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Prenatal and Neonatal Risk Factors for Sleep Disordered Breathing in School-Aged Children Born Preterm

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Abstract

Objectives—Previously published data from the Cleveland Children's Sleep and Health Study (CCSHS) demonstrated that preterm infants are especially vulnerable both to sleep disordered breathing (SDB) and its neurocognitive sequelae at age 8–11 years. In this analysis, we aimed to identify the components of the neonatal medical history associated with childhood SDB among children born prematurely.

Study design—This analysis focuses on the 383 children in the population-based CCSHS cohort who were born <37 weeks gestational age and who had technically acceptable sleep studies performed at ages 8–11 years (92% of all preterm children). Logistic regression was used to evaluate the associations between candidate perinatal and neonatal risk factors and the presence of childhood SDB by sleep study.

Results—Twenty-eight preterm children (7.3%) met the definition for SDB at age 8–11 years. Having a single mother and mild maternal pre-eclampsia were strongly associated with SDB in unadjusted and race-adjusted models. Unadjusted analyses also identified xanthine use and CPR and/or intubation in the delivery room as potential risk-factors for SDB. We did not find a significant link between traditional markers of severity of neonatal illness -- such as gestational age, birth weight, intraventricular hemorrhage (IVH), bronchopulmonary dysplasia (BPD), or duration of ventilation -- and childhood SDB at school age.

Conclusions—These results represent a first step in identifying prenatal and neonatal characteristics which place preterm infants at higher risk for childhood SDB. The strong association between mild pre-eclampsia and childhood SDB underscores the importance of research aimed at understanding in utero risk factors for neurorespiratory development.

Keywords

sleep disordered breathing (SDB); obstructive sleep apnea (OSA); pre-eclampsia; snoring; neonate

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Sleep disordered breathing (SDB) affects 0.7–4% of children.(1) SDB has been linked to hypertension,(2) growth failure,(3) enuresis,(4,5) and impairment of cognition, attention, and executive functions.(6–12) Identification of children at high risk for SDB and its associated morbidities is particularly important given the growing body of evidence that treatment with adenotonsillectomy may improve quality of life and neurocognitive function. (5,13–17)

Preterm infants are especially vulnerable both to SDB and its sequelae. In a Finnish cohort study, very low birth weight infants were shown to have a two-fold risk of SDB as young adults. (18) Previously published data from the Cleveland Children's Sleep and Health Study (CCSHS) demonstrated that former preterm children have a three-fold increase in the odds of childhood SDB compared to their term peers.(1) Furthermore, the association between sleep disordered breathing (SDB) and childhood cognitive impairment is stronger in preterm than term infants.(8) The mechanisms by which prematurity predisposes children to SDB are unknown. The association may be mediated by altered development of the lungs, airway, or nervous system. In this analysis, we aimed to identify the components of the prenatal and neonatal medical history associated with SDB occurring in children in the CCSHS studied at ages 8–11 years who had been born prematurely.

METHODS

The CCSHS is a population-based cohort derived by recruiting a stratified random sample of 490 term and 417 preterm children born between 1988 and 1993 at three Cleveland area hospitals as detailed previously.(1) Preterm infants were born < 37 weeks gestational age and admitted to neonatal intensive care for at least one week.

This analysis focuses on the 383 preterm children who had a medical chart review and a technically acceptable sleep study performed at age 8–11 years (92% of all preterm children). Institutional review boards at participating hospitals approved the protocol. The children's legal guardians provided informed consent and the children assented to participation.

Measurements and Definitions

Neonatal and maternal data were obtained by chart review of the birth and hospital records performed by a trained research assistant unaware of data collected at the age 8–11 year exam. Infants were diagnosed with respiratory distress syndrome (RDS) if they had a respiratory rate greater than 60, oxygen saturation less than 90%, increased work of breathing documented on exam, and onset at less than 12 hours of age. Bronchopulmonary dysplasia (BPD) was identified if an infant born at less than 30 weeks gestational age (GA) still had an oxygen requirement at 36 weeks GA, and if an infant born at greater than 30 weeks GA had an oxygen requirement for more than 28 days. We considered a child to have sustained a neurological insult if he or she had a grade III or IV intraventricular hemorrhage, periventricular leukomalacia, hydrocephalus, seizures, cerebral palsy, or a congenital neurological syndrome. Apnea of prematurity was defined as apnea requiring pharmacologic or non-pharmacologic intervention. Xanthine exposure included caffeine or theophylline treatment at any point in the neonatal hospitalization. Other neonatal data extracted from the medical records include: Apgar score at 5 minutes, chest compressions or intubation at delivery, small for gestational age (SGA, weight $<10^{th}$ percentile),(19,20) type and duration of respiratory support during the initial hospitalization (oxygen, continuous positive airway pressure, mechanical ventilation), use of postnatal corticosteroids, patent ductus arteriousus treated with indomethicin or surgery, and any cardiac, neurological, or craniofacial congenital anomalies. Maternal characteristics extracted from the birth records include obstetrician diagnosis of pre-eclampsia (blood pressure (BP) ≥ 140/90), which was further classified as mild (BP<160/100) or severe (BP≥160/100). Maternal reports of alcohol, tobacco, or other drug use during pregnancy were also recorded.

Childhood data—At the 8–11 year old exam, weight and height were measured and expressed as body mass index (BMI; weight/height^2). Tonsillar size was assessed during a physical examination and enlarged tonsils were defined as >50% obstruction of the airway based on physical examination and use of a standardized 4-point scale.(21) Symptoms and demographic data were obtained from a standardized questionnaire. History of asthma or wheezing was defined by parent report of asthma and asthma symptoms. Parents also reported whether the child's biological mother or father had a history of snoring or OSA, and whether they were single parents or part of a dual-parent household.

Sleep data—Limited channel cardiorespiratory recordings were collected in the home and included thoracic and abdominal excursions and estimated tidal volume by inductance plethysmography, pulse oximetry with waveform display, heart rate, and body position (PT-2 system, SensorMedics, Yorba Linda, California). Sleep was identified when physiological variables were consistent with both sleep (*e.g.*, demonstrating little movement, reduced heart rate) and sleep-wake times recorded by the parent in a sleep diary. Estimated sleep time was calculated as the total number of minutes identified as sleep. Obstructive apneas were scored when chest and abdominal efforts were asynchronous and estimated tidal volume was less than 25% baseline, irrespective of associated desaturation. Hypopneas were scored when respiratory efforts were accompanied by a 25 to 50% reduction in estimated tidal volume and accompanied by an at least 3% oxyhemoglobin desaturation. All obstructive apneas and hypopneas, each at least 8 seconds long, were tabulated and divided by the estimated sleep time to provide the AHI. Central apneas are not included in the AHI.

Our primary outcome variable was SDB defined as at least one obstructive apnea per hour (OAI $\geq$ 1) or an apnea hypopnea index (AHI) $\geq$ 5. However, exploratory analyses were also conducted defining SDB on the basis of an AHI $\geq$ 1, as this definition is also used in clinical practice. Methods for overnight home sleep study, physical measurements, and ascertainment of demographic and medical data have been previously described in detail.(1)

All records were scored without clinical correlates by scorers who regularly participated in scoring exercises to maintain inter-observer consistency. To document reliability of the AHI, we compared the AHI from the home study with the AHI derived from full attended polysomnography performed within 3 months of the home study in 55 children with a wide range of SDB. The mean AHI was 2.6 ± 8.0 and 2.9 ± 7.5, for laboratory *vs*. home studies, respectively (intraclass correlation coefficient = 0.85). Using a threshold value for SDB of at least 5 events per hour, the sensitivity for SDB classification by home studies was 88% and specificity was 98% compared with laboratory studies.

Statistical Analysis

Perinatal factors and childhood characteristics of preterm infants, stratified by SDB, were summarized using medians and the interquartile range for continuous measures, and counts and proportions for categorical variables. Logistic regression was used to assess the relationship between each of the infant and school-age characteristics and each of the two definitions of SDB. Candidate risk factors for SDB were grouped into domains: demographic characteristics, in-utero exposures, peri-partum resuscitation/transition, respiratory morbidity, neurological injury, family history, and congenital malformations.

Associations between characteristics and SDB are expressed as odds ratios (OR) with 95% confidence intervals (95% CI). Odds ratios were also reported adjusted for race, as this is a consistently reported characteristic associated with childhood SDB, and is associated with prematurity and many of the candidate risk factors.(1) Analyses were performed using SAS version 9.1.3 (SAS Institute, Inc, Cary, North Carolina).

RESULTS

Sample characteristics for the 383 formerly preterm children are described in Table I. Twenty-eight children (7.3%) met the primary definition for SDB and 52 children (13.6%) met the criteria for SDB using the secondary more liberal definition.

Associations of SDB with demographic factors

The odds of SDB were 3 to 4 fold higher in children whose mothers were single or who were of a minority race (Table II). The prevalence of SDB in black children (12.4%) was comparable with the prevalence among other non-white children (12.5%) and was significantly higher than for white children (3.9%) (p=0.0022). Gestational age, birth weight and sex were not significantly associated with SDB.

Associations of SDB with In-Utero Exposures

Sixty-one (15.9%) infants were born to a mother with a diagnosis of pre-eclampsia; 70% (n=43) were classified as severe, 15% (n=9) as mild, and 15% (n=9) as unknown severity. A history of mild pre-eclampsia was strongly associated with SDB. Compared with those without maternal pre-eclampsia, children whose mothers had mild pre-eclampsia had more than a 7-fold increased odds of SDB; in contrast, children whose mothers had severe pre-eclampsia were not at significantly increased odds of SDB. These associations did not appreciably change after adjusting for race. Although the point-estimates of the odds ratios for maternal smoking and SGA were 2.1 and 2.2 respectively, neither was significantly associated with SDB.

Associations of SDB with Peripartum Resuscitation

CPR and/or intubation in the early neonatal period was associated with a 2–3 fold increased odds of SDB; this association was attenuated following adjustment for race. A low Apgar 5-minute score was not significantly associated with SDB.

Associations of SDB with Perinatal Respiratory Conditions and Exposures

Xanthine use was associated with more than 2-fold increased odds of SDB which was slightly attenuated after race adjustment. None of the respiratory variables, including BPD, RDS, highest level of respiratory support, and duration of supplemental oxygen use, were significantly associated with SDB.

Other Associations

Neurological variables, congenital syndromes, and family history were not associated with SDB.

Childhood Characteristics

Covariates assessed at age 8 to 11 years that were positively associated with SDB were BMI and a history of removed tonsils (Table III). Children with a BMI >90th percentile had 2.8 times the odds of SDB compared to children with BMI ≤ 90th percentile. The odds of SDB were 2.9 times higher among children who had their tonsils removed compared with children who did not. Asthma/wheezing and enlarged tonsils were not significantly associated with SDB.

Inter-relationships of Exposures with Pre-eclampsia

Because mild pre-eclampsia was the strongest risk factor of SDB in this sample, we also explored associations between pre-eclampsia and other putative neonatal risk factors, recognizing that these analyses were under-powered to detect small to moderate effects. No significant differences in gestational age, birth weight, sex, race, maternal age, maternal

snoring, BPD, RDS, or duration of ventilation were observed among the severe, mild, and no pre-eclampsia groups. However, there was less maternal smoking in the severe group (11.6%) than in the mild (22.2%) or no pre-eclampsia (33.2%) groups (p=0.0132). There was less drug and alcohol use reported in the pre-eclampsia groups than those without pre-eclampsia (p<0.05). In addition, the mild and severe pre-eclampsia groups had a higher proportion of children born SGA (33.3% and 30.2%, respectively) compared with the group without pre-eclampsia (15.8%), (p=0.0328).

Finally, we performed an exploratory analysis using an alternative, more liberal definition of SDB (AHI ≥1, n=52). Associations were generally weaker than the results obtained when defining SDB as an obstructive apnea index ≥1 or AHI ≥ 5. The exception was a history of CPR and/or intubation after birth, which was significantly associated SDB after adjusting for race (OR 2.14; 95% C.I. 1.12, 4.08).

DISCUSSION

Previous studies have shown that preterm infants are both more likely to develop SDB at school age and more likely to have associated neurocognitive sequelae if they have SDB.(1,8) Our results indicate that among premature infants, minorities, those with single mothers, and those exposed to mild pre-eclampsia in utero are at highest risk for SDB. Strikingly, variables often associated with severity of neonatal illness and long-term pulmonary and developmental morbidities, such as gestational age, BPD, and abnormal head ultrasound findings, were not significantly associated with SDB at school age.

An association between childhood SDB and maternal pre-eclampsia has not been reported previously. The observed relationship was based on a small number of individuals with mild pre-eclampsia and thus needs to be interpreted cautiously as the association could be spurious. In general, pre-eclampsia has been associated with a variety of inflammatory mediators, and the effects of these on neurorespiratory development are largely unknown.(22,23) Alternatively, the association between pre-eclampsia and SDB could be mediated by fetal hypoxia. (24–30),(31) Pre-eclampsia may cause chronic fetal hypoxia directly via maternal vascular insufficiency with subsequent reduction of fetal oxygen delivery due to placental insufficiency, or may be acting as a marker for intermittent maternal hypoxia associated with maternal SDB. The association of childhood SDB with mild but not severe pre-eclampsia is of particular interest because it is consistent with proposed differences in the biology of mild versus severe pre-eclampsia. Differences in risk factors between women with mild and severe pre-eclampsia include higher maternal weight and a higher predilection for metabolic syndrome in those with the milder pre-eclampsia phenotype.(32) As it relates to SDB, mild pre-eclampsia may be a marker for women at risk for snoring or SDB when confronted with pregnancy-related weight gain or fluid changes;(33–37) or the association we observed may relate to an underlying genetic predisposition of both mothers and their children to upper airway obstruction or to obesity-related diseases.(38)

Differences in the association of SDB with mild as compared to severe pre-eclampsia may also be due to differences in smoking exposures in each group and potential confounding by this exposure. Maternal smoking is reported to reduce risk of pre-eclampsia(32); consistent with this, in our sample, the severe pre-eclampsia group had one half the prevalence of smoking than the mild group, and one-third the prevalence than those without pre-eclampsia, In our sample, maternal smoking also was associated with an approximately 2-fold increased risk of childhood SDB, which although not meeting statistical significance (p=0.0627) is consistent with a recent report relating maternal smoking and SDB in adults who had been very low birth weight.(18) Although it is also plausible to speculate that a combination of the placental effects

of pre-eclampsia and smoking placed the mild pre-eclampsia group at higher risk of SDB, the small sample size did not allow us to test for such an interaction.

Exposure to perinatal hypoxia with or without hyperoxia could also be the mechanism causing the apparent association between CPR and/or intubation in the delivery room and SDB. Pharyngeal trauma from emergent intubation leading to either laryngotracheomalacia or subglottic stenosis, compromising airway patency, is another potential causal link. Alternatively, underlying differences in respiratory control could cause both an increased likelihood of requiring resuscitation post-partum and a predilection to childhood SDB.

Xanthine exposure, but not a diagnosis of apnea of prematurity, was associated with childhood SDB in unadjusted analyses. Although certainly not proof of a causal association between neonatal xanthine exposure and childhood SDB, this finding is intriguing in light of new animal data suggesting that neonatal caffeine exposure can alter adult sleep architecture.(39) A potential causative association between xanthine use and school-aged SDB warrants further investigation, as caffeine is currently one of the most commonly used drugs in the NICU.(23) Alternatively, if xanthines were selectively prescribed for the most severe apnea of prematurity, an association between xanthines and SDB could be due to persistent underlying abnormalities in respiratory control in certain patients. Xanthine prescription could also be a marker for more severe neonatal intermittent hypoxia, which may alter the development of respiratory responses.(24–30) (39).

Having a single mother was associated with both SDB in unadjusted and race-adjusted analyses. We speculate that this variable is serving as a marker for socioeconomic factors. We have previously shown that neighborhood disadvantage was associated with SDB in the entire CCSHS cohort.(40) Possible mechanisms include higher exposures to allergens, irritants, or respiratory infections in this group, other co-morbid conditions, or inequities in interactions with the health care system. The association between single mothers and SDB serves as an important reminder that long-term pulmonary outcomes of prematurity, just like neurodevelopmental outcomes,(41,42) may be modified by important social factors after discharge from the NICU.

We did not find a significant association between any markers of brain injury in infancy and SDB. This is consistent with the hypothesis that the increased neurocognitive abnormalities previously reported in preterm infants with SDB are a consequence of SDB itself and not merely a clustering of long-term morbidities in the most severely affected preterm infants.(8) Despite the lack of association with central nervous system injury, changes in peripheral nervous system sensitivity and responses could still account for the increased SDB seen in preterm infants.

Our goals were to identify potential underlying risk factors that predispose preterm children to develop SDB in childhood. Given the paucity of prior work in this area, multiple comparisons were performed across a number of risk domains. Since this approach increases the likelihood of type I error, our findings will require replication in future research studies. Similarly, this study may have had insufficient statistical power to detect associations between several candidate risk factors and SDB with small to modest effects. In addition, the low sample prevalence of SDB limited our ability to adjust for multiple factors; residual confounding may have been operative. Additionally, inclusion criteria in the original cohort required an admission to the NICU of at least one week duration, which may have excluded late-preterm infants with low severity of illness; a different pattern of results may occur among samples that include healthier late-preterm infants. Nonetheless, the observed associations represent a starting-point for understanding the mechanisms leading to SDB in premature infants, and may identify several fruitful research directions.

The study has a number of important strengths, including the relatively large sample of children born at three area hospitals, detailed neonatal medical histories, and rigorous collection of sleep study data collected when the children were 8–11 years old.

In conclusion, having a single mother, minority race, and mild maternal pre-eclampsia were associated with SDB in this sample of preterm children. Unadjusted analyses also identified xanthine use and CPR and/or intubation in the delivery room as potential risk-factors for SDB. We did not find a link between traditional markers of severity in preterm infants--such as gestational age, birth weight, IVH, BPD, or duration of ventilation -- and SDB at school age. Although these findings need to be confirmed in other samples, and potential mechanisms further explored, these results represent a first step in identifying which premature infants are at higher risk for childhood SDB. In particular, the association between xanthine exposure and SDB serves as a reminder that neonatal interventions may have the potential to impact long-term respiratory control. Furthermore, the strong association between mild pre-eclampsia and childhood SDB underscores the importance of research aimed at understanding *in utero* risk factors for neurorespiratory development.

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Abbreviations

SDB, sleep disordered breathing; CCSHS, Cleveland Children's Sleep and Health Study; RDS, respiratory distress syndrome; BPD, bronchopulmonary dysplasia; GA, gestational age; SGA, small for gestational age; BMI, body mass index; AHI, apnea hypopnea index.

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Table I

Sample Characteristics.

Gestational Age (weeks)	32.0 (29.0, 34.0)
Birth Weight (g)	1483 (1041, 2040)
Male Sex	193 (50.4%)
Race	
White	230 (60.0%)
African American	137 (35.8%)
Other Races	16 (4.2%)
SDB (AHI ≥ 5 or OAI≥ 1)	28 (7.3%)
OAI ≥ 1	23 (6.0%)
AHI ≥ 1	52 (13.6%)

Listed as count (%) or median (25^{th} percentile, 75^{th} percentile)
SDB Sleep Disordered Breathing
OAI Obstructive Apnea Index
AHI Apnea Hypopnea Index

Table 2

Infant Characteristics and Odds of SDB at 8–11 yrs.

		No SDB† (n=355)	SDB† (n=28)	OR (95% CI) Unadjusted	OR (95% CI) Race-Adjusted
Demographic Characteristics	GA (weeks)	32.0 (29.0, 34.0)	31.0 (29.0, 33.0)	0.97 (0.86, 1.10)	1.03 (0.91, 1.18)
	Birth Weight (g) (OR per 100g)	1501 (1048, 2050)	1262 (1025, 1716)	0.95 (0.88, 1.02)	0.99 (0.91, 1.06)
	Male	182 (51.3%)	11 (39.3%)	0.62 (0.28, 1.35)	0.63 (0.29, 1.40)
	Minority Race (vs. white)	134 (37.8%)	19 (67.9%)	**3.48 (1.53, 7.92)**	-----
	Single Mother	99 (27.9%)	16 (57.1%)	**3.72 (1.67, 8.29)**	**2.54 (1.01, 6.39)**
In Utero Exposures	Maternal Smoking During Pregnancy	104 (29.3%)	13 (46.4%)	2.09 (0.96, 4.55)	1.81 (0.82, 3.99)
	Maternal Substance Use	48 (13.5%)	6 (21.4%)	1.74 (0.67, 4.52)	0.97 (0.35, 2.67)
	Alcohol	31 (8.7%)	3 (10.7%)	1.25 (0.36, 4.39)	0.80 (0.22, 2.90)
	Pre-Eclampsia				
	None	301 (87.0%)	21 (75.0%)	---Ref---	---Ref---
	Mild	6 (1.7%)	3 (10.7%)	**7.17 (1.67, 30.70)**	**7.56 (1.66, 34.48)**
	Severe	39 (11.3%)	4 (14.3%)	1.47 (0.48, 4.51)	1.50 (0.48, 4.69)
	SGA	64 (18.0%)	9 (32.1%)	2.15 (0.93, 4.98)	1.88 (0.80, 4.41)

		No SDB[†] (n=355)	SDB[†] (n=28)	OR (95% CI) Unadjusted	OR (95% CI) Race-Adjusted
Peri-Partum Resuscitation	CPR and/or Intubation	169 (47.6%)	20 (71.4%)	**2.75 (1.18, 6.41)**	2.00 (0.83, 4.86)
	5-minute APGAR <7	78 (22.0%)	5 (17.9%)	0.76 (0.28, 2.07)	0.54 (0.19, 1.51)
Respiratory Morbidity	Highest Level of Respiratory Support				
	No respiratory support	43 (12.1%)	1 (3.6%)	---Ref--	---Ref--
	No ventilation (O2 and/or CPAP)	65 (18.3%)	3 (10.7%)	1.99 (0.20, 19.71)	2.31 (0.23, 23.30)
	Ventilation	247 (69.6%)	24 (85.7%)	4.18 (0.55, 31.70)	3.74 (0.49, 28.67)
	Days on Ventilator (OR per 14 days)	4.0 (0.0, 12.0)	2.5 (1.0, 15.0)	1.01 (0.81, 1.26)	0.98 (0.73, 1.31)
	Days on Oxygen (OR per 14 days)	6.0 (1.0, 35.0)	3.0 (1.5, 37.5)	1.02 (0.92, 1.14)	1.00 (0.88, 1.13)
	RDS	298 (83.9%)	26 (92.9%)	2.49 (0.57, 10.77)	2.02 (0.46, 8.88)
	BPD	68 (19.2%)	5 (17.9%)	0.92 (0.34, 2.50)	0.79 (0.29, 2.19)
	Apnea of Prematurity	239 (67.3%)	21 (75.0%)	1.46 (0.60, 3.52)	1.30 (0.53, 3.18)
	Xanthines	196 (55.2%)	21 (75.0%)	**2.43 (1.01, 5.87)**	1.94 (0.79, 4.78)
	Corticosteroids for BPD	39 (11.0%)	3 (10.7%)	0.97 (0.28, 3.37)	0.87 (0.25-3.07)

		No SDB† (n=355)	SDB† (n=28)	OR (95% CI) Unadjusted	OR (95% CI) Race-Adjusted
Neurological Injury	Grade III–IV Intraventricular Hemorrhage	12 (3.4%)	0 (0.0%)	-----	-----
	Ventriculomegally	28 (7.9%)	2 (7.1%)	0.90 (0.20, 3.98)	0.90 (0.20, 4.04)
	Periventricular Leukomalacia	4 (1.1%)	1 (3.6%)	3.25 (0.35, 30.10)	2.66 (0.27, 26.01)
	Any Neurological Insult**	48 (13.5%)	6 (21.4%)	1.74 (0.67, 4.52)	1.71 (0.65, 4.50)
Family History	Mother or Father Snores	190 (53.5%)	15 (53.6%)	1.00 (0.46, 2.17)	1.29 (0.58, 2.85)
	Mother or Father has SDB	28 (7.9%)	4 (14.3%)	1.95 (0.63, 6.01)	2.55 (0.79, 8.21)
Congenital Malformations	Craniofacial Malformation	4 (1.1%)	1 (3.6%)	3.25 (0.35, 30.10)	4.64 (0.46, 46.79)
	Cardiac***				
	-Any Condition	19 (5.4%)	1 (3.6%)	0.66 (0.08, 5.08)	0.51 (0.06, 4.00)
	-Complex	3 (0.9%)	1 (3.6%)	4.35 (0.44, 43.21)	4.09 (0.38, 43.88)
	-VSD	6 (1.7%)	0 (0.0%)	-----	-----
	-PDA	44 (12.4%)	4 (14.3%)	1.17 (0.39, 3.52)	0.93 (0.30, 2.87)

† Listed as count (%) or median (25th percentile, 75th percentile).

* Includes oxygen, CPAP, or mechanical ventilation.

** Includes grade III or IV intaventricular hemorrhage, periventricular leukomalacia, hydrocephalus, seizures, cerebral palsy, or a congenital neurological syndrome.

*** Complex cardiac disease includes single ventrical, tetology of fallot, pulmonary valve stenosis and congenital heart block. Any cardiac disease additionally includes ASD, VSD, and supraventricular tachycardia.

Table 3

School-Age Characteristics and Risk Factors for SDB

	No SDB (n=355)	SDB (n=28)	OR (95% CI) Unadjusted	OR (95% CI) Race-Adjusted
Body Mass Index (BMI) Percentile (OR per 10% increase)	57.1 (23.9, 85.5)	79.7 (31.5, 97.0)	1.10 (0.97, 1.24)	1.09 (0.96, 1.24)
BMI >90th percentile	74 (20.9%)	12 (42.9%)	**2.85 (1.29, 6.28)**	**2.85 (1.28, 6.38)**
History of Asthma or Wheezing	128 (36.1%)	12 (42.9%)	1.33 (0.61, 2.90)	1.08 (0.49, 2.41)
Enlarged Tonsils	125 (35.2%)	15 (53.6%)	2.12 (0.98, 4.60)	1.86 (0.85, 4.09)
Removed Tonsils	25 (7.0%)	5 (17.9%)	**2.87 (1.01, 8.19)**	**3.76 (1.25, 11.29)**