Published in final edited form as:

Pediatrics. 2009 July ; 124(1): 218–225. doi:10.1542/peds.2008-2525.

Sleep-Disordered Breathing and Behaviors of Inner-City Children with Asthma

Maria Fagnano, MPH¹, Edwin van Wijngaarden, PhD², Heidi V. Connolly, MD³, Margaret A. Carno, PhD³, Emma Forbes-Jones, PhD⁴, and Jill S. Halterman, MD, MPH¹

¹ Department of Pediatrics and Golisano Children's Hospital at Strong, University of Rochester School of Medicine and Dentistry

² Department of Community and Preventive Medicine, University of Rochester School of Medicine and Dentistry

³ Department of School of Nursing, University of Rochester School of Medicine and Dentistry

⁴ Department of Psychiatry, University of Rochester School of Medicine and Dentistry

Abstract

Objective—To explore the relationship between sleep-disordered breathing (SDB) and behavioral problems among inner-city children with asthma.

Patients and Methods—We examined data for 194 children (age 4–10 yrs) who were enrolled in a school-based asthma intervention program (response rate: 72%). SDB was assessed using the Sleep-Related Breathing Disorder (SRBD) questionnaire that contains 3 subscales: snoring, sleepiness, and attention/hyperactivity. For the current study, we modified the SRBD by removing the 6 attention/hyperactivity items. A sleep score of $>.33$ was considered indicative of SDB. To assess behavior, caregivers completed the Behavior Problem Index (BPI) which includes 8 behavioral subdomains. We conducted bivariate analyses and multiple linear regression to determine the association of SDB with BPI scores.

Results—The majority of children (mean age 8.2 yrs) were male (56%), African American (66%), and insured by Medicaid (73%). Overall, 33% of children experienced SDB. In bivariate analyses, children with SDB had significantly higher (worse) behavior scores compared to children without SDB on total BPI (13.7 vs 8.8, $p<.001$), externalizing (9.4 vs 6.3, $p<.001$), internalizing (4.4 vs 2.5, $p<.001$), anxious/depressed (2.4 vs 1.3, $p<.001$), headstrong (3.2 vs 2.1, $p<.001$), antisocial (2.3 vs 1.7, $p=.013$), hyperactive (3.0 vs 1.8, $p<.001$), peer conflict (.74 vs .43, $p=.011$), and immature (2.0 vs 1.5, $p=.001$). In multiple regression models adjusting for several important covariates, SDB remained significantly associated with total BPI, externalizing, internalizing, anxious/depressed, headstrong, and hyperactive behaviors. Results were consistent across SDB subscales (snoring, sleepiness).

Conclusions—We found that poor sleep was independently associated with behavior problems in a large proportion of urban children with asthma. Systematic screening for SDB in this high-risk population might help to identify children who would benefit from further intervention.

Keywords

childhood asthma; inner-city; behavior; sleep-disordered breathing

INTRODUCTION

Asthma is one of the leading causes of childhood illness,^{1–3} affecting nearly 9 million children in the United States.⁴ The public health burden of childhood asthma is extensive including high rates of hospitalizations^{2,5–7} and emergency department visits,^{3, 5,8,9} absenteeism from school and work,^{5,10} and impaired quality of life.^{11,12} Furthermore, children from poor and African American backgrounds suffer disproportionately from asthma.^{8,13,14}

Several studies have linked asthma symptoms and childhood behavior problems, such as hyperactivity and inattention.^{15–17} For example, a meta-analysis of 26 studies found that children with persistent asthma symptoms had higher levels of behavioral problems compared to healthy children.¹⁶ Troubled behavior among children with asthma may be compounded by sleep-disordered breathing (SDB) which encompasses a continuum of sleep related disturbances ranging from primary snoring to overt obstructive sleep apnea (OSA). SDB is becoming increasingly recognized in children, with prevalence estimates ranging from 0.7%–3% for the more severe OSA^{18–21} to as high as 7–25% for the milder form of SDB, primary snoring.^{19,22–25} SDB in childhood may also be associated with persistent wheezing or asthma.^{20, 26,27}

There has been growing evidence that children with SDB have higher rates of behavioral problems compared to children without SDB^{24,25,28,29}, and improvement in sleep-disordered breathing may alleviate behavioral problems in children.^{30,31} However, limitations in the published literature preclude us from drawing a causal link between sleep and behavior,³² and additional studies are needed to help develop a more complete understanding of this relationship. Research in high-risk populations may be particularly useful since one would expect associations may be stronger in more susceptible groups of individuals.

We are not aware of studies that have specifically explored the relationship between SDB and behavior in a community sample of non-referred urban children with asthma. It is important to assess the relationship between SDB and behavior among this sample, as this is a high risk group of children for both sleep and behavior problems that may particularly benefit from appropriate interventions. In this study, we explored the association between SDB and troubled behaviors in a sample of urban children with asthma. We hypothesized that children with parent-reported poor sleep will have worse behaviors.

METHODS

Setting and Participants

This study utilizes data collected from an ongoing school-based asthma intervention.³³ This randomized controlled trial is designed to evaluate the impact of school nurse-administered maintenance asthma medications and an environmental tobacco smoke-reduction program for inner-city children in Rochester, NY. Our analysis includes a community sample of 226 children, ages 3–10 years, enrolled in the program (overall response rate=72%).

For enrollment, we identified children through school health forms, and a screening form was administered by telephone with the child's primary caregiver to determine eligibility for the intervention. Children with physician-diagnosed asthma and persistent symptoms in the past year based on national guidelines³⁴ were eligible. Written informed consent was obtained from all primary caregivers and assent was obtained from children >7 years of age prior to enrollment in this study.

From August 2006 to November 2006, each participating family received an extensive home visit to collect baseline data, including demographic information, asthma symptom severity, medications, healthcare utilization, child behaviors and caregiver factors. Families received a follow-up telephone call each month to discuss the child's asthma symptoms and healthcare utilization. At the end of the school year (approx. June 2007), we conducted an extensive final follow-up telephone call. We assessed symptoms, child behavior, sleep problems and additional information during this final interview. We also collected a saliva sample for cotinine measurement and measured the child's height and weight at the end of the school year.

For the current analysis we excluded 16 children without final follow-up data (7 withdrawn, 8 lost to follow-up, 1 incomplete data) and 2 children less than 4 years old because the behavior scale used here is not validated for this age group. We also excluded 14 children with an Autism diagnosis (including Autism, Asperger Syndrome, and Pervasive Developmental Disorder). Our final analytic sample included 194 children. The University of Rochester's Institutional Review Board approved the study protocol.

Assessment of Behavior

We assessed childhood behavior using the previously validated Behavior Problem Index (BPI).³⁵ The BPI was created by Peterson and Zill using many of the same questions as Achenbach's Childhood Behavior Checklist.³⁶ This 32-item survey is used to assess behaviors during the previous 3 months for children 4–17 years of age; 28 items are included in the survey for children 12 years and younger. Caregivers are asked to respond to statements of behavior by reporting whether each behavior is “Not true”, “Sometimes true”, or “Often true” of their child. All positive responses (sometimes true and often true) are scored as a 1 and summed to create a total behavior score (range 0–28). A score of >14 indicates significant behavior problems.³⁷ The BPI can also be divided into several subscales; externalizing (18 items), internalizing (10 items), anxious/depressed (5 items), antisocial (6 items), hyperactive (5 items), headstrong (5 items), peer conflict (3 items), and immature (4 items). Examples of statements included in the BPI include, “Has trouble getting along with others,” “Demands a lot of attention,” and “Is too fearful or anxious.”

Assessment of SDB

We assessed sleep problems by using the 22-item Sleep-Related Breathing Disorder (SRBD) scale.^{38,39} The SRBD is a validated subscale of the Pediatric Sleep Questionnaire (PSQ),³⁸ and contains questions about snoring, sleepiness, apnea, attention and hyperactivity. Parents respond to questions about sleep-related behaviors by responding, “Yes” = 1, “No” = 0 or “Don't know” = missing. The mean response from non-missing items creates a score between 0 and 1. A sleep score >.33 has been effective in identifying pediatric sleep-disordered breathing using polysomnography as the gold standard assessment.^{38,39} Use of the SRBD scale in the current study was permitted by creator Ronald D. Chervin, MD, MS (personal communication, 2007).

The SRBD contains 3 subscales: snoring, sleepiness, and attention/hyperactivity. Because we evaluated the relationship between SDB and behaviors, including hyperactivity, we modified the SRBD to exclude the six attention/hyperactivity questions. These items include statements about difficulty organizing tasks, fidgeting, and interrupting conversations. Analysis of the SRBD without the 6 attention and hyperactivity questions is consistent with prior work of Dr. Chervin.⁴⁰

Assessment of Covariates

We examined child, caregiver, and environmental covariates for this analysis. Child factors in this study consist of standard demographic variables for each child including, sex, race (white/

African American/other), ethnicity (Hispanic/not Hispanic), and child's age. We also included Medicaid insurance (yes/no), prematurity (yes/no), body mass index (age and gender adjusted Z-score), and current asthma severity (intermittent/persistent) as other variables that may be related to sleep and behavior. We assessed asthma severity during the final follow-up interview by asking parents to report the number of days in the previous 14 days their child had daytime asthma symptoms and the number of days with nighttime asthma symptoms. Children with ≥ 5 days of daytime symptoms or ≥ 2 nights with asthma symptoms during the past two weeks were considered to have persistent asthma symptoms based on national guidelines.³⁴

Caregiver factors include the caregiver's age ($<30/\geq 30$ years), caregiver's education ($<$ high school/ $\geq$ high school), parent depression, parent stress, and parent quality of life.

We evaluated parent depression using the Kessler Psychological Distress Scale (K10).⁴¹ The K10 is a 10-item scale used to assess symptoms of depression and anxiety. We asked caregivers how frequently they experienced each item (e.g., nervous, depressed) in the past 4 weeks ("None of the time" (score=1) to "All of the time" (score=5)). We summed scores from all items and higher scores indicate a higher risk of depression, anxiety or both (range 10–50). We then divided scores into four categories (Well, Mild, Moderate, and Severe psychological distress) based on previously validated domains.⁴² We measured parent stress using questions from the competence subscale of the Parenting Stress Index with permission from the publisher, Psychological Assessment Resources, Inc.⁴³ We included 5 items on a 5-point scale, and summed scores for a total parent stress score (range 5–25). Higher scores indicate increased parental stress.

Caregivers also rated their quality of life using the Pediatric Asthma Caregivers Quality of Life Questionnaire (PACQLQ) by Juniper et al.⁴⁴ Parents answered 13 questions about how their child's asthma may have interfered with normal daily activity over the past week. PACQLQ questions are rated on a 7-point likert scale with 1 being "All of the time" and 7 being "None of the time." Responses were averaged for a mean quality of life score (range 1–7).

Environmental tobacco smoke exposure was measured by both parent report and the child's level of salivary cotinine. Cotinine, a metabolite of nicotine, is used as a biomarker for many intervention studies for young children with asthma.^{45,46} We collected saliva samples from each child during the time of the final follow-up assessment using standard collection techniques. All samples were measured with a standard enzyme-linked immunosorbent assay and reported in nanograms per milliliter (ng/mL).

Analysis

Analysis was performed using SPSS version 15.0 software (Statistical Product and Service Solutions 15.0; SPSS Inc, Chicago, Ill). We conducted student t-tests to compare mean BPI scores for children with (sleep score $>.33$) and without (sleep score $\leq .33$) sleep-disordered breathing. Multiple linear regression analyses were conducted to determine whether children with SDB have more behavior problems. Initial covariates included in the regression analysis included demographic variables, covariates that were significant in the bivariate analysis, and key exposure variables (caregiver smokes, salivary cotinine, asthma severity, preventive asthma medication, and treatment group). We performed backward stepwise regression to include covariates with selection criteria of $p < .20$ for entry and $p < .15$ to remain in the model. These analyses were repeated for the behavioral subscales of the BPI. A 2-sided alpha $< .05$ for the primary hypothesis was considered statistically significant. With our sample size, we estimated that we could detect a three-point difference in total BPI scores between children with and without SDB, with 80% power and an alpha value of .05.

Results

Overall, the majority of children was male (56%), African American (66%), and insured by Medicaid (73%). Some children were born prematurely (11%), and the average age of the children was 8.2 years. Twenty-six percent of children had persistent asthma symptoms during the previous two weeks, and most children were prescribed a preventive asthma medication (86%). One third of parents had less than a high school education, and 41% of children lived with at least one smoker in the home (Table 1).

In this sample, children's sleep scores ranged from 0 to .88 with a mean score of .27 (SD = .20). Overall, 33% of the children had a sleep score $>.33$, indicating SDB. Children with SDB were more likely to be female, have a parent with less than a high school education, have nighttime asthma symptoms, and have a higher body mass index (Table 1). In addition, the parents of children with SDB were significantly more stressed, depressed, and had a lower quality of life. There were no differences in age, race, ethnicity, insurance status, exposure to tobacco smoke, prematurity, asthma severity, use of preventive asthma medication or treatment group between children with and without SDB.

Table 2 shows the scores on the total BPI and the behavior subscales. Overall, 32% of children had a total BPI above 14, indicating a significant behavioral concern that may warrant professional intervention. Compared to children with no sleep difficulties, children with SDB scored significantly higher on the total BPI (13.84 vs 8.9, $p<.001$) and on each of the behavior subscales (all $p<.05$).

The results of multiple linear regression analyses are shown in Table 3 using the sleep score as a dichotomous variable (SDB/no SDB). The initial model for each regression contained the following covariates: child's age, race, ethnicity, gender, parent education, BMI Z-score, parent smoking status, cotinine level, parent depression, parent stress, parent quality of life, asthma severity, nighttime asthma symptoms, use of preventive asthma medication, and treatment group. Using the backwards stepwise regression, many of these covariates did not remain in the final models which are indicated in Table 3. Overall, SDB remained significantly associated with total BPI, externalizing, internalizing, anxious/depressed, headstrong, and hyperactive behaviors when controlling for pertinent covariates (Table 3).

Because nighttime symptoms of asthma could be confused with sleep disordered breathing symptoms, particularly for items on the sleepiness subscale, we repeated the analyses using scores on the sleep subscales (snoring and sleepiness) separately. In each of these analyses we found similar significant associations shown between higher sleep scores and worse behaviors (results not shown).

DISCUSSION

This study examined the association between sleep-disordered breathing and childhood behavior problems among a group of inner-city children with asthma. We found that one third of urban children with asthma may be suffering from SDB. This is considerably higher than the current estimates of SDB in children, and suggests that routine screening for SDB might be particularly important for children with asthma. Similarly, we found that 32% of these children have behavioral symptoms severe enough to warrant further evaluation. It is clear from these findings that urban children with asthma are at risk for both SDB and poor behavior.

Children with asthma and sleep-disordered breathing had worse behavior compared to children without sleep difficulties. Children with SDB scored nearly 5 points higher on the total BPI compared to children without SDB. This means that children with SDB exhibited, on average, 5 more problem behaviors than children without sleep difficulties. These findings were

particularly prominent in the externalizing domains, including hyperactivity and headstrong behaviors, and remained even when controlling for important variables which can influence children's sleep, behavior, and parent's report of sleep and behavior.

Prior research has also demonstrated a relationship between sleep disturbances and externalizing behavior problems. For example, a recently published study of children with a clinical diagnosis of SDB compared children's scores on the SRBD scale (excluding the 6 attention/hyperactivity questions) with their behaviors before and after adenotonsillectomy.³⁰ The authors reported a strong association between children's sleep scores and inattention, oppositional behaviors, and an attention deficit and hyperactivity disorder index prior to surgery, with some suggestion of improvement after surgery. Another study found similar results among a large population based sample of children, where symptoms of SDB were present in 25% of children,²⁵ and these children were more likely to exhibit problem behaviors such as hyperactivity, inattention and aggressive behaviors.

A strength of our study is that we were able to account for many possible confounding variables in our analyses, which is noteworthy since the etiology of poor childhood sleep is complex. For example, African American children, children that are overweight or obese, and children who were born prematurely have been found to be at an increased risk for SDB.^{20,47,48} Furthermore, mental distress of parents has also been associated with poor child sleep.^{49,50} Similarly, behavior problems are more prevalent among poor and urban populations.⁵¹ Social and environmental stressors such as socioeconomic status, familial issues, and environment can influence both asthma and behavioral outcomes.⁵²

Our study is unique in that it explores the relationship between sleep and behavior among a non-referred, community-based sample of children, using previously validated surveys. Much of the literature assessing sleep and behavior has included children from clinical practices for sleep assessment, behavioral assessment or adenotonsillectomy.³² Our study observes the association between sleep and behavior among a group of non-referred, urban children with asthma, a population that could potentially benefit substantially from assessment and intervention.

Lastly, BPI and SDB surveys used in our study are brief and could be utilized in a clinical setting to help identify children with poor sleep or troubled behavior. Several studies have utilized the BPI as a parent-report measure to assess behavioral problems in children.^{15, 53, 54} In addition, the use of the SRBD scale in research as a way to identify children with sleep-disordered breathing is increasingly common.^{30, 39, 55}

Limitations

There are some limitations to this study. First, this is a cross-sectional study and therefore, we cannot establish a directional relationship between SDB and behavior problems in this sample of children. Additionally, behavior problems were assessed by caregiver only and were not confirmed with physicians, teachers, or with subsequent assessments. Similarly, sleep-disordered breathing was not confirmed with polysomnography, the current standard for diagnosis of SDB. However, recent studies have found a strong correlation between a sleep score of $>.33$ and a diagnosis of SDB using polysomnography.^{30, 39} In addition, we did not have information regarding prior surgeries including tonsillectomy or adenoidectomy.

All families were recruited from an inner-city community and many of these families experience stressful lives that may contribute to parents' report of both sleep and behavior problems. Fortunately, we are able to control for several factors including parent depression, stress and quality of life in our multiple regression analysis. In addition, this study uses data at the end of a 7–9 month asthma intervention, and while we were able to control for the

influence of the intervention in our models, we realize that caregivers may respond differently to questions depending on their views of the intervention.

Lastly, it is possible that parents may confuse some symptoms of sleep-disordered breathing with nighttime asthma symptoms. For example, symptoms such as ‘struggling to breathe’ or ‘intermittent breathing’ at night could be interpreted as either asthma symptoms or SDB. However, symptoms of snoring are less likely to be confused with symptoms of asthma, and when we repeated our analysis using the individual subscales (snoring and sleepiness) we found similar, consistent relationships between SDB and behavior.

Implications

Childhood sleep disorders are often overlooked in the clinical setting, and this study identifies a group of children who may be at particularly high risk. In 2002, the American Academy of Pediatrics recommended that physicians screen all children for snoring to determine risk of OSA.⁵⁶ This recommendation underscores the importance of sleep disorders and children’s health. The findings of this study suggest that clinicians should be particularly diligent about screening all children with asthma for SDB, and consider sleep disorders as a possible risk factor for behavior problems. Further investigation is needed to determine whether treatment of sleep disorders would help to decrease behavior problems in this population.

Acknowledgments

This study was funded by the National Heart Lung and Blood Institute (R01-HL079954) and the Halcyon Hill Foundation

We would like to thank Kelly Conn, MPH for her assistance with this manuscript.

Abbreviations

BPI	Behavior Problem Index
K10	Kessler Psychological Distress Scale
OSA	Obstructive Sleep Apnea
PACQLQ	Pediatric Asthma Caregivers Quality of Life Questionnaire
PSQ	Pediatric Sleep Questionnaire
SDB	Sleep-Disordered Breathing
SRBD	Sleep-Related Breathing Disorder

References

1. Adams PF, Marano MA. Current estimates from the National Health Interview Survey, 1994. Vital Health Stat 10 1995(193 Pt 1):1–260.
2. Centers for Disease Control and Prevention. Surveillance for Asthma - US, 1960–1995, (CDC Surveillance Summaries). MMWR 1995;47:1022–1025.

3. National Heart, Lung, and Blood Institute. Asthma Statistics. Bethesda, MD: National Institutes of Health, Public Health Services; January 1999. Data Fact Sheet.
4. Bloom B, Dey A. Summary Health Statistics for U.S. Children: National Health Interview Survey, 2004. National Center for Health Statistics. Vital Health Stat 2006;10(227)
5. Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma--United States, 1980–1999. MMWR Surveill Summ 2002;51(1):1–13.
6. McConnochie KM, Russo MJ, McBride JT, Szilagyi PG, Brooks AM, Roghmann KJ. Socioeconomic variation in asthma hospitalization: excess utilization or greater need? Pediatrics 1999;103(6):e75. [PubMed: 10353972]
7. Gergen PJ, Weiss KB. Changing patterns of asthma hospitalization among children: 1979 to 1987. JAMA 1990;264(13):1688–1692. [PubMed: 2398608]
8. Akinbami LJ, Schoendorf KC. Trends in childhood asthma: prevalence, health care utilization, and mortality. Pediatrics 2002;110(2 Pt 1):315–322. [PubMed: 12165584]
9. Halterman JS, Aligne CA, Auinger P, McBride JT, Szilagyi PG. Inadequate therapy for asthma among children in the United States. Pediatrics 2000;105(1 Pt 3):272–276. [PubMed: 10617735]
10. National Institute of Allergy and Infectious Diseases. Asthma: A Concern for Minority Populations. Bethesda, MD: National Institute of Allergy and Infectious Diseases; 1996.
11. Juniper EF, Guyatt GH, Feeny DH, Ferrie PJ, Griffith LE, Townsend M. Measuring quality of life in children with asthma. Qual Life Res 1996;5(1):35–46. [PubMed: 8901365]
12. Juniper EF, Guyatt GH, Feeny DH, Ferrie PJ, Griffith LE, Townsend M. Measuring quality of life in parents of children with asthma. Qual Life Res 1996;5:27–34. [PubMed: 8901364]
13. Carr W, Zeitel L, Weiss K. Variations in asthma hospitalizations and deaths in New York City. Am J Public Health 1992;82(1):59–65. [PubMed: 1536336]
14. Weiss KB, Wagener DK. Changing patterns of asthma mortality. Identifying target populations at high risk. JAMA 1990;264(13):1683–1687. [PubMed: 2398607]
15. Bussing R, Halfon N, Benjamin B, Wells KB. Prevalence of behavior problems in US children with asthma. Arch Pediatr Adolesc Med 1995;149(5):565–572. [PubMed: 7735414]
16. McQuaid EL, Kopel SJ, Nassau JH. Behavioral adjustment in children with asthma: a meta-analysis. J Dev Behav Pediatr 2001;22(6):430–439. [PubMed: 11773808]
17. Halterman JS, Conn KM, Forbes-Jones E, Fagnano M, Hightower AD, Szilagyi PG. Behavior problems among inner-city children with asthma: findings from a community-based sample. Pediatrics 2006;117(2):e192–199. [PubMed: 16452328]
18. Ali NJ, Pitson DJ, Stradling JR. Snoring, sleep disturbance, and behaviour in 4–5 year olds. Arch Dis Child 1993;68(3):360–366. [PubMed: 8280201]
19. Gislason T, Benediktsdottir B. Snoring, apneic episodes, and nocturnal hypoxemia among children 6 months to 6 years old. An epidemiologic study of lower limit of prevalence. Chest 1995;107(4):963–966. [PubMed: 7705162]
20. Redline S, Tishler PV, Schluchter M, Aylor J, Clark K, Graham G. Risk factors for sleep-disordered breathing in children. Associations with obesity, race, and respiratory problems. Am J Respir Crit Care Med 1999;159(5 Pt 1):1527–1532. [PubMed: 10228121]
21. Anuntaseree W, Rookkapan K, Kuasirikul S, Thongsuksai P. Snoring and obstructive sleep apnea in Thai school-age children: prevalence and predisposing factors. Pediatr Pulmonol 2001;32(3):222–227. [PubMed: 11536452]
22. Hultcrantz E, Lofstrand-Tidestrom B, Ahlquist-Rastad J. The epidemiology of sleep related breathing disorder in children. Int J Pediatr Otorhinolaryngol 1995;32(Suppl):S63–66. [PubMed: 7665302]
23. Ferreira AM, Clemente V, Gozal D, et al. Snoring in Portuguese primary school children. Pediatrics 2000;106(5):E64. [PubMed: 11061801]
24. Rosen CL, Storfer-Isser A, Taylor HG, Kirchner HL, Emancipator JL, Redline S. Increased behavioral morbidity in school-aged children with sleep-disordered breathing. Pediatrics 2004;114(6):1640–1648. [PubMed: 15574628]
25. Gottlieb DJ, Vezina RM, Chase C, et al. Symptoms of sleep-disordered breathing in 5-year-old children are associated with sleepiness and problem behaviors. Pediatrics 2003;112(4):870–877. [PubMed: 14523179]

26. Stores G, Ellis AJ, Wiggs L, Crawford C, Thomson A. Sleep and psychological disturbance in nocturnal asthma. *Arch Dis Child* 1998;78(5):413–419. [PubMed: 9659086]
27. Hanson MD, Chen E. Brief report: the temporal relationships between sleep, cortisol, and lung functioning in youth with asthma. *J Pediatr Psychol* 2008;33(3):312–316. [PubMed: 18056138]
28. Stein MA, Mendelsohn J, Obermeyer WH, Amromin J, Benca R. Sleep and behavior problems in school-aged children. *Pediatrics* 2001;107(4):E60. [PubMed: 11335781]
29. O'Brien LM, Mervis CB, Holbrook CR, et al. Neurobehavioral implications of habitual snoring in children. *Pediatrics* 2004;114(1):44–49. [PubMed: 15231906]
30. Wei JL, Mayo MS, Smith HJ, Reese M, Weatherly RA. Improved behavior and sleep after adenotonsillectomy in children with sleep-disordered breathing. *Arch Otolaryngol Head Neck Surg* 2007;133(10):974–979. [PubMed: 17938319]
31. Chervin RD, Ruzicka DL, Giordani BJ, et al. Sleep-disordered breathing, behavior, and cognition in children before and after adenotonsillectomy. *Pediatrics* 2006;117(4):e769–778. [PubMed: 16585288]
32. Ebert CS Jr, Drake AF. The impact of sleep-disordered breathing on cognition and behavior in children: a review and meta-synthesis of the literature. *Otolaryngol Head Neck Surg* 2004;131(6):814–826. [PubMed: 15577774]
33. Halterman JS, Borrelli B, Fisher S, Szilagyi P, Yoos L. Improving care for urban children with asthma: design and methods of the School-Based Asthma Therapy (SBAT) trial. *J Asthma* 2008;45(4):279–286. [PubMed: 18446591]
34. National Asthma Education and Prevention Program (NAEPP). US Department of Health and Human Services NIH publication no. 02–5075. Bethesda, MD: 2002. Expert Panel Report II: Guidelines for the Diagnosis and Management of Asthma-Update on Selected Topics 2002.
35. Peterson JL, Zill N. Marital disruption, parent-child relationships, and behavioral problems in children. *Journal of Marriage and the Family* 1986;48(2):295–307.
36. Achenbach TM, Edelbrock CS. Behavioral problems and competencies reported by parents of normal and disturbed children aged four through sixteen. *Monogr Soc Res Child Dev* 1981;46(1):1–82. [PubMed: 7242540]
37. Gortmaker SL, Walker DK, Weitzman M, Sobol AM. Chronic conditions, socioeconomic risks, and behavioral problems in children and adolescents. *Pediatrics* 1990;85(3):267–276. [PubMed: 2304779]
38. Chervin RD, Hedger K, Dillon JE, Pituch KJ. Pediatric sleep questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. *Sleep Med* 2000;1(1):21–32. [PubMed: 10733617]
39. Chervin RD, Weatherly RA, Garetz SL, et al. Pediatric sleep questionnaire: prediction of sleep apnea and outcomes. *Arch Otolaryngol Head Neck Surg* 2007;133(3):216–222. [PubMed: 17372077]
40. Chervin RD, Ruzicka DL, Archbold KH, Dillon JE. Snoring predicts hyperactivity four years later. *Sleep* 2005;28(7):885–890. [PubMed: 16124670]
41. Kessler RC, Barker PR, Colpe LJ, et al. Screening for serious mental illness in the general population. *Arch Gen Psychiatry* 2003;60(2):184–189. [PubMed: 12578436]
42. Andrews G, Slade T. Interpreting scores on the Kessler Psychological Distress Scale (K10). *Aust N Z J Public Health* 2001;25(6):494–497. [PubMed: 11824981]
43. Abidin, RR. Parenting Stress Index. Vol. 3. Odessa, FL: Psychological Assessment Resources, Inc; 1995.
44. Juniper EF, Guyatt GH, Feeny DH, Ferrie PJ, Griffith LE, Townsend M. Measuring quality of life in the parents of children with asthma. *Qual Life Res* 1996;5(1):27–34. [PubMed: 8901364]
45. Irvine L, Crombie IK, Clark RA, et al. Advising parents of asthmatic children on passive smoking: randomised controlled trial. *BMJ* 1999;318(7196):1456–1459. [PubMed: 10346773]
46. Crombie IK, Wright A, Irvine L, Clark RA, Slane PW. Does passive smoking increase the frequency of health service contacts in children with asthma? *Thorax* 2001;56(1):9–12. [PubMed: 11120897]
47. Rudnick EF, Walsh JS, Hampton MC, Mitchell RB. Prevalence and ethnicity of sleep-disordered breathing and obesity in children. *Otolaryngol Head Neck Surg* 2007;137(6):878–882. [PubMed: 18036414]

48. Rosen CL, Larkin EK, Kirchner HL, et al. Prevalence and risk factors for sleep-disordered breathing in 8- to 11-year-old children: association with race and prematurity. *J Pediatr* 2003;142(4):383–389. [PubMed: 12712055]
49. Meltzer LJ, Mindell JA. Relationship between child sleep disturbances and maternal sleep, mood, and parenting stress: a pilot study. *J Fam Psychol* 2007;21(1):67–73. [PubMed: 17371111]
50. Shang CY, Gau SS, Soong WT. Association between childhood sleep problems and perinatal factors, parental mental distress and behavioral problems. *J Sleep Res* 2006;15(1):63–73. [PubMed: 16490004]
51. Simpson GA, Bloom B, Cohen RA, Blumberg S, Bourdon KH. U.S. children with emotional and behavioral difficulties: data from the 2001, 2002, and 2003 National Health Interview Surveys. *Adv Data* 2005;(360):1–13. [PubMed: 16004071]
52. French TM. Psychogenic factors in bronchial asthma. *Psychosom Med* 1941;4:2.
53. Weitzman M, Gortmaker S, Sobol A. Maternal smoking and behavior problems of children. *Pediatrics* 1992;90(3):342–349. [PubMed: 1518686]
54. Spencer MS, Grogan-Kaylor A, McBeath B. The equivalence of the Behavior Problem Index across U.S. ethnic groups. *Journal of Cross-Cultural Psychology* 2005;36(5):573–589.
55. Davis CL, Tkacz J, Gregoski M, Boyle CA, Lovrekovic G. Aerobic exercise and snoring in overweight children: a randomized controlled trial. *Obesity* 2006;14(11):1985–1991. [PubMed: 17135615]
56. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2002;109(4):704–712. [PubMed: 11927718]

Table 1
Population Demographics and Covariates by Sleep-Disordered Breathing

	Overall (N=194)	No SDB (N=130)	SDB (N=64)	P-value
Child Sex: Male[#]	109 (56)	80 (62)	29 (45)	.045
Child Age [^]	8.17 (1.88)	8.14 (1.9)	8.22 (1.85)	.771
Race [#]				
White	17(9)	12 (9)	5 (8)	.337
African American	129 (66)	90 (69)	39 (61)	
Other	48 (25)	28 (22)	20 (31)	
Hispanic [#]	51 (26)	34 (26)	17 (27)	1.00
Medicaid Insurance [#]	141 (73)	93 (72)	48 (75)	.732
Parent Age <30 [#]	64 (33)	46 (36)	18 (28)	.331
Parent Education <HS[#]	64 (33)	36 (28)	28 (44)	.034
≥ 1 Smoker in the Home [#]	79 (41)	49 (38)	30 (47)	.277
Caregiver Smokes [#]	57 (29)	33 (25)	24 (38)	.095
Child Born Premature [#]	21 (11)	13 (10)	8 (13)	.623
Persistent Asthma [#]	51 (26)	30 (23)	21 (33)	.169
Nights with Asthma Symptoms (over 2 weeks)[^]	1.29 (2.8)	.95 (2.3)	1.97 (3.4)	.016
Parent Depression				
Mild-Severe [#]	60 (31)	34 (26)	26 (41)	.048
Parent Stress[^]	9.46 (3.62)	8.97 (3.5)	10.47 (3.6)	.006
Parent Quality of Life[^]	6.41 (.73)	6.52 (.59)	6.18 (.92)	.002
Child's BMI Z-score[^]	.80 (1.8)	.61 (2)	1.19 (1.12)	.040
Salivary Cotinine [^]	2.21 (1.9)	2.29 (1.9)	2.04 (1.8)	.412
Preventive Asthma Medication [#]	167 (86)	113 (87)	54 (84)	.662
Treatment Group [#]	92 (47)	66 (72)	26 (41)	.222

[^] Results shown as: Mean (SD), a high score indicates greater problem with behavior

[#] Results shown as: N (%)

Table 2

Overall and Subscales of Behavior Problem Index Scores by Sleep-Disordered Breathing

	Overall (N=194)	No SDB (N=130)	SDB (N=64)	P-value
Total BPI [^]	10.53 (7.3)	8.9 (7.3)	13.84 (6.3)	<.001
Externalizing [^]	7.4 (5.1)	6.38 (5.1)	9.47 (4.3)	<.001
Internalizing [^]	3.13 (2.7)	2.52 (2.6)	4.38 (2.6)	<.001
Anxious/Depressed [^]	1.68 (1.6)	1.3 (1.5)	2.45 (1.5)	<.001
Headstrong [^]	2.51 (1.7)	2.2 (1.7)	3.22 (1.5)	<.001
Antisocial [^]	1.96 (1.8)	1.75 (1.7)	2.4 (1.7)	.013
Hyperactive [^]	2.2 (1.8)	1.79 (1.7)	3.03 (1.65)	<.001
Peer Conflict [^]	.54 (.9)	.43 (.8)	.765 (.94)	.011
Immature [^]	1.64 (1.3)	1.48 (1.3)	1.97 (1.25)	.014
BPI>14 [#]	62 (32)	31 (24)	31 (48)	.001

[^] Results shown as: Mean (SD), a high score indicates greater problem with behavior

[#] Results shown as: N (%)

Table 3

Linear Regression Models: Dichotomous Sleep Score Predicting Behavior Problems

Dependent Variables	β	Std Error	R^2	p-value
Total BPI ^{2, 3, 7, 9, 10, 12, 14}	.313	.130	.294	.017
Externalizing ^{3, 7, 8, 9, 10, 13, 15}	.318	.126	.275	.013
Internalizing ^{7, 9, 10, 13, 15}	.303	.108	.337	.006
Anxious/Depressed ^{2, 4, 7, 8, 9, 10, 15}	.249	.087	.374	.005
Headstrong ^{2, 5, 7, 8, 10, 13}	.275	.097	.225	.005
Antisocial ^{2, 7, 8, 10}	.074	.101	.200	.462
Hyperactive ^{3, 6, 7, 9, 10, 11, 12, 15}	.288	.098	.356	.004
Peer Conflict ^{5, 6, 8, 9, 13, 14}	.065	.071	.237	.367
Immature ^{1, 2, 3, 7, 8, 9, 10}	.104	.089	.191	.245

The following covariates were included in the backwards stepwise regression analyses. The covariates that remained in the final model are indicated next to each of the dependent variables in the table above.

¹ Child Age

² Race

³ Ethnicity

⁴ Gender

⁵ Parent Education

⁶ BMI Z-score

⁷ Primary Caregiver Smokes

⁸ Salivary Cotinine Level

⁹ Parent Depression

¹⁰ Parent Stress

¹¹ Parent Quality of Life

¹² Asthma Severity

¹³ Nighttime Asthma Symptoms

¹⁴ Preventive Asthma Medication

¹⁵ Treatment Group