Snoring and Sleep-Disordered Breathing in Young Children: Subjective and Objective Correlates

Hawley E. Montgomery-Downs, PhD; Louise M. O'Brien, PhD; Cheryl R. Holbrook, MAT, RPSGT; David Gozal, MD

Kosair Children's Hospital Research Institute, and Division of Pediatric Sleep Medicine, Department of Pediatrics, University of Louisville, Louisville, KY

Study Objectives: We sought to assess the predictive validity of parental report of snoring and other behaviors by comparing such reports with objective findings from overnight polysomnography for the evaluation of sleep-disordered breathing in 2 nonclinical samples, namely, at-risk preschoolers and an older group reflective of the general community. Predictive validity of snoring alone and a score based on multiple child behaviors were compared to outcome at different levels of severity of sleep-disordered breathing.

Design: Retrospective observational study.

Setting: Questionnaires were distributed through school programs; polysomnography was performed at Kosair Children's Hospital in Louisville, Kentucky.

Participants: One hundred twenty-two preschoolers and 172 5- to 7-year-olds, and their parents, participated in both subjective-report and objective-recording portions of the study.

Measurements and Results: Compared to the presence of snoring on polysomnography, parental report of frequent snoring was highly sensitive and specific for both age groups. At all but the lowest level of severity of sleep-disordered breathing, predictive ability was higher for both groups when a parental-report score based on multiple measures of child behavior was applied, compared to parental report of snoring alone. The profiles of these predictive child behaviors differed between the 2 groups, as did their sensitivity and specificity, at their high ranges of parental report.

Conclusions: Scores derived from parental-report questionnaires of children's snoring and other sleep and wake behaviors can be used as surrogate predictors of snoring or sleep-disordered breathing in children. However, design and interpretation should consider age, risk status, and the purpose of the screening assessment.

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INTRODUCTION

HABITUAL SNORING IS A RELATIVELY COMMON OCCURRENCE IN OTHERWISE HEALTHY CHILDREN; THE PREVALENCE OF HABITUAL SNORING VARIES FROM COUNTRY TO COUNTRY AND HAS BEEN REPORTED TO BE BETWEEN 6% AND 27%.[1-6] However, snoring indicates the presence of increased upper-airway resistance and essentially constitutes the cardinal symptom of sleep-disordered breathing (SDB).[7] Sleep-disordered breathing, which includes obstructive sleep apnea (OSA) and upper-airway resistance syndrome (UARS), may affect up to 3% of children and is associated with reduced gas-exchange abnormalities during sleep and sleep fragmentation, and imposes significant clinical morbidity, primarily involving cardiovascular and neurobehavioral functions[8] (for review see Ali et al[1]).

Indeed, attention-deficit hyperactivity disorder (ADHD),[9-11] other behavioral manifestations,[12-14] and disturbances in cognitive development in school-aged children are prominent and important consequences of SDB.[3,11,15] Furthermore, children with SDB utilize increased health-care services[16] and are more likely to experience comorbid chronic illnesses.[2,17] Thus, the cumulative evidence clearly indicates that SDB is an important and frequent condition and that timely diagnosis and treatment are imperative to prevent its deleterious consequences.

Disclosure Statement

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Address correspondence to: David Gozal, MD, Kosair Children's Hospital Research Institute, University of Louisville School of Medicine, 570 S. Preston Street Suite 321, Louisville, KY 40202; Tel: 502-852-2323; Fax: 502-852-2215; E-mail: david.gozal@louisville.edu

When assessing for the presence of SDB, both research and clinical settings have relied upon parental reports of their children's snoring at home as a surrogate indicator of disease risk, such that this subjective component weighs heavily in the physician's decision to refer for overnight polysomnographic evaluation. However, self-report is generally considered suspect (for review see Stone et al[18]), and the accuracy of parental report for snoring in early childhood has not undergone comprehensive evaluation nor taken into consideration potential population-derived confounders.[7,8,19,20]

The purpose of the present study was to assess the predictive validity of parental report of snoring and other sleep and waking behaviors in preschoolers and first-graders by comparing such reports with objective findings derived from overnight polysomnography(PSG) in 2 groups of children. To further examine population-related reporting biases, 2 groups were specifically selected for comparison, namely, at-risk preschool children who were developmentally or socioeconomically disadvantaged and a representative community sample of children attending first-grade classes.

METHODS

The study was approved by the Institutional Review Board at the University of Louisville. Informed consent was obtained separately for participation in the parental-report questionnaire and for the overnight PSG portions of the study. Children who were older than 7 years of age signed an assent form for the overnight PSG.

Participants

The populations selected for the present study were part of 2 ongoing large-scale studies enrolling children who attended preschool and first-grade classes in the Jefferson County Public School System in Louisville, Kentucky, and consisted of preschoolers at risk for developmental problems or low socioeconomic status (SES) or children between the ages of 5 and 7 years recruited from the general population of the metropolitan area of Louisville.

Preschool students attended state-sponsored Early Jump Start pro-

Table 1—Instrument Questions and Component Loading Scores

Family and Health History Questions*	Component Loading Preschoolers	First-Graders
Father Snore	.16	<.01
Father Smoke	<.01	.23
Mother Snore	<.01	<.01
Mother Smoke	.17	.23
Siblings Snoring	.25	<.01
Allergies	.46	§
Vision Problems	<.01	.18
Poor Appetite	.47	.38
Ear Infections	.42	.12
Frequent Colds or Flu	.51	.52
Hearing Problems	.50	<.01
Poor Growth	.10	.14
Asthma	.51	.28
Constant Runny Nose	.45	.38
Sleep-disordered breathing questions†		
Is he/she a restless sleeper?	.34	.41
Does he/she have problems with bed wetting?	§	.26
Does your child stop breathing during sleep?	.68	.70
Does your child struggle to breathe while asleep?	.62	.79
Do you ever shake your child to make him/her breathe again when asleep?	.68	.58
Do your child's lips ever turn blue or purple while asleep?	.55	.14
Are you ever concerned about your child's breathing during sleep?	.63	.80
How often does your child snore?	.30	.59
How loud is the snore?‡	.12	.69
How often does your child have a sore throat?	.18	.56
Does your child complain of morning headaches?	.35	.46
Is your child a daytime mouth breather?	§	.42
Daytime Sleepiness Questions†		
Does your child have ADHD (also called hyperkinetic/attention deficit)?	<.01	.13
Or is your child hyperactive?	.25	.16
Is your child easy to wake up in the morning?	.38	-.25
Is your child sleepy during the daytime?	.47	.64
Does your child fall asleep at school?	§	.43
Does your child fall asleep while watching television?	.12	.59

*Response options: Yes, No
†Response options (unless otherwise noted): Never (never in the past 6 months), Rarely (once a week), Occasionally (2 times a week), Frequently (3-4 times a week), Almost Always (more than 4 times a week)
‡Response options: Mildly Quiet, Medium Loud, Loud, Very Loud, Extremely Loud.
§Data not available for this age group.
ADHD refers to attention-deficit hyperactivity disorder.

Table 2—Component Loading and Composite Scores for Polysomnography Variables

	Component Loading		Composite scores for polysomnography			
	Preschoolers	First-graders	0	1	2	3
Obstructive Apnea-Hypopnea Index	.771	.684	0 - 0.9	1.0 - 4.9	5.0 - 9.9	≥ 10.0
Respiratory Arousal Index	.857	.802	0 - 0.9	1.0 - 4.9	5.0 - 9.9	≥ 10.0
Total Arousal Index	.702	.464	0 - 9.9	10.0 - 14.9	15.0 - 19.9	≥ 20.0
SaO_2 Nadir	.517	.509	≥ 90%	85% - 89%	80% - 84%	≤ 79%

Table 3—Subject and Maternal Demographics

	Preschoolers (n = 173)	First-Graders (n = 280)	*P* value
Mean age, y, ± SD at questionnaire	4.3 ± .64	6.2 ± .55	*
Mean age, y, ± SD at PSG	4.5 ± .62	6.5 ± .52	*
Boys, %	52	58	
Race, %			
Caucasian	46	66	*
African American	44	23	
Other†	10	11	
Maternal education			
Junior High School	5%	1%	
High School	67%	29%	
College	22%	43%	*
Graduate School	7%	27%	

**P* < .001
†Hispanic, Asian, Pacific Islander, American Indian, other, unreported
PSG refers to polysomnography.

Table 4—Likelihood Ratios for Report of Snoring Frequency and Snoring on Polysomnography

Snoring Frequency	Preschoolers	First-Graders
Never	.25	.22
Rarely	*	.44
Occasionally	.78	.52
Frequently	.76	1.75
Almost Always	3.00	3.47

*Insufficient data for calculation of ratio

grams, the admission to which is restricted to children who are either developmentally disadvantaged, as determined through an Individual Education Plan, or who are financially disadvantaged. Families fulfilling the latter criterion must meet financial eligibility for the National School Lunch Program. Ninety-one percent of children were admitted to the Early Jump Start program on the basis of family-income eligibility (personal written communication by Donald Corson, Assessment, Research, and Planning, Jefferson County Public Schools, December 11, 2002). Questionnaires were sent to the homes of all children enrolled in Jump Start preschool classes, to be completed by the parent or parents, and returned to the school, where they were collected by 1 of the authors (HEM).

Questionnaires were also sent to the homes of all children enrolled in regular first-grade classes of the Louisville metropolitan public school system, to be returned by prestamped mail to the research office.

Questionnaire Instrument

In general, the information collected by the questionnaire included demographics for both parents and the child and the frequency of specific child behaviors. Specific variables derived from the questionnaire and used in the present study included family and child medical history, general health, daytime and sleeping behaviors thought to be associated with SDB, and measures consistent with the presence of daytime sleepiness (Table 1).

Overnight PSG

Subjects who completed the questionnaire were contacted by phone and invited to participate in the second phase of the study, including overnight PSG. Subjects were excluded from this phase of the investigation if the questionnaires were incompletely filled; if contact information was missing; or if chronic medical conditions, genetic, or overt craniofacial abnormalities were reported. Overnight PSG was not performed if an acute illness afflicted the child during the scheduled date of the test.

A standard overnight multichannel PSG evaluation was performed in the Sleep Medicine Center at Kosair Children's Hospital. Children were studied in the company of a parent or guardian for up to 12 hours in a quiet darkened room with an ambient temperature of approximately 24°C. Lights out was between 9:00 PM and 9:30 PM, and lights on usually occurred between 6:00 AM and 7:00 AM, unless subjects awoke spontaneously before that time. No drugs were used to induce sleep.

The following parameters were measured: chest and abdominal wall movement by respiratory impedance or inductance plethysmography and heart rate by electrocardiogram. Air flow was assessed with a sidestream end-tidal capnograph, which also provided breath-by-breath assessment of end-tidal carbon dioxide levels ($PETCO_2$; BCI SC-300, Menomonee Falls, Wisc), and with an oronasal thermistor. Arterial oxygen saturation (SpO_2) was assessed by pulse oximetry (Nellcor N 100; Nellcor Inc., Hayward, Calif), with simultaneously recorded pulse waveform. Bilateral electrooculogram, 8 channels of electroencephalogram, chin and bilateral anterior tibial electromyograms, and analog output from a body position sensor (Braebon Medical Corporation, NY) were also continuously monitored. All measures were digitized using a commercially available PSG system (Medcare Diagnostics, Buffalo, NY). Tracheal sound was monitored with a microphone sensor (Sleepmate, Midlothian,VA), and digital time-synchronized video images were collected for the duration of the recordings.

Table 5—Sensitivity and Specificity for Snoring Report when *Occasional* Snoring is Included or Excluded

	Preschoolers		First-Graders	
	OFA*	FA†	OFA*	FA†
Prevalence	0.724	0.724	0.590	0.590
Sensitivity	0.935	0.641	0.847	0.726
Specificity	0.200	0.571	0.505	0.734

*Report of *Occasionally* + *Frequently* + *Almost Always* (OFA) = positive snoring score
† Report of *Frequently* + *Almost Always* (FA) = positive snoring score

Sleep Variables

Sleep architecture was assessed by standard techniques.[21] Central, obstructive, and mixed apneic events were scored. Obstructive apnea was defined as the absence of airflow with continued chest-wall and abdominal movement for a duration of at least 2 breaths.[22,23] Hypopneas were defined as a decrease in nasal flow of at least 50% with a corresponding decrease in SpO_2 of at least 4%, an arousal, or both.[23] The obstructive apnea-hypopnea index (OAHI) was defined as the number of obstructive apneas and hypopneas per hour of total sleep time (TST). Mean SpO_2, and SpO_2 nadir were determined from visually validated pulse oximetry signals. The mean and peak $PETCO_2$ were also determined. Because criteria for arousal have not yet been specifically developed for children,[24] arousals were defined as recommended by the American Sleep Disorders Association Task Force report[25] and included respiratory-related (occurring immediately subsequent to an apnea,

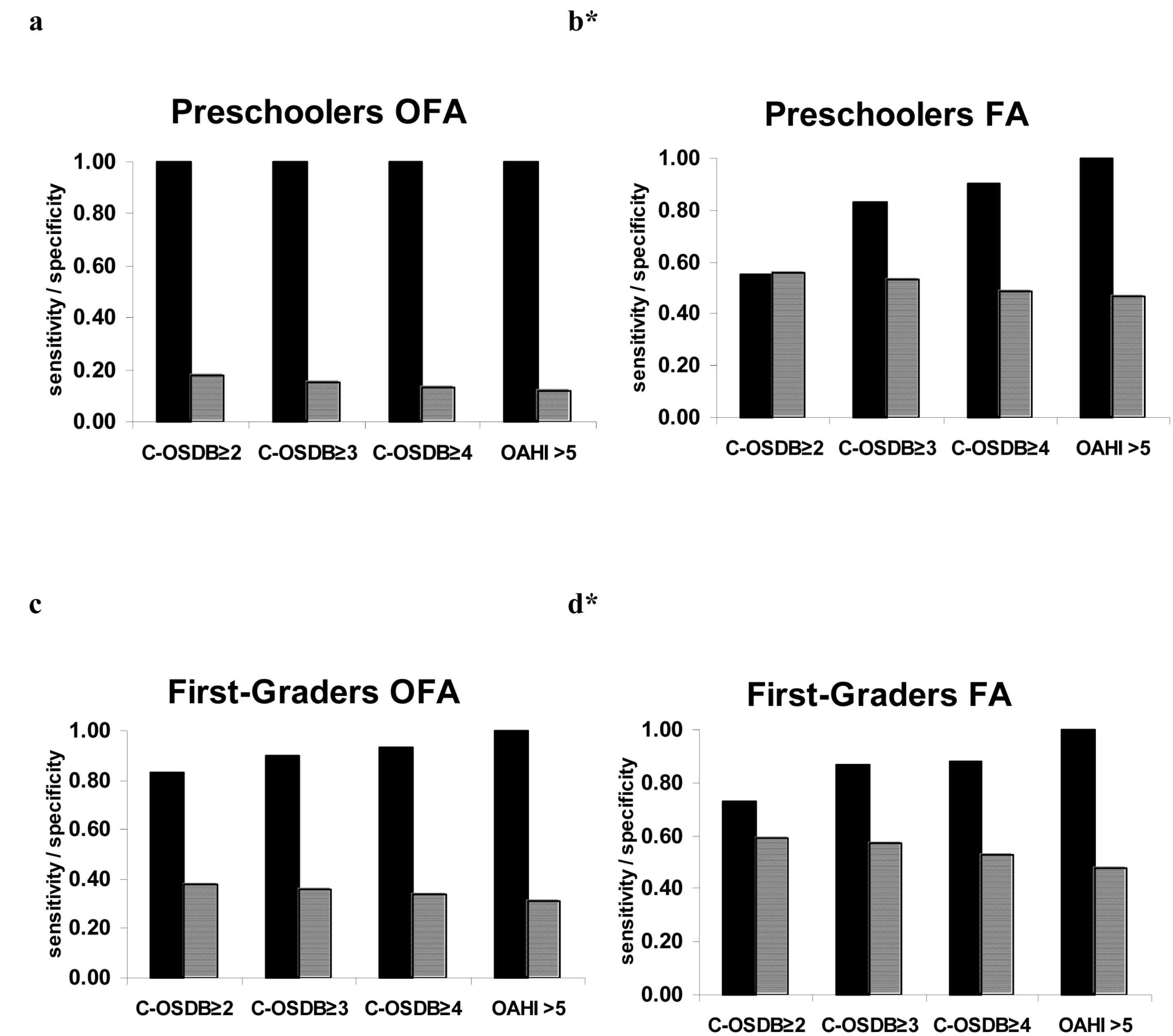

Figure 1—Sensitivity and specificity of OFA and FA snoring report for C-OSDB score ≥2, ≥3, ≥4, and OAHI >5 for preschool (n, 122) and first-grader cohorts (n, 172). Black bars represent sensitivity. Gray bars represent specificity.
*Likelihood Ratios and Positive Predictive Values are shown in Table 6.
OFA and FA refer to the presence of snoring as operationally defined from parental reports on the questionnaire to include snoring that occurred with a frequency rate of either *occasionally* or *frequently* or *almost always* (OFA) or *frequently* or *almost always* (FA); C-OSDB, polysomnography-derived severity score for obstructive sleep-disordered breathing; OAHI, obstructive apnea-hypopnea index.

hypopnea, or snore), technician-induced, and spontaneous arousals. The respiratory arousal index was expressed as the total number of respiratory-related arousals per hour of TST; the total arousal index was expressed as the number of all types of arousal per hour of TST.

Parental-Report Coding and Statistical Analyses

As a first step in the analysis, parental report of snoring as observed at home was compared with the presence or absence of snoring during PSG. Likelihood ratios[26] were calculated for each reporting-frequency category. The presence of snoring was operationally defined from parental report on the questionnaire to include snoring that occurred with a frequency rate of either (a) *occasionally* or *frequently* or *almost always* (OFA) or (b) *frequently* or *almost always* (FA). Control subjects were recruited based on a parental report of *never* for preschoolers and parental report of *never* or *rarely* for the older group. Using these values, sensitivity and specificity were calculated.

In a second stage, snoring-report frequency categories (ie, OFA or FA) were compared to objective evaluation of SDB during the PSG. It should be stressed at this point that several components can be integrated into the evaluation of whether any given PSG is considered abnormal in children. The PSG measures included in this semiquantitative grading of degree of SDB severity included OAHI, respiratory arousal index, lowest SpO_2 (SpO_2 nadir), and total arousal index. The PSG measures were ranked based on severity, with 0 representing a normal PSG variable and values 1-3 representing ranges in the PSG measures corresponding to mild, moderate, or severe, respectively (Table 2). A PSG-derived severity score for obstructive SDB was thus determined for each child by summation of each PSG-variable score (C-OSDB). Therefore, the C-OSDB has a minimum value of 0 (ie, no SDB) and a maximum value of 12 (most severe SDB) (Table 2). Principal component analysis of PSG-derived measures was used to verify the contributions of OFA or FA for

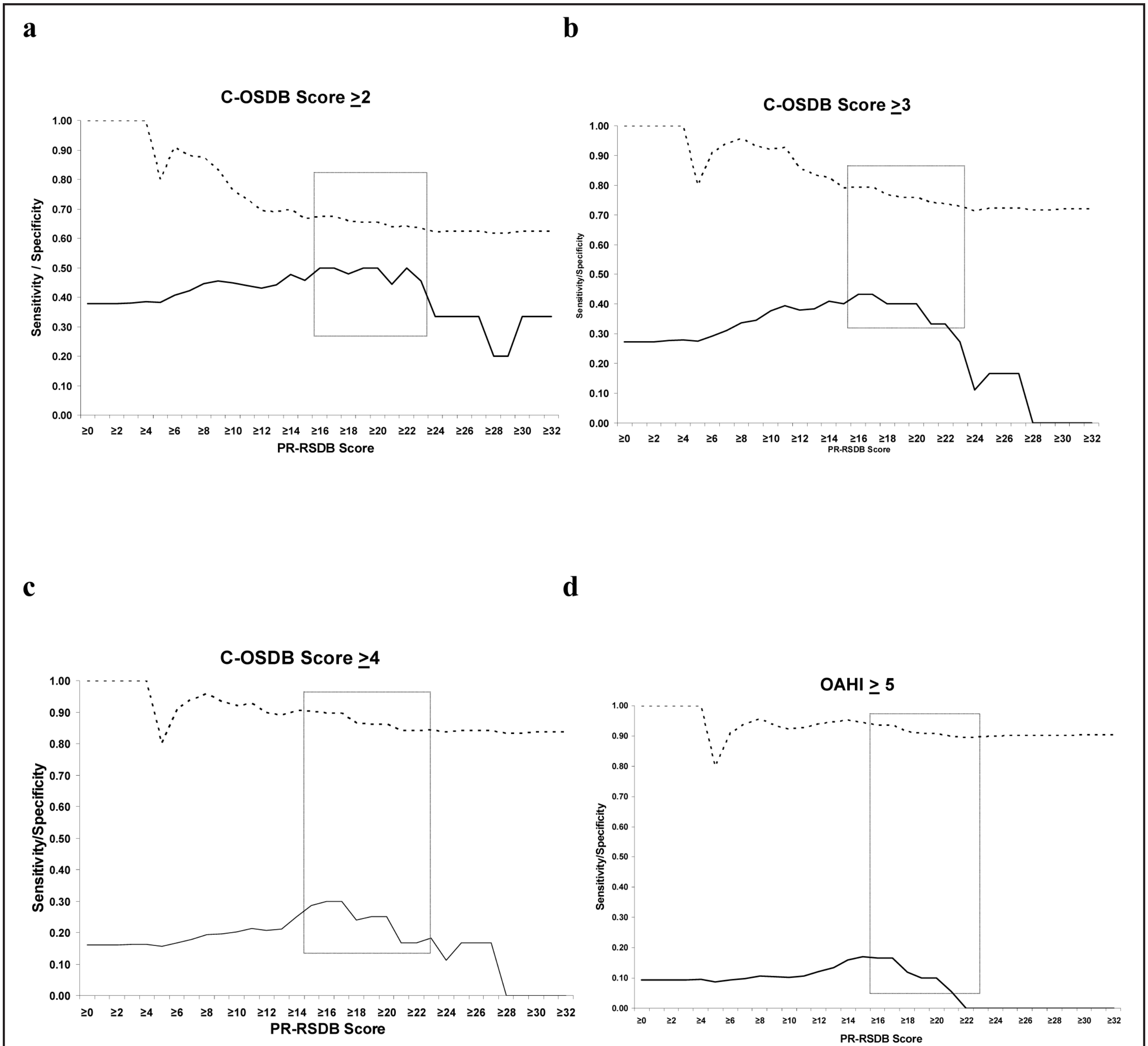

Figure 2—Receiver operator curves for sensitivity and specificity when using composite polysomnography-derived cutoff scores of (a) ≥2, (b) ≥3, and (c) ≥4, and for obstructive apnea-hypopnea index (OAHI) (d) >5 in the preschooler cohort (n, 122). Solid lines designate sensitivity. Dashed lines designate specificity. Cut-off rectangles represent high-sensitivity region described in Table 6. C-OSDB refers to polysomnography-derived severity score for obstructive sleep-disordered breathing; PR-RSDB, parental questionnaire-derived risk score for sleep-disordered breathing.

each of the 2 age-related study groups, using 3 cutoff values for the C-OSDB, namely 2 or greater, 3 or greater, or 4 or greater, and also for a PSG-defined presence of SDB based on OAHI alone (ie, OAHI > 5).

In a third stage of analysis, the frequency of occurrence on the questionnaire items was numerically coded with either a dichotomous allocation (*No* = 0, *Yes* = 1), or with a Likert scale (*Never* = 0, *Rarely* = 1, *Occasionally* = 2, *Frequently* = 3, and *Almost Always* = 4). For the question *Is your child easy to wake up in the morning?* The scores were reversed (*Almost Always* = 0, *Frequently* = 1, *Occasionally* = 2, *Rarely* = 3, and *Never* = 4). Principal component analysis was then performed, and measures loading at least 0.30 on the first component were considered to be significant and were therefore incorporated in the component sum, such as to create a parental questionnaire-derived risk score for SDB (PR-RSDB)(Table 1).

In the fourth and final stage of the analyses, the sensitivity and specificity for each PR-RSDB cutoff, were calculated for each age group and for each of the 3 C-OSDB scores, as well as for an OAHI greater than 5.

For all comparisons, a *P* value less than .05 was considered statistically significant.

RESULTS

There were 1,010 responders for preschoolers, and 5,728 responders for older children, representing 27% and 48% of the total number of subjects surveyed, respectively. Of these, 127 preschool students (from November 2001 through September 2002) and 266 children aged 5 to 7 years (from August 2000 to September 2001) participated in both the questionnaire and PSG portions of the study. Of these, 5 preschoolers and 94 older children had 1 or more PR-RSDB or C-OSDB measures missing and were therefore excluded from further analyses, such that 122 preschoolers and 172 older children were available for comparison of parental report and PSG data. For both groups, those with missing PR-RSDB or C-OSDB values did not differ from those with complete data in regard to age, sex, ethnicity, or maternal education.

As shown in Table 3, these 2 groups differed with respect to age when

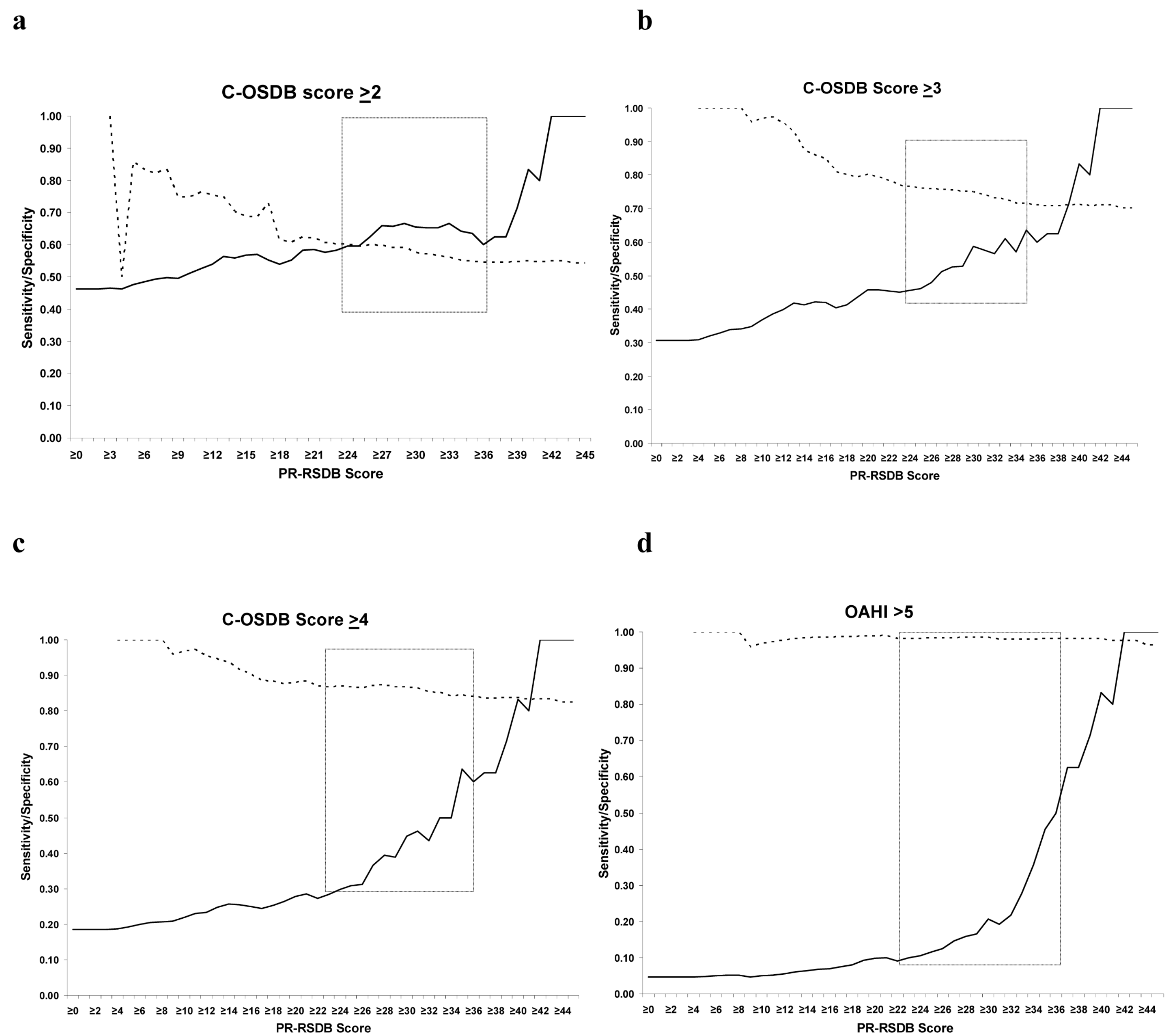

Figure 3—Receiver operator curves for sensitivity and specificity when using composite polysomnography-derived cutoff scores of (a) ≥2, (b) ≥3, and (c) ≥4, and for obstructive apnea-hypopnea index (OAHI) (d) >5 in the first-grade cohort (n, 172**)**. Solid lines designate sensitivity. Dashed lines designate specificity. Cut-off rectangles represent high-sensitivity region described in Table 6. C-OSDB refers to polysomnography-derived severity score for obstructive sleep-disordered breathing; PR-RSDB, parental questionnaire-derived risk score for sleep-disordered breathing.

the questionnaires were completed ($t = 22.5$, df = 262, $P < .001$), age at PSG ($t = 28.4$, df = 276, $P < .001$), ethnicity ($\chi^2 = 9.2$, df = 1, $P < .01$), and maternal education ($\chi^2 = 33.6$, df = 2, $P < .001$).

The likelihood ratios for agreement between parental report of snoring and actual snoring recorded during the PSG were similar for the preschoolers and the older children at each of the reporting-frequency categories (Table 4). Of note, the sensitivity was highest for OFA responses, (ie, when *occasiona*l snoring was included). However, while sensitivity for FA was lower, specificity increased (Table 5). Sensitivity was uniformly high and specificity was consistently low in both age groups when report of OFA snoring was matched against any of the C-OSDB cutoff values or matched for an OAHI greater than 5. For reports in the FA category, sensitivity decreased but remained relatively high in the older children, as well as in all but C-OSDB of at least 2 in the preschool sample. For both age groups, sensitivity increased as the threshold for determination of SDB increased in severity, while specificity remained relatively stable (Figure 1).

There were 17 measures identified in the questionnaire as contributing to PR-RSDB for preschoolers, and the summed component had an eigenvalue of 4.7. For older children, 15 contributing measures were identified, with an eigenvalue of 5.4. The contributing measures differed for the 2 groups. Namely, the preschool component included hearing problems, ear infections, asthma, being easy to awaken in the morning, and observation of blue or purple lips during sleep, none of which contributed more than 0.03 for older children. Snoring loudness, having a sore throat in the morning, and falling asleep while watching television were contributing measures for the older children but not for preschoolers. Four measures were unavailable for comparison between the groups: presence of allergies was not assessed in the older children; enuresis could not be reliably determined in the preschoolers due to the large number of children who were not yet toilet trained; daytime mouth breathing was left blank in the majority of responses from preschoolers, presumably because respondents did not understand the question; falling asleep in school could not be distinguished from scheduled naptime in preschoolers (Table 1).

Sensitivity and specificity were calculated at each PR-RSDB cutoff value for C-OSDB ≥ 2, ≥ 3, ≥ 4, and for an AHI > 5 for both the preschool-aged (Figure 2) and the older children (Figure 3). In preschoolers, PR-RSDB sensitivity initially increased but then decreased at the highest PR-RSDB values, while it continued to increase for the older pediatric sample. Specificity was initially high and showed a decreasing trend as PR-RSDB values increased in both groups.

Likelihood ratios and positive predictive values were calculated for each of the 3 cutoff values of C-OSDB and also for AHI > 5, in the context of an FA parental report of snoring (Table 6a) or for the sum scores of PR-RSDB corresponding to peak sensitivity (Table 6b). For C-OSDB ≥ 2, likelihood ratios and positive predictive values were highest for both groups when parental report of snoring (FA) was used to predict a positive PSG outcome (ie, the presence of SDB). For C-OSDB ≥ 3, C-OSDB ≥ 4, and AHI >5, the likelihood ratios and positive predictive values were higher when PR-RSDB rather than parental snoring report of FA was used.

Table 6a—Likelihood Ratios and Positive Predictive Values for Snoring Report and High-Sensitivity PR-RSDB Scores for Preschoolers

	C-OSDB			OAHI
FA Snoring Report	≥2	≥3	≥4	>5
LR	1.74	1.76	1.77	1.88
PPV	0.55	0.41	0.25	0.18

	High-sensitivity PR-RSDB scores							
	C-OSDB ≥2		C-OSDB ≥3		C-OSDB ≥4		OAHI >5	
PR-RSDB score	LR	PPV	LR	PPV	LR	PPV	LR	PPV
≥16	1.54	0.375	2.09	0.45	2.89	0.53	2.6	0.5
≥18	1.41	0.300	1.73	0.34	1.79	0.35	1.4	0.3
≥20	1.45	0.250	1.66	0.28	1.81	0.29	1.1	0.2
≥22	1.4	0.150	1.27	0.14	1.06	0.12	0	0
≥24	0.88	0.075	0.39	0.03	0.68	0.06	0	0

PR-RSDB refers to parental questionnaire-derived risk score for sleep-disordered breathing; FA, *Frequently + Almost Always* snoring report; ; C-OSDB, polysomnography-derived severity score for obstructive sleep-disordered breathing; OAHI, obstructive apnea-hypopnea index; LR, likelihood ratio; PPV, positive predictive value.

Table 6b—Likelihood Ratios and Positive Predictive Values for Snoring Report and High-Sensitivity PR-RSDB Scores for Older Children

	C-OSDB			OAHI
FA Snoring Report	≥2	≥3	≥4	>5
LR	1.78	2.05	1.86	1.92
PPV	0.55	0.41	0.26	0.06

	High-sensitivity PR-RSDB scores							
	C-OSDB ≥2		C-OSDB ≥3		C-OSDB ≥4		OAHI >5	
PR-RSDB score	LR	PPV	LR	PPV	LR	PPV	LR	PPV
≥24	1.5	0.43	1.96	0.49	2.31	0.53	6.11	0.75
≥26	1.56	0.38	1.99	0.43	2.3	0.47	7.81	0.75
≥28	1.61	0.31	2.15	0.38	3.13	0.47	10.66	0.75
≥30	1.55	0.24	2.34	0.32	3.4	0.41	14.9	0.75
≥32	1.5	0.19	2.12	0.25	2.96	0.31	10.87	0.63
≥34	1.44	0.11	2.02	0.15	3.18	0.22	18.93	0.63
≥36	1.32	0.08	2.08	0.11	3.76	0.19	27.17	0.63

PR-RSDB refers to parental questionnaire-derived risk score for sleep-disordered breathing; FA, *Frequently + Almost Always* snoring report; ; C-OSDB, polysomnography-derived severity score for obstructive sleep-disordered breathing; OAHI, obstructive apnea-hypopnea index; LR, likelihood ratio; PPV, positive predictive value.

DISCUSSION

This study shows that the accuracy of parental reports of nighttime snoring in their children is not influenced by SES or the age of the child. However, inclusion of *occasional snoring* as assessed by parents modifies the sensitivity and specificity for the presence of SDB in the 2 age groups, such that improved prediction is achieved when this parentally derived frequency is excluded. Furthermore, we evaluated an alternative screening method for determining the risk of SDB by adding other sleep and waking behavior reports to that of snoring. While such composite questionnaire-derived scores (PR-RSDB) markedly improved likelihood ratios of SDB in both age groups studied, the cutoff values were different for the 2 groups, and the overall predictive accuracy was better for the older cohort. Thus, as previously reported by Carroll and colleagues,[7] surveys of snoring alone are relatively reliable for accuracy of snoring occurrence but are clearly unreliable in the prediction of SDB. Furthermore, incorporation of other sleep and waking behavior reports markedly improves SDB prediction but requires the application of different criteria for younger children who are developmentally or socioeconomically disadvantaged and for older children who are representative of the general population.

Before we address the potential implications of our findings, some methodologic issues deserve further comment. Questionnaire response rates were relatively low in both groups, even if they are relatively favorable compared to usual response rates in this type of survey. Therefore, sampling biases cannot be excluded with certainty. While we attempted to prevent this problem in our recruitment steps for the PSG stage of the study, it is possible that parents who agreed to participate in the overnight PSG may have been particularly sensitive to their child behaviors, thereby leading to skewed responses. This was not apparent from the distribution of the overall response data, and from evidence indicating that the ethnic distribution of the study groups was representative and similar to that of the general population enrolled in both preschool classes (personal written communication with Donald Corson, Assessment, Research, and Planning, Jefferson County Public Schools, July 11, 2002) and first-grade classes (personal communication from Jefferson County Public School System) during the same academic years.

As anticipated, the agreement between parental report and objectively recorded snoring was highest when the parental report corresponded to the highest possible occurrence. The sensitivity of parental report of snoring compared to recorded snoring during the PSG was high in both study groups, particularly when *occasional* snoring was included. However, when *occasional* snoring was excluded, the specificity of parental report doubled for preschoolers and was higher for first-graders. Thus, parental report of snoring may be considered generally accurate at relatively low occurrence levels but less so for at-risk preschoolers.

Since snoring is considered as the predominant clinical symptom of SDB,[7] we examined whether parental report of snoring could also predict the presence or absence of SDB during a nocturnal PSG. Parental reports on the presence of frequent or more often snoring was relatively sensitive and specific for the presence SDB at any level of composite severity. However, inclusion of occasional snoring markedly lowered the specificity. In contrast, the presence of snoring in the PSG had less predictive value than did the parental report of snoring. Thus, the data suggest the need for using frequency categorical components in the assessment of a positive parental response to the question of whether their child snores during sleep. Our findings further support the concept that a more elaborate composite score that incorporates sleep and waking behaviors can ameliorate the prediction of SDB in children. Indeed, using questionnaire-based elements that had a significant weight in the principal component analysis permitted development of a parentally derived child sleep profile (ie, the PR-RSDB) and further examination of various cutoff values for this instrument. In general, the PR-RSDB showed improved likelihood ratios and positive predictive values for SDB compared to parental reports of snoring alone, except when composite scores of SDB severity were low (ie, C-OSDB $\geq$ 2). However, while specificity of PR-RSDB in the preschool group was uniformly high, sensitivity for this group actually decreased at the highest range of PR-RSDB scores, suggesting a biphasic pattern of parental reporting among the parents of low-SES young children, with increased misperception of sleep-wake gradients with increased symptom burden. This did not occur in the older children sampled from the general population. Indeed, while sensitivity to identify SDB was high in both parental-reported snoring alone or using the PR-RSDB, increasing scores of the latter yielded the anticipated increases in specificity. Future study focused on the perception of those reporting in the high end of PR-RSDB in the younger and at-risk group should include assessment of reporting styles within cosleeping families, a measure that was not included in the present study.

The preschool sample was both younger and demographically distinct from the first-graders. More specifically, the preschoolers sampled were part of a developmentally disadvantaged or low-income population. The profile of parental-reported risk for SDB differed between these groups, supporting the conclusion that history taking in evaluating the risk for SDB should consider not only age, but also SES. These findings further support the notion that either younger age, low SES, or both, may lead to reduced predictability of SDB using parentally derived responses and that these population characteristics need to be incorporated in the estimates of disease prevalence when using questionnaire-based approaches. In addition, different factors and symptom-based severity scores (PR-RSDB) need to be used to optimize the accuracy of predicting SDB in different populations. Indeed, the measures contributing to the PR-RSDB component differed between the 2 groups: the preschool component included hearing problems, ear infections, asthma, being easy to awaken in the morning, and observation of blue or purple lips, none of which contributed significantly to the PR-RSDB scores among first-graders; conversely, snoring loudness, having a sore throat in the morning, daytime mouth breathing, and falling asleep while watching television contributed to PR-RSDB for older children but not for preschoolers. While it could be perceived that the fact that the groups in this study differed with respect to both age and SES risk status may be a shortcoming, the absence of any previous data on the potential interactions between age, SES, or both, and sleep-questionnaire validity essentially negates such a priori considerations in study design. However, current findings clearly support the need for future work in this area to elucidate the respective contributions of age and SES to the receiver operator curves associated with sleep-questionnaire validation in this pediatric age range.

Previous studies have attempted to develop a screening method for discriminating pediatric populations at risk for SDB.[8,9] However, such studies have had several limitations, including small sample sizes with wide age ranges. In contrast, the present study utilized large numbers, which were community based rather than clinic based. Thus, the utility of previous questionnaires may best serve as a screening tool within tertiary referral centers, whereas broad community populations may require a fundamentally different screening approach. Thus, rather than enable extrapolation of the current findings to other pediatric populations, it is likely that individual community-derived tools will need to be developed and validated for each specific community, either in the context of research or clinically based activities.

Principle component analysis revealed that the loading values for respiratory arousal index was higher than for AHI for both preschool and first-grader cohorts. These findings would suggest that sleep fragmentation, such as that associated with respiratory events, may play an important role in daytime functioning in children. In studies conducted in adults, experimental sleep fragmentation induced by episodic arousals using an auditory stimulus revealed cognitive-performance deficits and increased sleepiness the following day.[27,28] However, although sleep fragmentation is often observed in adults with SDB, children with SDB appear to have a reduced susceptibility to sleep fragmentation,[29] such that objective sleepiness emerges only when more-severe SDB is present.[30] Notwithstanding such considerations, the present findings emphasize the relevance of a parental report of restless sleep, a highly contributory measure to the PR-RSDB components in both cohorts, to the actual occurrence of SDB. Furthermore, the data indicate that the respiratory arousal index should be incorporated into the assignment of SDB severity derived from PSG.

In summary, parental reports, preferentially using composite scores derived from questionnaire-based assessments of snoring, health status, and sleep and wake behaviors can be used as surrogate predictors of SDB in children. However, the finite elements included in the optimized prediction tools need to include consideration of the age and the SES of the child being screened, the purpose of the actual screening process (ie, presence or absence of snoring vs presence or absence of SDB), as well as the severity of SDB that needs to be identified. Parental reports of snoring and other empirical methodologies such as those developed in the present study should therefore be considered complementary because they meet different requisites of research or clinical questions. Thus, their unique contributions to epidemiologic and clinical data collection need to be balanced by appropriate accommodation of their limitations.

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