Sleep Health 5 (2019) 532–538

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

Racial and ethnic disparities in sleep outcomes among urban children with and without asthma☆

Daphne Koinis-Mitchell, PhD [a,b,c,*], Julie Boergers, PhD [a,b,c], Sheryl J. Kopel, MSc [a,b], Elizabeth L. McQuaid, PhD [a,b,c], Michael L Farrow, MA [b], Monique LeBourgeois, PhD [d]

[a] Alpert Medical School, Brown University, Providence, RI
[b] Bradley/Hasbro Children's Research Center, Providence, RI
[c] Department of Pediatrics, Hasbro Children's Hospital/Rhode Island Hospital, Providence, RI
[d] University of Colorado at Boulder, Boulder, CO

ARTICLE INFO

Article history:
Received 17 May 2019
Received in revised form 12 August 2019
Accepted 14 August 2019

Keywords:
Sleep disparities
Asthma
Urban children

ABSTRACT

Background: Suboptimal sleep has been documented in at-risk groups such as urban minority children, particularly those with asthma. It is therefore critical to examine differences in sleep outcomes across specific racial and ethnic groups and to identify factors that contribute to such variations in sleep outcomes to inform tailored interventions to improve sleep health.
Objectives: The objectives were to examine racial/ethnic differences in sleep outcomes among urban children with and without asthma and to evaluate the extent to which asthma status and aspects of sleep hygiene and the sleep environment contribute to racial/ethnic differences in sleep outcomes in this sample.
Methods: Two hundred and sixteen African American, Latino, or non-Latino white (NLW) urban children, ages 7-9 years, with ($n = 216$) and without asthma ($n = 130$) and their primary caregivers were included. Objective sleep duration and efficiency were assessed via actigraphy. Asthma status was assessed by a study clinician. Caregiver-reported sleep hygiene and exposure to noise were assessed using a questionnaire.
Results: Minority children in the sample had, on average, shorter sleep duration compared to NLW children during the monitoring period (mean difference Latino vs NLW = −22.10, SE = 5.02; mean difference AA vs NLW = −18.69, SE = 5.28) Additionally, several racial/ethnic group differences in sleep outcomes emerged and were dependent on whether or not children had asthma. Specifically, Latinos had lower *mean number of awakenings* compared to NLWs but only among control participants with no asthma. Furthermore, specific aspects of sleep hygiene and exposure to nighttime noise in the home and neighborhood contributed to racial/ethnic differences in sleep outcomes.
Conclusion: Considering urban stressors and asthma status when treating pediatric populations is important, as factors related to urban stress and asthma management may influence sleep hygiene practices and sleep outcomes.

Introduction

Racial, ethnic, and socioeconomic disparities exist in children's sleep health outcomes. Ethnic minority children are at greater risk for shorter sleep duration, as assessed by subjective[1,2] and objective measures,[3,4] compared to non-Latino Whites (NLWs).[5–15] Many factors can contribute to shorter sleep among ethnic minority children including lower socioeconomic status (SES).[16] Furthermore, sleep-disordered breathing (SDB; snoring, obstructive sleep apnea) is twice as likely in young African Americans (AAs) as in NLWs.[17] Parental reports of witnessed apneas, snoring, and daytime sleepiness also are more likely in Latino than NLW children.[14] Given that many minority families live in/near urban centers, sleep disparities may, in part, be due to stressors of urban living that disrupt the initiation of sleep or sleep continuity and/or make it difficult for families to employ consistent bedtimes and bedtime routines.[18,19] Some conceptual frameworks have been offered to help understand multilevel contributors to sleep disparities[18,20] among urban and ethnic minority children. These models involve an interaction of factors across individual, family/

☆ Conflict of interest: none.
* Corresponding author at: Bradley/Hasbro Children's Research Center, 1 Hoppin St, Providence, RI 02903, USA. Tel.: +1 401 793 8632; fax: +1 401 350 2692.
E-mail address: dkoinismitchell@lifespan.org (D. Koinis-Mitchell).

https://doi.org/10.1016/j.sleh.2019.08.003
2352-7218/

cultural, environmental, and community levels that may impact variations in sleep outcomes in children from specific racial/ethnic and socioeconomic backgrounds.

Asthma is the most prevalent chronic illness among children, and it is disproportionately present in urban minority children, particularly those from Latino and AA backgrounds.[21] The presence of asthma symptoms can make it difficult for children to fall asleep and/or disrupt the continuity of sleep.[4] A growing body of research has shown links between nocturnal asthma worsening and shorter sleep duration as well as poorer sleep efficiency among urban children, with Latino and AA children most affected.[19,22] To date, the extent to which asthma contributes to racial/ethnic disparities in sleep outcomes among urban children remains poorly understood. This is an important area of research given that urban minority children are at greater risk for asthma morbidity and because asthma that is inadequately controlled due to challenges with asthma management (eg, low medication adherence, inaccurate symptom perception, poor trigger control) has been shown to contribute to shorter sleep[22] and/or poorer sleep quality.[22] Furthermore, both asthma management and sleep behaviors are modifiable targets for intervention. Learning more about which specific groups are more vulnerable to poorer asthma outcomes (eg, more compromised lung function, poorer asthma control, more frequent symptoms) and sleep outcomes can inform interventions tailored for families who have children with asthma at risk for poorer sleep.

Sleep hygiene refers to the practice of using sleep-related strategies such as a consistent sleep/wakefulness schedule; a calm, developmentally appropriate, bedtime routine; and a healthy sleep environment (eg, minimal bedroom disruptions). Good sleep hygiene is critical for the promotion of good general health in children.[19,22] Maintaining optimal sleep hygiene in children can be challenging for all families and is a particular challenge in families who experience stressors related to urban living.[18,19] Previously, we have shown that poor sleep hygiene can exacerbate the association between asthma control and sleep disturbances in urban children.[23] However, it is not clear which specific sleep behaviors and which aspects of the sleep environment may contribute to variations in sleep outcomes among specific racial/ethnic groups. Sleep hygiene behaviors, as well as components of children's sleep environments, may be within urban families' abilities to modify and thus may be realistic targets for intervention.

The current study has 2 goals. First, we sought to examine racial/ethnic disparities in sleep outcomes, namely, sleep duration, sleep efficiency, and nighttime awakenings, via objective assessments (actigraphy) in a sample of urban children with and without asthma from AA, Latino, and NLW backgrounds. Based on prior research showing that urban minority children are at greater risk for poorer sleep outcomes, we expected that urban minority study participants would have poorer sleep outcomes than NLW participants. Our second goal was to examine whether having asthma or sleep behaviors and aspects of the sleep environment relevant to urban children contributes to these racial/ethnic disparities in sleep outcomes. We expected that asthma status would moderate the association between racial/ethnic background and sleep outcomes, with the poorest sleep outcomes observed in AA and Latino children with asthma. We also examined whether specific aspects of sleep hygiene and disruptors in the sleep environment that are common in urban settings (eg, noise in the family's home or neighborhood) contributed to disparities among this sample of urban children with and without asthma. We expected that aspects of sleep hygiene and disruptors in the child's environment would have a moderating role in the association between racial/ethnic background and sleep outcomes. Given prior literature showing higher levels of urban and cultural stressors faced by these groups, we expected that AAs and Latinos would have less optimal sleep hygiene behaviors and would be at greater risk for exposure to noise that would disrupt sleep outcomes.

Methods

Data examined in this report were collected as part of a larger study, Project NAPS (Nocturnal Asthma and Performance in School), that investigated the co-occurrence of asthma sleep quality and academic performance among urban children, ages 7-9, with persistent asthma and a group of urban peers without asthma.[4,22] Data in the current report were collected in the fall/early winter in 1 of the 4 study years.

All participants (children with and without asthma) were recruited from the 4 largest school districts in an urban metropolitan area in the Northeastern USA, in hospital-based and ambulatory pediatric clinics, and in a hospital-based asthma educational program in the same urban area as the targeted school districts. Trained research assistants screened caregivers to determine eligibility.

All eligible child participants were between 7 and 9 years old, attended 1 of the targeted urban school districts, and had caregivers who self-identified as Latino (Dominican or Puerto Rican), NLW, or Black/AA. Additional inclusion criteria for children in the asthma group included that they had to previously have been diagnosed with asthma or breathing problems by a physician or had breathing problems within the last 12 months. Furthermore, during initial screening, caregivers provided additional information regarding their child's asthma status. Eligible children had persistent asthma, as recognized by a current asthma controller medication prescription and/or recurrent daytime or nighttime asthma symptoms, exercise or activity limitation, rescue inhaler medication use, or less than 2 oral steroid bursts within the previous 12 months.[24] Children in the non-asthma group also needed to not have asthma, allergies, an allergic skin condition, or any other confounding medical conditions (eg, diabetes). Those who met the criteria for inclusion above and expressed interest in participating in the study were deemed eligible. Exclusionary criteria for child participants in the current study included moderate to severe cognitive impairment, use of stimulant medication for ADHD, another pulmonary or chronic health condition, or a diagnosed sleep disorder (eg, restless leg syndrome) or any other medical condition(s) that would confound analysis of the primary hypotheses of the larger study. We did not exclude children with SDB, as this condition is highly comorbid with asthma and we are interested in designing "real-world" interventions for this group of children. We assessed the extent of SDB in our sample using a well-validated caregiver report measure.[17]

During an initial research visit, caregivers provided demographic information as well as information regarding their child's asthma and allergic rhinitis (AR) status for children with asthma. A second research session ("clinic visit") was completed at our hospital-based clinic no sooner than 2 weeks later. At the clinic visit, study clinicians examined asthma status for each participant; asthma severity was evaluated, and current asthma medication was confirmed. Participants then began an in-home 4-week monitoring period in which they completed a daily diary of their asthma symptoms, AR status, and sleep behaviors. During this monitoring period, participants were instructed to use a portable device twice daily to assess lung function. Each participant and their caregiver were trained by research personnel using standardized procedures to use study devices.[4,22,25–27] The informed consent/assent and all study assessments were administered verbally in English or Spanish by research staff fluent in both languages. Child and caregiver language preference was established during initial screening process. Using standardized procedures,[21] all materials were translated from English to Spanish. At the end of each research visit, participants received monetary compensation for completing that research visit. Approval for the larger study was obtained from the local Institutional Review Board.

Measures

Demographic and descriptive information

Poverty status was determined by dichotomizing the family's annual income by the US federal per capita poverty threshold for a family of that size during the calendar year of their study participation (Table 1).[4,28] Caregivers reported on children's risk for SDB using the SDB scale of the Pediatric Sleep Questionnaire, a well-validated and reliable questionnaire.[15]

Physician query

Child participants' primary care providers *or* asthma specialists completed a form detailing the date of the child's last office visit, asthma diagnosis, asthma triggers, relevant medical history, and current asthma regimen. Study clinicians used information from the physician query during clinic visits to evaluate asthma status.

Asthma diagnosis and severity classification

At the clinic visit, study clinicians reviewed the participant's medical history, completed a physical examination, and administered a pulmonary function test. Confirmation of the child's asthma and severity level was determined using standard National Heart, Lung, and Blood Institute Expert Panel Report 3 (NHLBI EPR-3) guidelines.[29] Asthma medication prescription was confirmed. Lung function measurements (eg, Forced expiratory volume in one second [FEV1]) were evaluated using the KoKo incentive spirometer (nSpireHealth, Longmont, CO) before and after administration of short acting bronchodilators.[30]

In vivo lung function: FEV1 percent predicted

Each participant's lung function was measured twice daily, in the morning and evening, by a handheld spirometer (Jaeger AM2; ERT, Yorba Linda, CA). Participants were instructed to perform a forced expiration into the device 3 times, both in the morning and in the evening. The blow yielding the highest FEV1 value at each time point was retained for data analysis. Previously established[26] standardized procedures were used for data cleaning and reduction. Child participants and their caregivers were trained by research staff on the proper use of the study device.

Sleep indicators

Participants wore a Phillips Respironics Actiwatch 2 ((Pittsburgh, PA) on their nondominant wrist during the at-home monitoring period. One-minute epochs estimated whether the participant was awake or sleep using Actiware-Sleep software V 2.53. A scoring algorithm was applied to portions of the record identified as sleep through a combination of diary reports and actiwatch event markers set by participants at "lights off" and "lights on." To increase validity of scoring sleep/wakefulness intervals, the daily diary included questions about when the child was sick with an illness other than asthma, morning wake times and evening sleep times, and when the actiwatch was removed (eg, during contact sports). [22] Standard scoring rules from our previously published work were applied.[22] Data were excluded when the actiwatch was off for all/part of the sleep period, supplementary daily dairy reports were unavailable, or the diary reported illnesses other than asthma that may have altered sleeping behavior. Actigraphy data were not available for 37 children due to poor protocol adherence (n = 34) or device loss/technical failure (n = 3). Actigraphy data were available for 212 children, with an average of 18 scorable nights (SD = 8, range = 2-40).

Sleep hygiene

Caregivers completed the 22-item Children's Sleep Hygiene Scale,[31] which includes items that assess physiological, cognitive, emotional, and environmental factors associated with sleep hygiene behaviors. Responses range from never (1) to always (6); higher scores indicate better sleep hygiene. Measure subscale and total scores were used in analyses. Internal consistency for the full scale was moderate (Cronbach $\alpha = .72$). Caregivers also completed the General Sleep Inventory, a 35-item caregiver-reported measure that has been used in previous studies,[19,32] to assess sleep disruptions in the sleep environment. Two items included in this measure assessed the extent to which (ie, Likert-type scale from never to always) the child is typically disturbed by noises in the home and/or neighborhood. (eg, "How frequently is your child awoken by noises from their home such as those that come from their own sleep space or other areas of the home?" and "How frequently is your child awoken by noises outside of their room but in the neighborhood?"). These items only were used for this study. Each individual item is rated via a 5-point Likert scale, with 0 = "Never" and 5 = "Always." Higher scores on these items indicated a greater amount of perceived sleep disruptions.

Sleep outcomes

Three variables were computed using actigraphy data.[32] *Sleep efficiency* was defined as the % time asleep/total time in bed (lights-off to lights-on time). Sleep duration was computed as the total minutes of sleep between evening sleep onset and morning wake time. Mean number of awakenings per night was the number of wake bouts with a duration ≥3 minutes.

Table 1
Participant characteristics: full sample and by ethnic/racial group

	Sample	Latino	Black/AA	NLW	Ethnic/racial group differences	Effect sizes[a]
n (%)	379	171 (45%)	129 (34%)	79 (21%)	–	–
Age, *M* (SD)	8.3 (0.86)	8.3 (0.9)	8.3 (0.8)	8.2 (0.8)	$F = 1.1$	.01
Sex, % male	201 (53%)	93 (54%)	73 (57%)	35 (44%)	$\chi^2 = 3.2$	.10
At/below poverty threshold (%)	235 (66%)	130 (80%)	79 (65%)	26 (37%)	$\chi^2 = 40.9$*	.34
Asthma clinical characteristics						
SDB, % high risk	130 (38)	61 (40)	49 (42)	20 (27)	$\chi^2 = 4.6$	.12
On controller asthma medication (%)	172 (80%)	84 (79%)	62 (84%)	26 (74%)	$\chi^2 = 1.49$	.08
AR not well/poorly controlled (%)	89 (36%)	36 (31%)	40 (46%)	13 (28%)	$\chi^2 = 5.95$	.15

M denotes mean.
[a] ANOVA effect sizes are partial omega squared (ω^2); χ^2 effect sizes are Cramer Phi (c)
* $P < .05$

Analysis plan

Demographic, asthma, sleep hygiene, and sleep outcome variables were summarized for the aggregated sample. Bivariate correlation analysis was used to identify potential confounders for the proposed analyses. Specifically, Spearman rank order correlations were used to test for potential associations between demographic variables hypothesized a priori as potential confounders (age, sex, poverty level, and asthma severity) and independent and dependent variables (race/ethnicity and sleep outcomes, respectively). A variable was considered a confounder if it was associated (at the $P < .10$ level) with both the independent variable (race/ethnicity) and dependent variables (sleep outcomes). Significant confounders were held constant in subsequent analyses.

Race/ethnic disparities in sleep outcomes

Analyses were conducted on the sample of urban children with and without asthma. Unadjusted effects of race/ethnicity on each of the sleep outcomes were assessed using analysis of variance (ANOVA). A series of generalized linear models was used to assess race/ethnic disparities in sleep outcomes, adjusting for confounders. Models used effect level coding so that all 2-way comparisons (Latino vs NLW, AA vs NLW, and Latino vs AA) could be made with respect to sleep outcomes using a single model.

Moderators of race/ethnic disparities in sleep outcomes

Using a series of generalized linear models, we assessed whether racial/ethnic differences in sleep outcomes were moderated by asthma status, as well as sleep hygiene subscales and key variables (chosen a priori). Models included main effects of race/ethnicity, the potential moderator (eg, asthma status, sleep hygiene scale/item), as well as the interaction between race/ethnicity and the moderator. Each moderator was tested separately. Moderators were considered to be those variables for which an interaction was significant at a $P < .05$ level. All models were adjusted for poverty threshold, which was identified as a confounder in the correlation analysis.

All analyses addressed a priori hypotheses about moderators of racial/ethnic disparities in sleep outcomes. Given this approach, we followed Rothman,[33] who recommends not adjusting for multiple comparisons, which minimizes errors in interpretation and avoids increasing type II error rates at the expense of type I errors. All analyses were carried out using SAS (Cary, NC) 9.3, and significance was set at $\alpha = .05$ a priori.

Results

Results from preliminary analyses

Participants (N = 379) were 8.3 years of age on average (SD = 0.86); more than half were male (53%) and reported living at or below the poverty threshold (66%). Of the sample, 249 (or 66%) of children had asthma. Forty-five percent of caregivers identified themselves as Latino, 34% as Black or AA, and 21% as NLW. Overall, 31.2% of children reported at least 1 nap during the fall monitoring period (median = 0, range = 18.00). A full sample description appears in Table 1. Differences in sleep outcomes by race/ethnicity are reported below and in Table 2.

Racial/ethnic disparities in sleep outcomes among urban children with and without asthma

Unadjusted differences between race/ethnic groups with respect to sleep outcomes are presented in Table 2. There were no racial/ethnic differences in number of nighttime awakenings ($P = .65$) or sleep efficiency ($P = .15$). However, there were significant differences in sleep duration ($P < .001$), with NLW children having longer mean sleep duration, followed by AA and Latino children. Adjusted analyses (generalized linear models adjusting for poverty threshold) suggest a similar pattern of results, namely, significant disparities with respect to sleep duration: $b = -22.10$ (SE = 5.02), $P < .001$ for Latino vs NLW; $b = -18.70$, SE = 5.28, $P < .001$ for AA vs NLW; and $b = -3{,}40$, SE = 4.34, $P = .43$ for Latino vs AA. Regression coefficients can be interpreted as the mean differences in sleep duration between racial/ethnic groups, adjusting for poverty threshold (which was found to be a significant confounder in correlation analysis).

Moderators of racial/ethnic disparities in sleep outcomes: asthma status

Overall, results suggest a significant moderating effect of asthma status on racial/ethnic disparities in sleep outcomes. Data suggest that Latinos have a lower *mean number of awakenings* compared to NLWs but only among control participants with no asthma. Specifically, Latino participants in the control group had 1 fewer awakening on average compared to NLWs ($P = .02$). There were no race/ethnic differences in mean number of awakenings among children with asthma ($P > .05$). A full description of the model appears in Table 3.

We found a significant interaction between race/ethnicity and asthma status ($P = .05$) in models of *sleep efficiency* such that mean sleep efficiency was lower for AA vs NLWs among children with asthma ($b = -1.34$, SE = .76, $P = .05$). Latinos had better sleep efficiency compared to AAs among children with asthma ($b = 1.13$, SE = .55, $P = .03$). Finally, Latinos had better sleep efficiency compared to NLWs but only among controls ($b = 1.18$, SE = .64, $P = .05$). These effects correspond to significant interaction terms in the models.

Models including *sleep duration* also suggest a significant interaction between race/ethnicity and asthma status ($P = .05$). Results suggest that, among children with asthma, Latinos had shorter sleep duration compared to NLWs ($b = -29.73$, SE = 6.78, $P < .001$) and AAs had shorter sleep duration compared to NLWs ($b = -22.20$, SE = 7.18, $P = .002$). Among controls, AAs had shorter sleep duration compared to NLWs ($b = -17.89$, SE = 8.14, $P = .03$).

Moderators of racial/ethnic disparities in sleep outcomes: sleep hygiene

In analyses including the entire sample, results did not support a moderating effect of the total sleep hygiene score in the association between race/ethnicity (all Ps > .2) and sleep outcomes. In models

Table 2
Unadjusted ethnic/racial differences in sleep outcomes

	Sample	Latino	Black/AA	NLW	Ethnic/racial group differences	Effect sizes[a]
Wakings, *M* (SD)	5.2 (2.37)	5.0 (2.51)	5.2 (2.35)	5.3 (2.10)	$F = 0.43$	0.05
Sleep efficiency, *M* (SD)	87.0 (3.39)	87.3 (3.39)	86.5 (3.50)	87.2 (3.15)	$F = 1.89$	0.11
Sleep duration,* *M* (SD)	556.0 (35.32)	550.2 (34.12)	553.6 (36.5)	572.3 (31.26)	$F = 10.11$*	0.24

M denotes mean (standard deviation) presented
[a] ANOVA effect sizes are partial omega squared (ω^2).
* $P < .05$.

Table 3
Moderators of ethnic/racial disparities in sleep outcomes

Moderator	Awakenings	Sleep efficiency	Sleep duration
Asthma status			
Latino	−1.01 (.44),* $t = -2.07$	1.18 (.64),* $t = 2.05$	−11.73 (7.98), $t = -1.47$
AA	−0.61 (.52), $t = -1.17$	0.56 (.76), $t = 0.73$	−17.89 (8.14),* $t = -2.27$
Asthma×Latino	0.98 (.71), $t = 1.38$	−1.34 (.76),* $t = -2.36$	−17.99 (9.55),* $t = -2.07$
Asthma×AA	0.89 (.71), $t = 1.25$	−1.90 (1.04), $t = -1.83$	−4.31 (10.74), $t = -0.4$
Sleep hygiene (overall score)			
Latino			
AA	1.27 (2.80), $t = .45$	−1.61 (4.11), $t = -.39$	−8.97 (41.25), $t = -.22$
Hygiene×Latino	−2.34 (2.92), $t = -.80$	2.35 (4.28), $t = .55$	−24.81 (42.93), $t = -.58$
Hygiene×AA	−.35 (.60), $t = -.59$	.41 (.88), $t = .47$	−2.32 (8.82), $t = -.26$
	.50 (.62), $t = .80$	−.65 (.91), $t = -.71$	1.83 (9.17), $t = .2$
Emotional sleep hygiene			
Latino			
AA	−.94 (2.55), $t = -.37$	2.65 (3.73), $t = .71$	−57.77 (37.72), $t = -1.53$
Hygiene×Latino	−3.80 (2.63), $t = -1.44$	4.51 (3.81), $t = 1.18$	−85.33 (38.54),* $t = -2.21$
Hygiene×AA	.12 (.46), $t = .26$	−.45 (.67), $t = -.68$	6.44 (6.78), $t = .95$
	.69 (.48), $t = 1.45$	−.94 (.69), $t = -1.37$	12.09 (6.96),* $t = 2.07$
Environmental hygiene			
Latino			
AA	1.08 (2.90), $t = .37$	−4.08 (4.32), $t = -.95$	−93.94 (44.02),* $t = -2.13$
Hygiene×Latino	−5.61 (3.08), $t = -1.82$	4.75 (4.58), $t = 1.04$	−113.89 (46.71),* $t = -2.44$
Hygiene×AA	−.25 (.14),* $t = -2.47$	.79 (.80), $t = .99$	13.36 (8.14), $t = 1.64$
	1.04 (.57), $t = 1.82$	−1.01 (.85), $t = 1.19$	17.69 (8.64),* $t = 2.05$
Bedtime routine			
Latino	.51 (1.05), $t = .48$	−.84 (1.52), $t = -.55$	15.07 (15.33), $t = .98$
AA	.62 (1.11), $t = .56$	−1.35 (1.62), $t = -.83$	10.43 (16.31), $t = .64$
Routine×Latino	−.22 (.25), $t = -.87$	.27 (.37), $t = .74$	−9.24 (3.70),* $t = -2.50$
Routine×AA	−.17 (.26), $t = .65$	.17 (.38), $t = .45$	−7.15 (3.83), $t = -1.87$
Nighttime noise in home			
Latino			
AA	1.15 (.74), $t = 1.56$	−1.96 (1.06),* $t = -2.08$	−23.00 (10.92),* $t = -2.11$
Noise×Latino	1.08 (.81). $t = 1.34$	−2.21 (1.17),* $t = 2.09$	−17.59 (11.98), $t = -1.47$
Noise×AA	−.94 (.44),* $t = -2.11$	1.40 (.64),* $t = 2.19$	.71 (6.58). $t = .11$
	−.72 (.50), $t = 1.43$	.99 (.72), $t = 1.37$	−.71 (7.43). $t = -.10$
Nighttime noise in neighborhood			
Latino			
AA	−.42 (/65), $t = -.65$	−.07 (.94), $t = -.07$	7.88 (9.50), $t = -.83$
Noise×Latino	.28 (.74), $t = .37$	−1.42 (1.08), $t = -1.31$	1.60 (10.89), $t = -.15$
Noise×AA	.11 (.39), $t = .27$	.14 (.56), $t = .25$	−10.07 (5.65),* $t = -2.78$
	−.24 (.48), $t = -.50$	.55 (.69), $t = .80$	−12.27 (6.92),* $t = -2.77$

Unstandardized regression coefficient (SE) presented for both main effects and interactions. Each row block represents a separate model and each column a separate outcome. Taken together, the main effects and interactions yield estimates of the association of ethnicity/race for each level of the moderator. Models adjusted for poverty threshold.
* $P < .05$.

testing the moderating role of the specific sleep hygiene subscales, however, there was a significant interaction between race/ethnicity and the *emotional sleep hygiene subscale* on *sleep duration* such that AAs had significantly lower sleep duration relative to NLWs among those with lower emotional hygiene scores, $b_{\text{interaction}} = 12.09$, SE = 6.96, $P = .05$ (Table 3). In addition, there was a significant interaction between the *environmental hygiene subscale* and race/ethnicity on sleep duration ($b_{\text{interaction}} = 17.69$, SE = 8.64, $P = .04$) such that AAs had lower sleep duration compared to NLWs among those with lower environmental sleep hygiene scores. Furthermore, there was a significant interaction between the *bedtime routine sleep hygiene subscale* and race/ethnicity on sleep duration such that Latinos had lower sleep duration compared to NLWs among those with high bedtime routine hygiene scores, $b_{\text{interaction}} = -9.24$, SE = 3.70, $P = .01$. There was a similar pattern for AAs vs NLWs, $b_{\text{interaction}} = -7.15$, SE = 3.83, $P = .05$.

Finally, there was a significant interaction between the *environmental hygiene subscale* and race/ethnicity on *night awakenings* such that Latinos had a higher number of awakenings compared to NLWs among those with lower environmental hygiene scores, $b_{\text{interaction}} = -.25$, SE = .14, $P = .03$. There were no other interactions between race/ethnicity and the sleep hygiene subscales (physiological, cognitive, and sleep stability, *P*s> .05).

Nighttime noise in the home or neighborhood

Key sleep hygiene items were chosen a priori as potential moderators of racial/ethnic disparities in sleep (noise in the house or neighborhood). Nighttime noise in the house was a significant moderator in a model of awakenings, with Latinos having more awakenings compared to NLWs among those who report more frequent noises in the house ($b_{\text{interaction}} = -.94$, SE = .44, $P = .04$). Similarly, worse sleep efficiency was found for Latinos compared to NLWs when they reported more noise in the house, $b_{\text{interaction}} = 1.40$, SE = .64, $P = .02$. Noise in neighborhood at night was also a significant moderator of racial/ethnic disparities in sleep duration. Both Latinos ($b_{\text{interaction}} = -10.07$, SE = 5.65) and AAs ($b_{\text{interaction}} = -12.27$, SE = 6.92) had worse sleep duration compared to NLWs among those who reported more frequent noises in the neighborhood, *P*s = .05. A full description is presented in Table 3.

Discussion

The primary goal of this study was to examine racial/ethnic differences in sleep outcomes among an urban sample of school-aged children with and without asthma. An additional goal was to determine whether children's asthma status or specific sleep hygiene processes contributed to racial/ethnic differences in sleep disparities. This study included a carefully evaluated sample of urban children from Latino, Black/AA, and NLW backgrounds. Given the impact of insufficient and/or lower-quality sleep on children's daily functioning and that poorer sleep has been documented in at-risk groups such as minority children—particularly those with asthma—it is critical to identify factors that contribute to variations in sleep outcomes among specific groups of children to inform tailored sleep health interventions. The study also used objective home-based monitoring of sleep via actigraphy over a period of 4 weeks, which provided continuous assessment of sleep over time. Examining a range of sleep indicators allowed for a more precise understanding of which aspects of sleep health may be more at risk for specific groups.

Results involving the examination of racial/ethnic differences in sleep outcomes showed that the average amount of sleep children had over the monitoring period was shorter among the minority groups of children; Latinos has the shortest sleep duration followed by AA children and then NLW children. Previous work has shown that many children living in urban areas are exposed to suboptimal sleep environments.[18] In addition to urban stressors, Latino children are more likely to face unique cultural stressors related to their race/ethnic background (eg, acculturation stress, language barriers) that may negatively impact their sleep behaviors.[22] More research is needed to examine specific urban stressors and sleep behaviors that disrupt sleep to determine how best to tailor sleep strategies and interventions to meet the sleep needs of children at higher risk for poorer sleep.

An important aim of pediatric sleep disparities research is to identify factors that contribute to racial/ethnic differences in sleep outcomes among children. A goal of the current study was to address this important gap in the literature. As such, we examined risk factors relevant to urban children's sleep and whether each played a moderating role in racial/ethnic differences in sleep outcomes: children's asthma status (asthma vs nonasthma status) or specific aspects of sleep hygiene (sleep hygiene behaviors, noise in the home or neighborhood). Minority children appeared to be at greater risk for poorer sleep outcomes, particularly those with asthma. For example, among children with asthma, Latinos had on average shorter sleep duration than NLWs, as did AA children compared to NLWs. Among urban children with no asthma, AAs also had shorter sleep than NLWs. As demonstrated by our prior work, asthma status is an important risk factor to consider when treating urban children with sleep problems, as nocturnal asthma worsening can shorten the amount of sleep children obtain across the sleep period.[22]

Urban AA children with asthma had poorer sleep efficiency than NLW children and Latino children in the sample, on average, across the monitoring period. However, in children *without* asthma, Latinos had higher sleep efficiency than NLW children. Again, asthma status is important to consider when developing recommendations on how to improve the quality of children's sleep, which may be disrupted by both urban stressors and poor asthma symptom control. Medication use has been shown to be inconsistent in race/ethnic minority groups of children[34]; therefore, more attention is needed to improve not only the consistent use of daily controllers but the availability and use of rescue medications prior to and during the night to treat symptoms.

We also examined whether aspects of sleep hygiene and the sleep environment played a role in racial/ethnic disparities in sleep health outcomes among urban children with and without asthma. Although the overall sleep hygiene score did not contribute to racial/ethnic disparities in sleep outcomes, specific aspects of sleep hygiene were important to sleep health, particularly sleep duration and number of night awakenings, and minority children were at the greatest risk. For example, AA children had shorter sleep duration than NLWs among those with lower scores on the emotional, environmental, and bedtime routine sleep hygiene subscales. Interestingly, Latinos had shorter sleep duration than NLWs among those with higher scores on the bedtime routine subscale compared to NLWs. It is unclear whether the current measurement used adequately captures the range of bedtime routines in specific groups of children. Other factors related to the sleep environment may have contributed to shorter sleep more so than those related to bedtime routines, but this needs to be examined in further research because there is limited published work on cultural and contextual factors related to sleep outcomes among Latino children and families. Furthermore, results suggest that more research is needed to identify specific factors related to children's sleep environment (eg, sleep space) and their emotional status prior to and during bedtime that may contribute to shorter sleep among specific minority groups of children. Disruptors in the child's bedroom that may be related to urban poverty (eg, multiple family members sharing a room, noise) or asthma activity (eg, triggers in the child's bedroom), as well as psychological factors (eg, stress, anxiety), may shorten and/or disrupt sleep and require specific intervention using an integrative approach tailored to urban families' needs and resources.

Finally, with respect to night awakenings, Latino children had more night awakenings than NLW children among those with lower scores on the environmental sleep hygiene subscale. In contrast, aspects of sleep hygiene that involve physiological arousal (eg, caffeine use), cognitive arousal (eg, using the bed for nonsleep activities), and sleep stability (eg, consistent sleep schedule and location) appeared less salient for our sample. Taken together, future interventions for urban children may consider targeting specific sleep hygiene practices that were especially relevant to the sleep health of our sample, including emotional sleep hygiene, which refers to managing distress and worries at bedtime. In addition, environmental sleep hygiene taps into a number of important (and modifiable) characteristics of the sleep environment that facilitate sleep onset and maintenance, including sleeping on a comfortable sleep surface in a room with minimal light, comfortable temperature and airflow, and no electronics. Finally, the importance of a regular bedtime routine that is calming and consistent, with relaxing activities just before bedtime (such as reading or music), should be considered. Although all of these aspects of sleep hygiene may be more challenging for families within urban settings, due to greater stressors of daily living, space and financial constraints, and busy schedules, all are amenable to change.

Our results also indicate that noise in the home and neighborhood at night plays an important role in racial/ethnic differences in the sleep health of our urban sample. We found that minority children were at increased risk for noise exposure: Latino children had more night awakenings and poorer sleep efficiency than NLWs among those who reported more noise in the home during the night. Among children who were exposed to more nocturnal neighborhood noise, Latinos and AAs had shorter sleep duration than NLWs. Thus, considering noise exposure in interventions and treatments geared toward improving the sleep health of urban youth is necessary. Focusing on the specific sources of noise in the home could tailor these strategies, as well as identifying modifiable strategies for decreasing outdoor noise exposure (eg, sleeping with earplugs or using white noise).

Several limitations of the current paper warrant consideration. First, our study questions need to be applied to larger samples of urban diverse children with and without asthma to evaluate reliability of findings. Other sociocultural (eg, sleep beliefs) and environmental factors (eg, irritants and allergens), as well a clinical characteristics relevant to asthma status (eg, asthma control, medication adherence), that may contribute to variations in sleep health require further study. Comorbid conditions relevant to asthma status and sleep also should be examined in future work assessing sleep health in this population, such as allergic rhinitis, SDB, and obesity status, as our prior work has shown that these conditions can affect academic functioning and sleep[35] and are more prevalent in urban minority children. Other sleep indicators also need to be considered in future research identifying contributors to sleep disparities, such as sleep timing and sleep onset latency, although these outcomes did not result in ethnic/racial differences across the sample regardless of asthma status. Furthermore, potential variability in sleep outcomes needs to be analyzed in this group, as more variability may be more predictive of decrements in short- and long-term health outcomes, as well as academic functioning. More fine-grained analysis assessing length of awakenings and average time between awakenings may be meaningfully different based on asthma status and ethnic/racial background and should be examined in future work. Finally, there is also a host of sleep disruptors related to urban poverty that warrant consideration in future work with this population, such as number of family members in the home, and in specific sleep settings that may make it difficult for children to fall asleep and maintain sleep. The role of napping also needs to be examined, as napping can affect children's sleep onset latency and duration.

In summary, minority urban youth are at higher risk for poor sleep health outcomes and asthma status. They may also be exposed to more stressors related to urban (eg, poverty) and ethnic background (eg, acculturation stress, language barriers) that can challenge effective disease management[36] and optimal sleep health.[37] Sleep recommendations for urban children with asthma need to consider children's asthma control and management strategies relevant for optimal sleep (eg, available rescue inhaler, trigger-free sleep environment). Typical sleep hygiene recommendations may not be appropriate; sleep hygiene behaviors and disruptors in the sleep environment more common in urban settings need to be considered by health care providers working with urban children. Given that sleep health can affect all aspects of children's functioning, interventions that consider multilevel contributors to sleep outcomes and use risk assessments to identify those sleep risks that are modifiable may be more successful at meeting the sleep needs of urban minority children and, in doing so, address important sources of health disparity among one of the most vulnerable populations.

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