial/ethnic differences in sleep scores for black (by 24%) and Hispanic children (by 32%) but strengthened the differences for Asian children by 14%. Further adjustment for environmental and behavioral variables did not substantially change these differences. Independently, low maternal education, living in households with incomes < $70,000, viewing more TV, and having a TV in the child’s bedroom were associated with lower sleep scores.

Conclusions: Chronic sleep curtailment from infancy to mid-childhood was more prevalent among black, Hispanic, and Asian children. These differences were partially but not entirely explained by socio-contextual variables. Independently, children from lower socioeconomic status and those with greater exposures to TV also had greater sleep curtailment.

Keywords: sleep curtailment, race, ethnicity, socioeconomic status, health disparities


INTRODUCTION

Sleep is a dynamic physiologic process that varies across developmental periods. From birth to adolescence, sleep duration declines considerably, from a daily average of 13 hours for infants to an average 9 hours for 14- to 18-year-olds.1-4 Sleep structure and sleep-wake distribution also change, as bedtimes become more delayed,5 schedules become increasingly influenced by activities, and children’s circadian rhythms are established, leading to eventual consolidated, monophasic sleep at about age 5 years when daytime napping usually ceases.

Sleep curtailment, defined as shortened sleep compared to age-specific average sleep duration, is the most common cause of daytime sleepiness in children.6 Accumulating evidence has linked sleep problems, including sleep curtailment or low quality sleep, with negative effects on cognitive function, behavior, and an increased risk for psychiatric disorders.7-15 Several cross-sectional and longitudinal studies have found an association between short sleep and increased weight status in children and adults.16-22 Additionally, although sleep problems are often temporary and improve with time,1,2,23 longitudinal studies suggest that sleep disturbances in infancy can predict sleep problems in childhood.11,24,25

Previous studies1,2,26-32 have examined correlates of insufficient sleep in children and have identified sociodemographic, developmental, cultural, environmental, and behavioral influences on sleep. However, few studies have examined whether the burden of insufficient sleep is equally distributed throughout the population, and accumulating evidence shows that racial/ethnic minority children sleep less than their white counterparts.33,34,8,35-37 Additionally, there are limited longitudinal studies on chronic sleep curtailment, and few studies have examined racial/ethnic differences in sleep independent of socioeconomic, environmental, or behavioral risk factors.1,38

The purpose of this study was to examine the association between race/ethnicity and sleep curtailment from infancy to mid-childhood and the extent to which sociodemographic, behavioral, and environmental factors explain these racial/ethnic differences. Additionally, this study examines the independent relationship between these socioeconomic, behavioral, and environmental factors and sleep curtailment.

METHODS

Subjects/Study Design

Study subjects were participants in Project Viva, a prospective cohort study that recruited women during early pregnancy from Harvard Vanguard Medical Associates, a multi-specialty...
group practice located in eastern Massachusetts. Eligibility criteria included fluency in English, gestational age less than 22 weeks at the initial prenatal clinical appointment, and singleton pregnancy. Details of recruitment and retention procedures are available elsewhere.

Since our main exposure was chronic sleep curtailment from 6 months to 7 years, of the 2,128 women who delivered a live infant, we excluded 840 participants who did not have sleep data for these time points. Thus, our sample size for analysis was 1,288 children. Compared to the 1,288 participants in this analysis, nonparticipants were less likely to have college-educated mothers (53% vs. 72%) and to have an annual household income greater than $70,000 (50% vs. 63%). The sample for this study included a higher percentage of white children (69% vs. 53%) and lower percentages of black (13% vs. 22%), Hispanic (3% vs. 9%), and Asian children (3% vs. 6%) compared to nonparticipants.

After obtaining informed consent, we performed in-person visits at the end of the first and second trimesters, after delivery, during infancy (median 6.3 months), early childhood (median 3.2 years), and mid-childhood (median 7.7 years). Mothers completed mailed questionnaires at 1, 2, 4, 5, and 6 years after birth. Institutional review boards of Harvard Pilgrim Health Care, Brigham and Women’s Hospital, and Beth Israel Deaconess Medical Center approved the study protocols.

Measurements

Main Exposures
At 3 years postpartum, we asked mothers, “Which of the following best describes your child’s race or ethnicity?” Mothers had the option of choosing one or more of the following racial/ethnic groups: Hispanic or Latina, white or Caucasian, black or African American, Asian or Pacific Islander, American Indian or Alaskan Native, and Other (please specify). For participants who chose “Other,” we compared the given responses with US census definitions for the other 5 races and ethnicities and reclassified them when appropriate.

Outcome Measures
At 6 months and yearly from 1 to 7 years, mothers reported their children’s sleep duration in a usual 24-hour period. Details on the specific questions mothers answered can be found in the supplemental material. The primary outcome is a sleep curtailment score from 6 months to 7 years. We based the sleep score on mean daily sleep duration at each of the 8 measurement times, 6 months and yearly from 1 to 7 years. Using sleep duration thresholds in the literature associated with an increased risk for elevated BMI in children and crude analyses of increased obesity risk at age 7 years in Project Viva, along with age-specific daily sleep recommendations, we coded sleep duration at each measurement occasion as follows: at 6 months to 2 years, score was 0 for < 12 h/day and 1 for ≥ 12 h/day; at 3 to 4 years, < 10 h/day = 0, 10−10.9 h/day = 1, and ≥ 11 h/day = 2; at 5 to 7 years, < 9 h/day = 0, 9−9.9 h/day = 1, and ≥ 10 h/day = 2. The range of the total score was 0–13, where 0 indicated the maximal sleep curtailment and 13 indicated never having curtailed sleep.

At enrollment, we collected information about SES characteristics, including maternal age, education, parity, household income, marital status, and foreign-born status. Information about environmental characteristics was collected at enrollment, including smoking status (never, former, during pregnancy), and during the postpartum period, including breastfeeding initiation and duration. Mothers also reported gestational age and birth weight. Additional environmental and behavioral characteristics were repeatedly measured throughout the study period. Beginning at 6 months and yearly thereafter, we asked parents to report the number of hours their children watched TV/videos on an average weekday and weekend day in the past month. At 2 years and yearly thereafter, we asked mothers to report the number of hours their children were involved in active play on an average weekday and weekend day in the past month. Response categories for the TV/video and active play questions were “None, < 1, 1–3, 4–6, 7–9, and ≥ 10 h/day.” We assigned numeric values to the categories (0, 0.5, 2, 5, 8, and 10 respectively) and computed weighted averages to construct approximately continuous measures of TV/video viewing and active play in h/day. At 4, 5, 6, and 7 years postpartum, mothers reported whether there was a television in their child’s bedroom.

Statistical Analysis
We first examined the bivariate relationships of the child’s race/ethnicity with other covariates and the child’s sleep score. We then used multivariable linear regression models to examine the association between race/ethnicity and the child’s sleep score. Our first model, Model 1, included child gender, race/ethnicity, gestational length, and birth weight. We then adjusted for potential covariates, including sociodemographic variables (Model 2) and environmental and behavioral characteristics (Model 3).

The covariates in our analyses were not available for all subjects. We therefore used multiple imputation to generate several plausible values for each missing value. We used a chained equations approach with predictive mean matching based on linear regressions for approximately continuous variables and logistic or generalized logistic regression for dichotomous or more generally categorical variables. The “completed” data set comprises the observed data and one imputed value for each missing value. We replicated this analysis across completed data sets and then combined them in a structured fashion that accurately reflects the true amount of information in the observed data, i.e., without erroneously presuming that the imputed values are known true values, but recovering the information in partially observed subjects. We generated 50 complete data sets and combined multivariable modeling results (Proc MI ANALYZE in SAS version 9.3 (SAS Institute, Cary NC)).

From these multiple imputation results, we report adjusted regression effect estimates (β) from regressions and 95% confidence intervals (CI).

RESULTS
Characteristics of the study participants, overall and by race/ethnicity, are shown in Table 1. In this cohort, 68% of the children were white, 13% black, 3% Hispanic, 3% Asian, and 12% were...
“Other.” Table 2 summarizes sleep duration patterns. Black, Hispanic, and Asian children slept less than white children at every age period and had lower sleep scores, indicating more sleep curtailment from 6 months to 7 years. The mean (standard deviation, range) sleep curtailment score from 6 months to 7 years was 10.2 points (2.7; 0 to 13). Overall, 4.1% of children had a total score of 0 to 4 points, which indicates chronic sleep curtailment with curtailed sleep at multiple ages. Chronic sleep curtailment was more prevalent among black (11.6%), Hispanic (10.3%), and Asian (5.3%) children compared to white children (1.4%).

In multivariable analyses adjusted for the child’s gender, gestational length, and birth weight (β [95% CI]), black (−2.73 [−3.15, −2.30] points), Hispanic (−2.24 [−3.07, −1.41] points), and Asian (−1.58 [−2.40, −0.76] points) children had lower sleep scores than white children (Table 3). In Model 2, after adjustment for sociodemographic covariates, differences in sleep scores were attenuated for black and Hispanic children by 24% and 32%, respectively, but were minimally strengthened for Asian children by 14%. After additional adjustment for environmental and behavioral covariates (Model 3), the racial/ethnic differences were further attenuated for black children by 7% (−1.92 [−2.39, −1.45]) and Asian children by 5% (−1.71 [−2.55, −0.86]) children, but not for Hispanic children (−1.58 [−2.43, −0.72]) (Figure 1).

In Model 3, independent of race/ethnicity, maternal educational attainment less than a college degree (0.57 [−0.93, −0.22] points), having a household income < $40,000 (−1.01 [−1.55, −0.48], vs. a household income ≥ $70,000), and viewing more TV (−0.43 [−0.63, −0.23] points per additional h/d) was associated with lower sleep scores. In a separate model replacing duration of TV viewing with having a TV in the child’s bedroom, children with a TV in their bedroom from 4 to 7 years of age (−0.58 [−0.95, −0.20]) had lower sleep scores. Also, compared to a maternal age ≥ 35 years, maternal age < 35 years was associated with a higher sleep score (Table 3).

**DISCUSSION**

In this cohort study, black, Hispanic, and Asian children were more likely than white children to experience chronic sleep curtailment. The observed racial/ethnic differences in sleep...
curtailment were partially but not entirely explained by sociodemographic, environmental, and behavioral covariates. Adjustment for sociodemographic variables attenuated the observed differences in sleep curtailment for black and Hispanic children by 24% and 32%, respectively. However, adjustment for sociodemographic variables strengthened the relationship for Asian children. Further adjustment for environmental and behavioral variables did not substantially change our observed associations.

Our study also identified independent risk factors from the prenatal period and across childhood associated with sleep curtailment even after adjusting for race/ethnicity, including lower maternal educational attainment, lower household income, more TV viewing and having a TV in the child’s bedroom. Maternal age was inversely related to sleep scores. Marital status, nativity, birth weight, gestation duration, breastfeeding duration, and active play duration did not independently affect sleep scores.

Our findings of racial/ethnic differences in sleep duration are consistent with most but not all previous studies.\textsuperscript{13,44} Similar to previous cross-sectional studies, we found that black, Hispanic, and Asian children slept less than their white counterparts during infancy and childhood.\textsuperscript{33,34,8,35–37} Our study extends previous research by being one of the few to have examined racial/ethnic differences in sleep duration across infancy to mid-childhood. We also used multiple, repeated sleep measures and adjusted for several potential sociocultural covariates. In a previous longitudinal study of children and adolescents, Adam and colleagues\textsuperscript{38} observed racial/ethnic differences in sleep duration after controlling for many sociodemographic and environmental covariates, including school schedules and family functioning variables. Black adolescents slept less than their white counterparts by an average of 25 minutes on weekdays and 28 minutes on weekend days. Asian children slept 41 minutes less than white children on weekdays and had later bedtimes. Hispanic children slept 24 minutes less on weekend days than white children. Similar to Adam et al., these racial/ethnic differences persisted after adjusting for sociodemographic covariates. However, Adam et al. had only two waves of data collection, while participants in our study had sleep data for up to 8 time points, which helps decrease the impact of transient effects on sleep duration.

In another recent longitudinal study, Williams et al.\textsuperscript{3} studied the median sleep duration in black, Hispanic, and white children. The study found that between ages 5 and 7 years, black children slept less than white children, with a maximum difference of 15 minutes at age 7 years. Unlike our analyses,
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the study showed that the median sleep duration of Hispanic children was significantly higher than that of black and white children, except between ages 5 and 8 years. The different statistical methods and sample composition may contribute to the differing results. Williams et al. examined median sleep duration by race/ethnicity, while our study examined racial/ethnic differences using a sleep curtailment score, which was derived from mean sleep duration data and sleep thresholds.

Data from 1,288 children in Project Viva. Values presented as effect estimate (95% confidence intervals). Model 1 includes adjustment for the child’s characteristics (gender, race/ethnicity, gestational length, and birth weight). Each subsequent model includes the adjustments in the preceding model, with the following further adjustments: Model 2 includes sociodemographic variables (marital status, maternal age, nativity, maternal education, and household income), and Model 3 includes environmental and behavioral characteristics (maternal smoking status, child TV/video viewing, active play, and breastfeeding duration). *The range of the total sleep score is 0–13 points, where 0 indicates the maximal sleep curtailment and 13 indicates never having curtailed sleep.
Additionally, Williams et al. did not adjust for potential covariates, including socioeconomic risk factors.

In the current study, adjusting for SES substantially attenuated the observed racial/ethnic differences in sleep curtailment, by as much as 32% in Hispanic children. However, SES did not fully explain racial/ethnic differences. Recognizing that SES indicators can affect sleep via different pathways, we used two proxies of SES, maternal education and annual household income. Consistent with prior studies, children who lived in households with lower incomes and lower parental educational attainment were at increased risk for sleep problems and shortened sleep.

Household income, a proxy for resources and physical environment, had the greatest attenuating effects on the relationship between race/ethnicity and sleep curtailment, suggesting that the environment may not be conducive to sufficient sleep. Disadvantaged children live in noisier environments and are more exposed to chronic life stressors and violence. They are more likely to co-sleep and have lower quality bedding. They are also less likely to have consistent bedtime routines.

In agreement with prior studies, our study also found an association between lower maternal education attainment and sleep curtailment. This finding may suggest the need for improved sleep counseling among mothers of lower educational attainment.

However, the relationship between lower SES and sleep curtailment did not hold for Asian children, as adjusting for sociodemographic variables strengthened the relationship between Asian race/ethnicity and sleep curtailment. This finding highlights the complex interactions between specific cultures and the socioeconomic context.

It is possible that Asian children living in households with higher SES may be exposed to more stress, either from parents’ personal stress or pressures parents place on children. It is important to note that our sample size of Asian children was relatively small with a high proportion of college-educated mothers and higher income levels.

The persistent racial/ethnic disparities in sleep curtailment may be further explained by cultural differences. Prior studies have found that racial/ethnic minority children nap more frequently until older ages and are less likely to have established and enforced bedtime routines. The lack of routines, increased environmental stressors, and parents’ expectations, including academic pressures, may explain why minority children tend to have delayed bedtimes and more variation in sleep duration. Moreover, cultural values such as collectivism in Asian cultures, may also influence sleep practices, such as co-sleeping, which is more prevalent and accepted in Asian, African American, and Hispanic cultures, independent of space availability. In our study, however, maternal foreign-born status was not associated with sleep curtailment.

Our study also found an association between viewing more hours of TV/video and having a TV in the bedroom and more curtailed sleep, in agreement with prior studies. Stimulating programs and light exposure can delay the circadian clock and disrupt the sleep/wake cycle. A child with a TV in the bedroom is also more likely to watch more TV during the presleep period, more commonly show bedtime resistance, have later bedtimes and more irregular bedtime schedules. Still, TV use is the most common presleep activity in children, followed by dressing/undressing and brushing teeth. Many parents place televisions in their children’s bedroom partly as a sleep aid and as part of the child’s bedtime routine. These findings suggest that parents may be unaware of the negative impact of media use on sleep.

While previous studies usually include maternal age as a control variable, our study found that older maternal age was an independent risk factor for sleep curtailment. To the best of our knowledge, this is the first study to show an inverse relationship between maternal age and child sleep duration. It is possible that younger mothers are more likely to be first-time mothers or have fewer children, which may positively influence parenting around sleep practices and the child’s sociocontextual environment. More studies are needed to evaluate how maternal age relates to sleep.

In this manuscript we studied several covariates that could act as mediators of the relationship between race/ethnicity and chronic sleep curtailment including environmental characteristics such as smoking and behavioral characteristics such as TV/video viewing. Examining these covariates as mediators allows for studying potential pathways that may link our

**Figure 1**—Multivariable adjusted associations of race/ethnicity with sleep curtailment score, compared to white children. Model 1 adjusts for the child’s characteristics. Each subsequent model includes the adjustments in the preceding model, with the following further adjustments: Model 2 includes sociodemographic variables, and Model 3 includes environmental and behavioral characteristics.
exposure (race/ethnicity) to the outcome (chronic sleep curtailment). However, there are other potential mediators that we did not have available in this study and should be considered in future studies including sleep routines, napping behaviors, co-sleeping, bedding quality, and noise level.

Our study had several strengths. First, we used repeated measures of sleep duration from 6 months to 7 years of age to examine chronic sleep curtailment. This minimized the influence of transient effects on sleep duration. We also included a wide range of potential predictors and covariates from the prenatal period through early childhood. Our study also had limitations. First, we measured sleep duration by mother’s report as opposed to using objective sleep measures such as accelerometers. Additionally, mothers’ reported sleep duration may include time spent in bed awake, which my overestimate total sleep duration. It is also not known whether any misclassification from self-report may differ across groups and thus contribute to the observed findings. Second, although prior studies have found a high prevalence of short sleep in infancy, given that 38.6% of infants 6 months to 2 years were identified as having insufficient. It is also possible that mothers underreport infant sleep, especially since infant sleep is more fragmented. Third, the education and income levels of our participants were relatively high. Thus, our results may not be generalizable to more socioeconomically disadvantaged populations.

CONCLUSIONS

Our study identified racial/ethnic minority children as potentially vulnerable populations for chronic sleep curtailment. The observed racial/ethnic differences in sleep curtailment were partially but not entirely explained by sociodemographic, environmental, and behavioral variables. Additionally, we identified independent risk factors for sleep curtailment, including lower SES and more TV exposure. The substantial clinical and social consequences of sleep curtailment highlight the urgency for further research on the determinants of sleep, their interactions and their impact across the lifespan.

REFERENCES


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