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School performance, race, and other correlates of sleep-disordered breathing in children

Ronald D. Chervin[a,*], Dave F. Clarke[a], Jennifer L. Huffman[b], Erica Szymanski[a], Deborah L. Ruzicka[a], Vnona Miller[c], Arie L. Nettles[d], MaryFran R. Sowers[e], Bruno J. Giordani[b]

[a]*Michael S. Aldrich Sleep Disorders Laboratory, Department of Neurology, University of Michigan, 8D8702 University Hospital, Box 0117, 1500 E. Medical Center Dr., Ann Arbor, MI 48109-0117, USA*

[b]*Division of Child and Adolescent Psychiatry, Department of Psychiatry, University of Michigan, Ann Arbor, MI, USA*

[c]*Ypsilanti Public School System, Ypsilanti, MI, USA*

[d]*University of Michigan School of Education, Ann Arbor, MI, USA*

[e]*Department of Epidemiology, University of Michigan School of Public Health, Ann Arbor, MI, USA*

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Abstract

Objectives: Childhood sleep-disordered breathing (SDB) has been associated with poor school performance. Both problems are common among African–American (AA) children, but potential confounders such as low socioeconomic status (SES) and obesity have not been well studied.

Methods: Children in second and fifth grades at six urban elementary schools were evaluated by teachers' ratings and year-end reading and math assessments. Risk for SDB was assessed with the validated parental Pediatric Sleep Questionnaire, and SES by qualification for school lunch assistance.

Results: Among 146 children whose parents completed surveys, risk for SDB was associated with AA race, low SES, and poor teacher ratings ($P < 0.01$), but not assessment scores ($P > 0.1$). In multiple regression models, poor school performance was consistently and independently predicted by low SES ($P < 0.01$) but not by AA race or SDB risk. Risk for SDB was associated with low SES before, but not after body mass index (BMI) was taken into account.

Conclusions: The SDB symptoms, AA race, and low SES all vary to some extent with poor school performance, but the only consistent and independent covariate of performance is SES. Risk for SDB is associated with low SES, perhaps because of a third variable, namely high BMI.

Keywords: Child; Sleep disorders; Snoring; Sleep apnea; Obstructive; Socioeconomic status; Pediatric Sleep Questionnaire; Performance; Race

1. Introduction

Sleep-disordered breathing (SDB) affects at least 1–3% of children [1], and cognitive impairments may be among the most important consequences of the condition [2]. For example, in a study of 297 poorly performing first grade children, 54 (18%) showed evidence of SDB [3]; those who were treated showed significantly better grades the following year, whereas those not treated showed no improvement. In addition, a subsequent study of seventh and eighth grade students showed that earlier childhood snoring – a common symptom of SDB – predicted current school performance [4]. Neuropsychometric studies suggest that SDB, even when mild, may impair executive functions crucial to good school performance [5–7].

School performance also varies with racial background, and this observation is a frequent cause of concern in the lay press. An 'achievement gap' between African–American (AA) children and their peers has been variously attributed to differential resources, pre-school experiences, adult expectations, and other factors [8]. At the same time, cross-sectional studies have suggested that AA children have SDB at 3–4 times the frequency of non-AA children [9], and that when present, SDB may be more severe among AA than non-AA children [10]. Neither the studies of SDB in AA children, those of SDB and school performance, nor many of the studies of achievement gap have accounted for socioeconomic status (SES), a potentially important confounder. Whether an increased frequency of SDB

* Corresponding author. Tel.: +1-734-647-9064; fax: +1-734-647-9065. *E-mail address:* chervin@umich.edu (R.D. Chervin).

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among AA children could explain part of the achievement gap has not been studied.

We therefore surveyed parents of second and fifth grade students, in an urban school district, about the sleep of their children, and compared these data to subjective and objective performance measures provided by the children's schools. We sought to determine whether poor school performance is associated with SDB symptoms, AA race, or SES, and to test the hypothesis that an increased frequency of SDB might help to explain poor performance among AA children in comparison to non-AA children.

2. Methods

2.1. Subjects and setting

On May 29, 2001, students attending second and fifth grades in the six public elementary schools of the Ypsilanti School District took home cover letters, parental consent forms, child assent forms, and surveys. Several days later, to maximize yield, a second packet of consents and surveys was sent out again. Neither parents nor children were compensated directly for their participation. However, as incentives to the schools, the two with the highest questionnaire return rates from students were given $200 to spend for the benefit of the students. The second and fifth grades were chosen for this study because second graders are at an age when adenotonsillar hypertrophy is typically prominent, fifth graders have had an additional 3 years to develop any consequences of SDB, and objective performance assessments were available for all students in these two grades. The study was approved by the University of Michigan IRB and the research committee for the school system.

Questionnaires were considered completed and were included in analyses when data were available on teacher-rated performance, racial background, and SDB scores. Questionnaire packets were distributed to teachers or principals of 806 students, and 145 (18%) were completed. Participation rates among the six schools ranged from 13 to 33%. In comparison to other surveys performed in this school district, which serves a highly urbanized community about 30 miles west of Detroit, this overall participation rate was considered by a district administrator to be excellent: previous surveys for research purposes had generated only single-digit response rates.

For comparison to the study sample, the District provided the following data. Fifty-two percent of all students are male, and 59% of elementary school students qualify for school lunch assistance. District student racial distributions are: 0.2% American Indian, 2.0% Asian or Pacific Islander, 54% Black, 2.7% Hispanic, 41.1% White, and 2.4% multiracial.

2.2. Measures

Two measures of student performance were included. First, teachers rated the students' overall performance, relative to their classmates, using a 5-point Likert scale from 1 (worse) to 5 (better). Though not validated against other performance measures, this variable provided concise summary data collected in a similar manner and at the same time point from all teachers. Second, a district-wide grade-specific reading and mathematics assessment, administered in the school district annually, was used as an objective score. This instrument, the Wayne RESA Benchmark (Wayne RESA Assessment and Evaluation Services, Wayne, MI, USA), was developed to assess the degree to which school systems successfully teach material outlined in the Michigan Curriculum Framework (Standards and Benchmarks). The mathematics section has 35 multiple-choice items for second graders and 59 items for fifth graders. The reading section has 40 items for second graders and 60 items for fifth graders. No cut-point scores or normative data are available, but the 2001 district-wide average second grade scores were 52 ± 18 (s.d.) % in math and $61 \pm 24\%$ in reading; fifth grade scores averaged $46 \pm 17\%$ in math and $69 \pm 19\%$ in reading. Children's scores were used in the current study as a relative measure of the extent to which each had learned the year-long curriculum. The Benchmark evaluation was designed to avoid racial and gender bias, and was subjected to formal gender and racial bias review. It has not been reported, in several years of use, to show differential functioning for race or gender (Wayne RESA Assessment and Evaluation Services, personal communication).

Additional variables collected in this study included parent-reported race, which was then classified into one (occasionally more) of six categories commonly used by the Department of Health and Human Services. SES was determined by identifying participation in the school lunch assistance program, qualification for which involves an objective assessment of financial need. Specifically, eligibility for either free or reduced-price lunches is based on family income and the number of dependents in the family, as determined from a Department of Social Services registry or an application from parents to Food Services, an agency of the Department of Agriculture.

The risk of SDB was assessed with a validated subscale of the Pediatric Sleep Questionnaire [11]. Question-items ask about snoring frequency and loudness, breathing during sleep, daytime sleepiness, and other behaviors. In a previous study of children with polysomnographically confirmed SDB and controls, the full 22-item SDB subscale showed a sensitivity of 81% and specificity of 87%, and correctly classified 85% of the subjects [11]. In the current study, the SDB scale was used without six items – those that ask about inattention and hyperactivity – to avoid artificial associations with poor school performance. The excluded items are not disproportionately important to overall performance of the scale [11]. Children at high risk for SDB have SDB subscale scores ≥ 0.33 (i.e. 33% of symptoms present).

Table 1
Grade level, sex, lunch assistance, teacher-rated performance, and Benchmark scores are shown for all subjects, African–American (AA) subjects, and non-AA subjects[a]

	All subjects ($n = 145$)	AA subjects ($n = 61$)	Non-AA subjects ($n = 84$)
No. (%) grade 2	85 (59)	44 (72)*	41 (49)
No. (%) male	58 (40)	23 (38)	35 (42)
No. (%) with lunch assistance	63 (43)	36 (59)*	27 (32)
No. (%) with poor performance	25 (17)	16 (26)*	9 (11)
Benchmark score	63 ± 18	57 ± 18*	67 ± 17

[a] *$P < 0.05$ for difference between AA and non-AA subjects (chi-square tests for dichotomous variables and t-test for continuous variables).

2.3. Analysis

Data were summarized as proportions or means and standard deviations. Teacher-rated performance did not follow a normal distribution and was dichotomized to poor performance (rating of 1 or 2) and adequate performance (ratings of 3, 4, or 5). Logistic regression models were then constructed to assess associations between poor performance and normalized SDB symptom scores, race (AA vs. non-AA), and SES (lunch assistance vs. none). In an analogous manner, the normally distributed Benchmark total scores (average of percent correct on reading and math sections) were regressed (multiple linear regression) on the explanatory variables. All regressions controlled for grade level. In analyses designed to determine what variables may contribute to risk for SDB, high risk was modeled by multiple logistic regression on SES, and several potential confounders that could be associated with both SDB and SES: normalized body mass index (BMI, kg/m^2), asthma, AA race, and typical hours in bed (rise time–bedtime). Analyses were performed with SAS®, version 8.1 (SAS Institute Inc., Cary, NC, USA). The level of significance was set at $P < 0.05$.

3. Results

3.1. Subjects

Grade level, sex, lunch assistance program participation, teacher performance ratings, and Benchmark scores are shown for all students, AA students, and non-AA students in Table 1. The mean age of the second grade students ($n = 85$) was 8.1 ± 0.4 (s.d.) years, and the mean age of fifth grade students ($n = 60$) was 11.1 ± 0.4 years. Among second grade students, 36 (42%) were males, and among fifth grade students, 22 (37%) were males. Race was reported by parents as follows: four (3%) American Indian or Alaskan Native; seven (5%) Asian or Pacific Islander; 61 (42%) Black, non-Hispanic; 77 (53%) White, non-Hispanic; ten (7%) Hispanic; six (4%) other or unknown. The total race reports ($n = 165$) exceeds the number of subjects ($n = 145$) because some parents listed more than one race for individual children.

Parental identification of AA race, with or without additional racial backgrounds, was significantly associated with the SDB score (Wilcoxon rank sums, $P = 0.0062$) and with lunch assistance (chi-square, $P = 0.0013$). Also, the SDB score was associated with lunch assistance (Wilcoxon, $P = 0.0036$). Among 63 children who received lunch assistance, 12 (19%) had high SDB scores, whereas among 82 children without lunch assistance, only four (5%) had similarly high SDB scores.

3.2. Poor performance and low benchmark scores

Poor teacher-rated performance was associated with AA race, increased SDB scores, and lunch assistance (Table 2). Benchmark scores showed inverse associations with AA race and lunch assistance, but no significant association with SDB score (Table 3 and Fig. 1). Habitual snoring alone, assessed with one Pediatric Sleep Questionnaire item by parents of 139 subjects, was associated similarly with poor teacher-rated performance (chi-square = 3.87,

Table 2
Logistic regressions of poor teacher-rated performance on African–American (AA) race, sleep-disordered breathing (SDB) symptom score (normalized), and low socioeconomic status (lunch assistance): beta coefficients, standard errors, tests of significance, and odds ratios are shown[a]

	Beta	s.e.	P-value	Odds ratio
AA race	1.26	0.48	0.0088	3.53
SDB score	0.56	0.20	0.0049	1.74
Lunch assist.	2.94	0.68	≤ 0.0001	18.94

[a] All models adjusted for grade level.

Table 3
Linear regressions of Benchmark total scores on African–American (AA) race, sleep-disordered breathing (SDB) symptom score (normalized), and low socioeconomic status (lunch assistance): beta coefficients, standard errors, tests of significance, and Part R^2 are shown[a]

	Beta	s.e.	P-value	$100 \times$ Part R^2*
AA race	− 10.74	3.13	0.0008	7.74
SDB score	− 2.52	1.60	0.1182	1.73
Lunch assist.	− 11.59	3.06	0.0002	9.26

[a] All models adjusted for grade level. *Part R^2, also called the semi-partial R^2, is the difference in R^2 for the model with and without the indicated variable.

$P = 0.049$) but not Benchmark scores ($t = 1.37$, $P = 0.17$). Among 22 children with habitual snoring, seven (32%) had poor teacher-rated performance, whereas among 117 non-habitual snorers, only 17 (15%) had poor performance.

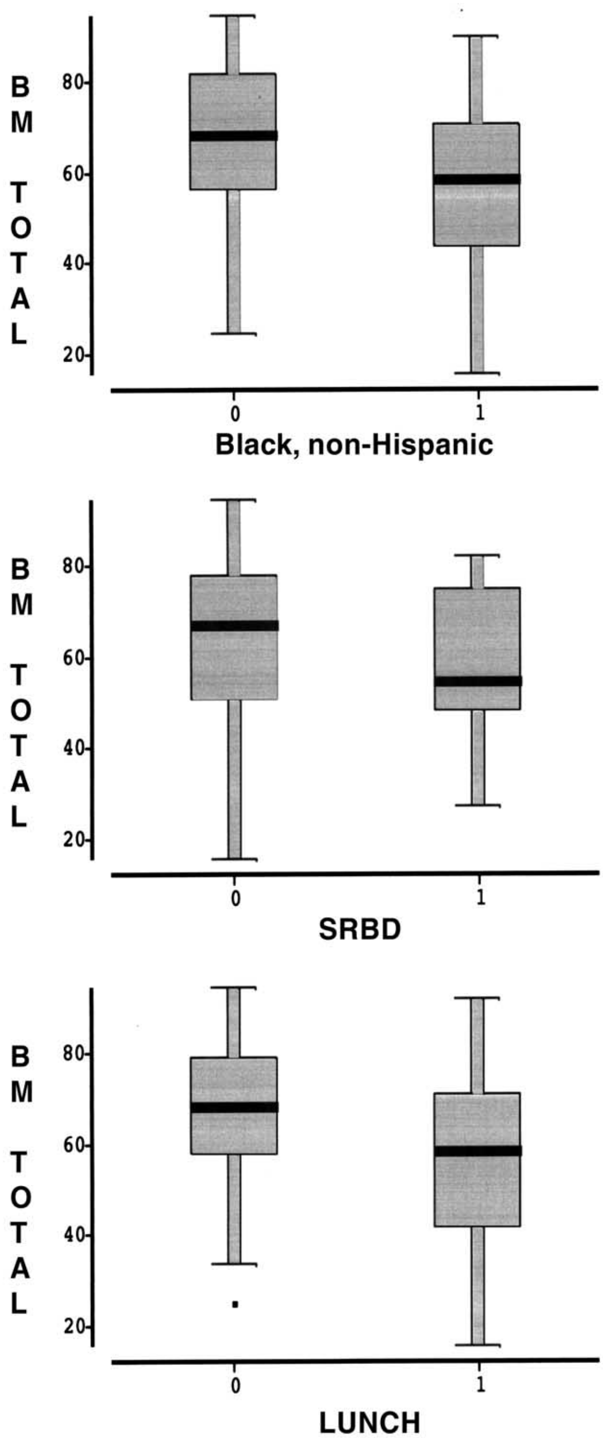

Fig. 1. Benchmark total scores (BMTOTAL) for subjects who were (1) and were not (0) reported to be Black, non-Hispanic (top panel); to have high risk for a sleep-related breathing disorder (SRBD, defined by an SDB score >0.33, middle panel); and to qualify for a lunch assistance program (bottom panel). Box plots show median (dark bar), 25th (bottom of box), 75th (top of box), 10th (bottom serif), and 90th (top serif) percentiles.

Multiple logistic regression models that simultaneously included AA race, SDB score, and lunch assistance (and grade level) showed that poor teacher-rated performance was still associated with lunch assistance (OR = 13.76, $P = 0.0002$) after controlling for the other variables. However, neither AA race (OR = 2.18, $P = 0.15$) nor SDB score (OR = 1.29, $P = 0.25$) retained a significant association with poor performance after accounting for lunch assistance. An analogous multiple linear regression of Benchmark total score on the explanatory variables showed that both AA race ($100 \times \text{Part } R^2 = 4.55$, $P = 0.0077$) and lunch assistance ($100 \times \text{Part } R^2 = 5.82$, $P = 0.0027$) retained significance, but SDB score did not ($100 \times \text{Part } R^2 = 0.04$, $P = 0.80$).

In exploratory analyses, Benchmark reading and math scores separately were regressed on explanatory variables in simple and then multiple linear regression models. The results for reading and math were uniformly similar to each other and to the Benchmark total score results presented previously.

3.3. Correlates of SDB risk

Several potential third variables from parent questionnaires were tested in an effort to explain the association, between low SES and SDB risk, that had left no discernable association between SDB risk and performance. The SES, BMI, presence of asthma, race, and reported hours spent in bed are shown in Table 4 for all subjects, those at high risk for SDB, and those at low risk. Multivariable logistic regression models showed that low SES retained association with high SDB risk after adjusting for asthma history, AA race, or hours in bed. However, low SES showed no association with high SDB risk after including BMI in the model (Table 5). A multiple stepwise logistic regression to evaluate high SDB risk considering low SES, BMI, asthma, AA race, and hours in bed excluded SES and confirmed that high SDB risk was best explained by BMI (beta = 0.78, s.e. = 0.31, OR = 2.2 [1.2, 4.2]) and asthma (beta = 1.5, s.e. = 0.77, OR = 4.7 [1.0, 21.7]). These results implied that high BMI was associated with low SES: a logistic regression showed a trend (beta = 0.38, s.e. = 0.22, OR = 1.5 [1.0, 2.3]).

Among 139 children with data on habitual snoring, 61 were classified as low SES and 14 (23%) of these snored habitually, whereas 78 children were not classified as low SES and only eight (10%) of these snored habitually (chi-square = 4.1, $P = 0.04$). Low SES was a significant correlate of habitual snoring (beta = 0.96, s.e. = 0.48, OR = 2.6 [1.0, 7.0]) before, but not after, adjustment for BMI (beta = 0.48, s.e. = 0.64, OR = 1.6 [0.4, 5.8]).

4. Discussion

This study of second and fifth grade students in an urban public school system shows that SDB symptoms, AA race, and SES all vary with academic performance, but the only

Table 4
Characteristics of all subjects, those at risk for SDB, and those at less risk[a]

	All subjects ($n = 145$)	High risk for SDB ($n = 16$)	Low risk for SDB ($n = 129$)
No. (%) grade 2	85 (59)	9 (56)	76 (59)
No. (%) male	58 (40)	8 (50)	50 (39)
No. (%) with lunch assistance	63 (43)	12 (75)*	51 (39)
Body mass index (mean ± s.d.)**	13.9 ± 4.1	17.6 ± 6.1*	13.5 ± 3.5
No. (%) with asthma	24 (17)	7 (44)*	17 (13)
No. (%) African–American	61 (42)	10 (63)	51 (40)
Hours in bed	9.8 ± 0.8	9.8 ± 0.6	9.8 ± 0.8

[a] $*P \leq 0.01$ for difference between high SDB risk and low SDB risk subjects (logistic regression; $P > 0.05$ for all others). $**n = 90$ subjects for whom height and weight were reported by parents. Children with and without height and weight data showed identical frequencies of high SDB scores.

variable independently associated with both objective and teacher-rated performance is SES. High unadjusted SDB symptom scores showed an association with poor teacher-rated performance, but not low test results. Low SES, as assessed by qualification for a lunch assistance program, was strongly associated with high SDB scores, which showed no significant association with performance after SES was taken into account. Similarly, accounting for SES substantially reduced or eliminated the association between AA race and performance measures.

Several potential correlates of low SES – BMI, asthma, and AA race – were also associated with SDB risk, but only BMI explained a large part of the association between low SES and SDB risk. While correlative studies cannot prove causality, if low SES does increase SDB risk, the current results suggest that the effect may be mediated by increased obesity [9]. Although care must be taken in the extrapolation of results because of the low participation, the findings raise important considerations in interpretation of previous reports that childhood SDB is associated with poor school performance. Finally, an excess frequency of SDB among AA children does not appear to be a direct explanation for the ‘achievement gap’.

Few previous reports have examined associations between SES and risk for childhood SDB. One study of 4–5 years old children reported that lower SES, as defined by a father’s manual as opposed to non-manual work, was associated with increased SDB symptoms before, but not after maternal smoking was taken into account [12]. However, BMI was not studied, the SDB questionnaire-items had been validated without polysomnography, and the six SDB symptoms analyzed included three (coughs and colds, restless sleep, and problem related to sleeping) that may assess overall sleep quality rather than SDB specifically. Overall sleep quality is known to correlate with SES among adults [13]. For example, a French survey of 5622 people aged 15 years or more found that lower family income correlated with insomnia [14]. A subsequent study of 205,347 French patients showed that those with low buying power, more often than others, reported that they suffered from a sleep disorder [15]. Neither of these studies, however, focused on SDB. In one previous study of 496 adults, more specific questionnaire evidence of snoring and SDB showed no association with ‘socio-professional’ categories [16].

Table 5
Logistic regressions of high sleep-disordered breathing risk on low socioeconomic status, after adjustment for each specified risk factor: socioeconomic status beta coefficients, standard errors, odds ratios, and odds ratio 95% confidence intervals are shown

Risk factor taken into account	Beta	s.e.	Odds ratio	95% CI
Body mass index (kg/m^2)*	0.78	0.73	2.2	[0.5, 9.7]
Asthma	1.46	0.62	4.3	[1.4, 16.5]
African-American	1.37	0.62	3.9	[1.2, 15.1]
Hours in bed*	1.49	0.61	4.4	[1.4, 16.7]

* These variables were normalized; the change modeled was therefore an increase by one standard deviation.

Why our subjects from poor families tended to have high body mass indices is uncertain. These children may have higher calorie, less nutritive diets more likely to produce obesity. Such children may have few opportunities for sports and other activities that could reduce weight. In developed countries, persons with low SES are more likely to be overweight, although the association is stronger and more consistent among adults than among children [17]. Obesity among children from low-income families is a growing public health problem in the US [18], especially in this state (Michigan), which has one of the highest frequencies of childhood obesity. Adenotonsillar hypertrophy and craniofacial anomalies may be the most frequent anatomical features in childhood SDB, but obesity is also a known correlate in this age group [9], and the importance of obesity is likely to grow as obesity becomes more prevalent.

Besides obesity and perhaps maternal smoking, several unstudied variables, to which children might be more vulnerable than adults, also could contribute to an association between lower SES and SDB risk. Low SES is associated with poor health overall, deficient diets, more limited access to health services, and lower participation in health promotion activities such as non-emergent routine care. Untreated adenotonsillar hypertrophy or asthma increases the risk for SDB [9,19]. Low SES may also be associated with insufficient sleep or poor sleep hygiene, due to parents' work schedules, the sleeping environment, or other factors. Inadequate sleep could increase SDB scores by making children more sleepy, and if chronic, directly increase the risk for SDB [20].

Consistent with our data, previous investigations also found an association between poor grades and childhood SDB [3,4], but evidence that SDB actually causes or contributes to poor grades has not been conclusive. One study that showed improvement in school grades 1 year after treatment for SDB relied on parents, not randomization, to decide whether to pursue treatment for SDB [3]. Obesity, SES, access to health care, and related factors often have not been assessed, though one study did match high performing students to low performers who lived on the same street or nearby, in an effort to match for SES [4]. Additional evidence that SDB could affect school performance arose from studies that documented neurocognitive deficits and hyperactive behavior in association with SDB or related symptoms [5,7,21], but these studies also did not control for SES. One study found relative deficits in attention, memory, and intelligence in 16 snoring children who were compared to 16 non-snoring controls [6]. This study did adjust for maternal occupation, but this measure of SES showed no association with snoring or most psychometric results, perhaps due to sample size limitations or imprecision of the SES measure. The current results suggest that future studies of SDB, race, and school performance should incorporate more direct measures of SES and obesity.

Current results also suggest that detection of associations between school performance and SDB may depend on the performance measure used. Previous studies that relied on teachers' grades to gauge performance found associations with SDB [3,4]. Our study suggests that objective test scores may not show these associations. Teachers' grades may reflect other factors – hyperactive and disruptive classroom behavior, for example – that could be influenced by SDB or SES [21,22].

In contrast to sleep-related studies, a number of previous reports on achievement did address SES. Data collected by the National Longitudinal Survey from approximately 2000 children suggest a strong effect of family financial capital on math and reading scores [23]. Family income shows an association with achievement and ability-related outcomes in studies of children [24] and, more specifically, AA children [8,25]. Furthermore, the achievement gap can persist between Black and White populations after stratification by SES levels, though test-specific characteristics also could explain such results [26].

This study is the first, to the authors' knowledge, to examine the possibility that an increased frequency of SDB could contribute to poor school performance among AA children. The data, which do not support the hypothesis, demonstrate the importance of a broad analysis of multiple factors likely to contribute to poor school achievement. However, the idea that SDB may contribute to an achievement gap cannot be discounted definitively by current results. The study design was correlational, and unsuspected confounders could have obscured underlying relationships. Moreover, gold-standard measures were abandoned in favor of instruments that would cause less disruption of the school day and permit inclusion of larger numbers of subjects. The Pediatric Sleep Questionnaire has good validity but is not equivalent to polysomnography. Qualification for the public school lunch assistance program requires an objective and relatively rigorous screening of family finances, but every qualified family may not apply. SES can be assessed in more detail, rather than a single dichotomous measure, by other methods. Lunch assistance conceivably could affect food consumption and obesity in some manner not directly related to SES. Perhaps most importantly, our survey return rate of 18% – though commendable in this urban school setting – raises the possibility that the sample was not representative of the target population. However, the sample did not show major differences with the entire school district in racial composition or SES. In addition, any selection bias that might have affected frequencies or levels of study variables probably would have had less effect on associations (between those variables) which form the main findings of this report.

In conclusion, this study did not support the initial hypothesis that an increased frequency of SDB may explain a substantial portion of the achievement gap between AA and non-AA school children. Instead, a simple but objective measure of SES appeared to account for the association between SDB and poor performance, perhaps because low SES was associated with high BMI. Physicians, school nurses, and health officials whose work involves children from low-income families should be aware that these patients may be at increased risk for SDB. The question of whether AA children have increased risk for SDB because of their race, SES, BMI, or other factors remains an important public health question. The outcomes of SDB in children are poorly defined, and further research is needed to determine the extent to which SDB may have cognitive, behavioral, and academic consequences. However, such studies should account for SES and obesity, and attempt to determine whether these variables – as opposed to SDB or race – may explain associated morbidity.

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