CROSS-SECTIONAL STUDY

Opportunity for Interprofessional Collaboration: Screening for Pediatric Sleep-Disordered Breathing by Dentists

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Abstract: ***Purpose:*** *This study's purpose was to examine the sociodemographic and clinical correlates of sleep-disordered breathing in children receiving care at health center dental clinics.* ***Methods:*** *Data were collected from the Pediatric Sleep Questionnaire and the health records for two- to 18-year-old children at health centers located in seven states.* ***Results:*** *Subjects included 1,000 children (46.3 percent female, 53 percent Hispanic, 70.7 percent white), with mean (± standard deviation) age of 6.89±2.51. Of the sample, 11.9 percent had a Pediatric Sleep Questionnaire score of at least eight. On multiple logistic mixed-effect analysis, age, American Society of Anesthesiology status, anterior overjet, attention deficit hyperactivity disorder, and obesity were significant predictors of the presence of a Pediatric Sleep Questionnaire score of at least eight at a significance level of P=0.05.* ***Conclusions:*** *With 11.9 percent of the subjects at risk for sleep-disordered breathing conditions, dentists have an opportunity for interprofessional collaboration with primary and specialist physicians. Dentists should routinely screen children with the Pediatric Sleep Questionnaire tool, cross-reference-associated clinical indicators (such as age, American Society of Anesthesiology status, anterior overjet, attention deficit hyperactivity disorder, and obesity), optimize orofacial growth and development, and refer to and coordinate with physicians to manage high-risk children.* *(Pediatr Dent 2020;42(6):436-40) Received May 27, 2020 | Last Revision August 7, 2020 | Accepted August 10, 2020*

KEYWORDS: PEDIATRIC, SLEEP-DISORDERED, BREATHING, SCREENING, DENTISTS

Pediatric sleep disorders include sleep issues that meet diagnostic criteria for obstructive sleep apnea (**OSA**), parasomnias, narcolepsy, and insomnia.[1] These disorders often go undiagnosed and are persistent in children, leading to increased hospital visits, brain damage, seizures, coma, and cardiac complications.[2,3] Additional complications include daytime sleepiness, learning disabilities, growth retardation, and behavioral problems.[4] Conservative estimates are that 12 percent to 15 percent of children are diagnosed with sleep-related breathing disorders.[5] Comparatively, the Centers for Disease Control and Prevention estimates that 7.5 percent of children are diagnosed with asthma.[6] In 2006, the Institute of Medicine (now known as the National Academy of Medicine) published its deep and probing report: "Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem."[7] The key conclusions of this seminal report illuminate an opportunity for dentists to join the medical community for integrative care of children with sleep-disordered breathing (**SDB**). The report specifically notes that there is a high demand for the care of children with SDB and a great shortage of health care providers to diagnose and treat these children; additionally, it recommends an interdisciplinary approach that involves dentistry in conjunction with a myriad of other medical and health care domains.

American Academy of Pediatric Dentistry (**AAPD**) guidelines, which are pertinent to all dentists who treat children, state "all children/adolescents should be screened for snoring" and "polysomnography should be performed in children/adolescents with snoring symptoms/signs of OSA."[8] The guidelines focus on the screening, clinical assessment, compliance, therapy of patients, and referral to medical specialists for patients. It is critically important that dentists who treat children conduct a thorough history and clinical screening for SDB. Parents should be asked if their children exhibit any symptoms of OSA. Since the AAPD guidelines were only recently published in 2016, it is unknown how many dentists have implemented these guidelines into their daily practice.

The gold standard for diagnosing SDB is polysomnography. Since the AAPD guidelines recommend screening children for snoring and sleep-related breathing disorders, the statistically validated Pediatric Sleep Questionnaire (**PSQ**), with high levels of specificity and sensitivity, serves as an excellent screening tool.[9] Factors associated with OSA include craniofacial dysmorphology, adenotonsillar hypertrophy, obesity, upper airway inflammatory processes, and neuromuscular weaknesses.[3] Additional factors significantly associated with SDB include quality of life, oral health impact, dental caries, periodontal pocket depth, and gingival bleeding upon probing.[10]

The purpose of this study was to identify the associations between pediatric subjects, who respond positively to the Pediatric Sleep Questionnaire, (i.e., "yes" to eight or more items on the PSQ), and their sociodemographic and clinical findings. It is hypothesized that a PSQ score of eight more is positively associated with sociodemographic and clinical findings, such as American Society of Anesthesiologists (**ASA**) status, attention deficit hyperactivity disorder (**ADHD**), obesity, age, and anterior overjet.

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HOW TO CITE:
Okuji D, Healy E, Wu Y. Opportunity for Interprofessional Collaboration: Screening for Pediatric Sleep-Disordered Breathing by Dentists. Pediatr Dent 2020;42(6):436-40.

Methods

Sampling frame, subject recruitment, and enrollment. The sample population included the dental records of 1,000 two- to 18-year-old pediatric subjects who were registered patients at health centers in Arizona, Florida, Hawaii, Maryland, Massachusetts, New York, and Tennessee that are approved training locations with the Postdoctoral Dental Residency Programs at NYU Langone Hospitals, New York City, N.Y., USA. The date period for data collection was March 18, 2018, to September 30, 2019.

The pediatric subjects and their legal caregivers were selected from a convenience sample of patients who met the inclusion criteria at approved health centers with NYU Langone Hospitals-Division of Dental Medicine. These health centers are classified as Federally Qualified Health Centers (**FQHC**), which are funded by the federal government and tasked to care for vulnerable and underserved populations.

The legal caregivers were recruited at their child's regularly scheduled dental visit by the dental resident/investigator, who described the nature, risks, and voluntary nature of the study. The legal caregivers were administered the PSQ survey, and children, with the legal caregiver responding "yes" to eight or more items on the PSQ, were determined to have suspected SDB.

Statistical analysis. SDB status for this analysis was indicated by scores from the PSQ with a cutoff point of eight. The comparison of continuous variables between patients at different health centers was performed using the one-way analysis of variance test or Kruskal-Wallis rank-sum test, as appropriate. Categorical variables are expressed as frequency distribution and were compared using the chi-square test or Fisher's exact test. Due to missing data and a 23.2 percent loss of subjects, a multiple imputation procedure was conducted, which used all available demographic and clinical data to statistically impute missing values.[11] The number of imputed datasets was set at 30 such that stable estimation was obtained. All further analysis was based on imputed datasets, and pooled results were presented. The odds ratio of all demographic and clinical variables for SDB status were calculated using univariate logistic mixed-effect models. The heterogeneity of health centers and within-cluster correlation were modeled as random effects. Variables with a P-value <0.1 were further included in the multiple logistic mixed-effect models and used to determine adjusted associations. The linearity of the age variable's effect was investigated by plotting the prevalence of sleep-related breathing disorder status versus age using locally estimated scatterplot smoothing (**LOESS**) in R statistical software (The R Foundation for Statistical Computing, Vienna, Austria). A squared or higher-order term of the age variable was included in models when any nonlinear relationship was observed. All statistical analyses were performed with the significance level set at P=0.05.

Results

The sample population included 1,000 participants (46.3 percent female, 53 percent Hispanic, 70.7 percent white), and the mean (± standard deviation) age was 6.89±2.51 years. The median interquartile range PSQ score was 2.00 (0.00, 5.00). Of the sample, 11.9 percent had a PSQ score of eight or greater and were categorized as having suspected SDB. Table 1 presents the summary statistics of the sample. The percentages of PSQ of eight or greater in the overall sample by sex and race were as follows: male (12.7 percent); female (10.6 percent); white (11.9 percent); black or African American (13.7 percent); and other races (9.6 percent).

Analyses that compared the distributions of all variables were significantly different by health center locations. In particular, the rates of PSQ of eight or greater were significantly

Table 1. DEMOGRAPHIC CHARACTERISTICS AND DISTRIBUTION*

	Overall	Missing (%)
N	1,000	
Age (mean±SD)	6.89±2.51	0.1
Sex: Female (%)	462 (46.3)	0.3
Ethnicity: Hispanic (%)	522 (53.0)	1.6
Race (%)		5.6
Other	146 (15.5)	
Black or African American	131 (13.9)	
White	667 (70.7)	
ASA Class 2 (%)	169 (17.0)	0.7
Health center locations		0.0
Arizona	278 (27.8)	
Florida	42 (4.2)	
Hawaii	137 (13.7)	
Maryland	266 (26.6)	
Massachusetts	142 (14.2)	
Tennessee	79 (7.9)	
New York	56 (5.6)	
History of caries=yes (%)	727 (73.0)	0.4
History of gingivitis=yes (%)	330 (33.6)	1.9
History of gingival bleeding=yes (%)	215 (22.2)	3.1
Diagnostic history of bruxism=yes (%)	45 (4.6)	2.3
Anterior overjet ≥2 mm (%)	354 (38.9)	9
Anterior overbite=1+ mm (%)	670 (74.9)	10.6
Presence of posterior crossbite=yes (%)	60 (6.1)	2
Presence of anterior crossbite=yes (%)	66 (6.7)	2.2
Presence of anterior open bite=yes (%)	19 (2.0)	2.6
Molar classification (%)		4.5
Class 1	487 (51.0)	
Class 2	145 (15.2)	
Class 3	323 (33.8)	
Mallampati score (%)†		6.5
Class 1	435 (46.5)	
Class 2	338 (36.1)	
Class 3 and 4	162 (17.3)	
ADHD=yes (%)	76 (7.8)	2.4
Obese=yes (%)	240 (24.1)	0.5
PSQ score (median [IQR])	2.0 [0.0, 5.0]	0.1
PSQ score ≥8 (%)	119 (11.9)	0.1

Abbreviations used in this table: ASA=American Society of Anesthesiologists; ADHD=attention deficit hyperactivity disorder; PSQ=Pediatric Sleep Questionnaire; IQR=interquartile range.

* Means (standard deviations) are presented for continuous variables; frequencies (%) are presented for categorical variables.

† Mallampati score (%).[18]

different, which confirmed heterogeneity of health centers and the use of random effects to account for the heterogeneity.

Table 2 demonstrates the distributions of demographic and clinical variables by SDB status. Since the distributions were not adjusted for heterogeneity of health center locations, *P*-values for comparisons were not presented and this table should be viewed as descriptive only. The prevalence of PSQ of eight or greater was more than twice for participants with ASA Class 2 than that for participants with ASA Class 1. Large differences were also observed for a history of gingivitis, anterior overjet, attention deficit hyperactivity disorder (**ADHD**), and obesity. For age, the linearity of its effect was examined by plotting the average prevalence of a PSQ of eight or greater using the LOESS smoother. The resulting unadjusted plot shows a quadratic trend such that prevalence in the sample increased with age and reached a peak between age seven and eight years and decreased thereafter (Figure).

Table 3 presents odds ratios of demographic and clinical variables for PSQ of eight or greater, adjusted for heterogeneity of health centers and within-cluster correlation, followed by multiple logistic mixed-effect analysis. The analysis demonstrated that age squared term (P=0.036), ASA status (P=0.003), anterior overjet (P=0.011), ADHD (P<0.001), and obesity (P<0.001) were significant predictors of the presence of PSQ of eight or greater.

For age, the linear term was borderline significant (P=0.077) and the squared term was significant, indicating the quadratic relationship was retained after adjusting for other variables' effect and the peak prevalence of PSQ of eight or greater occurred around age seven years.

Table 2. SAMPLE CHARACTERISTICS BY SLEEP-DISORDERED BREATHING STATUS*

	PSQ score ≥8	
	False	True
N	880	119
Age (mean±SD)	6.87±2.55	7.03±2.26
Sex: Female (%)	412 (46.9)	49 (41.9)
Ethnicity: Hispanic or Latino (%)	467 (53.7)	55 (48.7)
Race (%)		
Other	132 (15.9)	14 (12.6)
Black or African American	113 (13.6)	18 (16.2)
White	587 (70.6)	79 (71.2)
ASA Class=2 (patient with mild, systemic disease) (%)	126 (14.4)	43 (36.1)
History of caries=yes (%)	633 (72.2)	94 (79.7)
History of gingivitis=yes (%)	278 (32.1)	52 (45.2)
History of gingival bleeding=yes (%)	185 (21.6)	30 (26.8)
Diagnostic history of bruxism=yes (%)	39 (4.5)	6 (5.2)
Anterior overjet category ≥2 mm (%)	298 (37.1)	56 (52.3)
Anterior overbite=1+ mm (%)	593 (75.3)	77 (72.6)
Presence of posterior crossbite=yes (%)	54 (6.3)	6 (5.1)
Presence of anterior crossbite=yes (%)	58 (6.7)	8 (6.8)
Presence of anterior open bite=yes (%)	18 (2.1)	1 (0.9)
Molar class (%)		
Class 1	421 (50.0)	66 (58.4)
Class 2	130 (15.4)	15 (13.3)
Class 3	291 (34.6)	32 (28.3)
Mallampati score (%)†		
Class 1	386 (46.9)	49 (43.8)
Class 2	298 (36.2)	40 (35.7)
Class 3 and 4	139 (16.9)	23 (20.5)
ADHD=yes (%)	48 (5.6)	28 (23.9)
Obese=yes (%)	193 (22.0)	47 (39.8)

Abbreviations used in this table: ASA=American Society of Anesthesiologists; ADHD=attention deficit hyperactivity disorder; PSQ=Pediatric Sleep Questionnaire; IQR= interquartile range.

* Means (standard deviations) are presented for continuous variables; frequencies (%) are presented for categorical variables.

† Mallampati score (%).[18]

Discussion

The associations of SDB with ASA status, ADHD, and obesity continue to support the findings in previously published literature.[2,4] The hypothesis, that a PSQ score of eight or more is positively associated with sociodemographic and clinical findings, was supported with the results for ASA status, ADHD, and obesity aligning with multiple studies[2,4] and identified new findings of association with age,[12] and anterior overjet[13]. A new finding was that peak prevalence of suspected SDB occurred between age seven and eight years, which contrasts with a 2008 systematic review concluding: "Available data seem

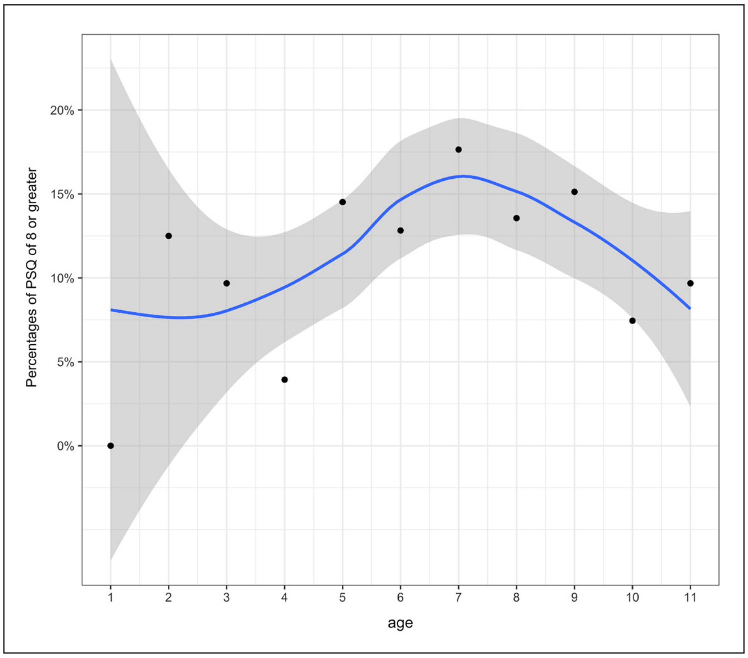

Figure. The average prevalence of a Percentages of Pediatric Sleep Questionnaire (PSQ) eight or greater by age. The solid black dots represent percentages of PSQ of eight or greater at different ages in the sample. The solid blue line is estimated and drawn by the LOESS (locally estimated scatterplot smoothing) smoother, which approximates the sample relationship between the prevalence of PSQ of eight or greater and age. The grey area represents the 95 percent confidence band of the LOESS curve. The wide band on the left was due to a relatively small number of observations at early ages. The quadratic trend motivates the use of both linear and quadratic terms of age in the multiple logistic mixed-effect model.

Table 3. ODDS RATIOS (95% CONFIDENCE INTERVAL [CI]) FOR VARIABLES AND PEDIATRIC SLEEP QUESTIONNAIRE (PSQ) OF EIGHT OR GREATER ESTIMATED BY MULTIPLE LOGISTIC MIXED-EFFECT MODELS*

	Odds ratio	95% CI		*P*-value
Age (linear term)	1.607	0.95	2.718	0.077
Age (squared term)†	0.961	0.926	0.997	**0.036**
Sex: Male	–	–	–	–
Sex: Female	0.842	0.551	1.287	0.425
Race: Other	–	–	–	–
Race: Black or African American	1.098	0.389	3.099	0.860
Race: White	1.041	0.406	2.667	0.934
Ethnicity: Non-Hispanic	–	–	–	–
Ethnicity: Hispanic or Latino	0.662	0.376	1.168	0.154
ASA: Class 1	–	–	–	–
ASA: Class 2	2.188	1.3	3.684	**0.003**
Anterior overjet: <2 mm	–	–	–	–
Anterior overjet: >2 mm	1.815	1.149	2.866	**0.011**
ADHD: No	–	–	–	–
ADHD: Yes	3.347	1.818	6.16	**<0.001**
Obesity: No	–	–	–	–
Obese: Yes	2.347	1.514	3.636	**<0.001**

Abbreviations used in this table: ASA=American Society of Anesthesiologists; ADHD: attention deficit hyperactivity disorder.

* Pooled results based on 30 imputed datasets were shown. *P*-values in bold-font indicate that the corresponding variables are statistically significant at a significance level of 0.05.

† Age (squared term) is defined as the squared or higher-order terms of the age variable, which is included in statistical models when any non-linear relationship is observed.

insufficient to prove that SDB differs systematically by age."[12] Another new finding was the association of suspected SDB with anterior overjet greater than two millimeters, which is similarly supported by a meta-analysis study demonstrating that a cephalometric difference of 1.54 degrees or greater in the angle between the relative anterior-posterior position of the maxilla to the mandible (i.e, Steiner analysis, ANB) is positively associated with primary snoring in children.[13]

The results of this study demonstrate opportunities for dentists who treat children to play a crucial role in screening, referring, and collaboratively managing SDB symptoms and risk factors in support of primary and specialist physicians. It is, therefore, important to increase dentists' awareness of SDB, increase the rate of early screening and diagnosis, and avoid SDB-related sequelae by delivering appropriate referrals and treatment in collaboration with the medical team.

While SDB continues to be underdiagnosed in pediatric patients, many pediatric SDB patients are not receiving appropriate and timely treatment. Comparatively, this study found that 11.9 percent of the pediatric subjects had suspected SDB, which is nearly 60 percent higher than the 7.5 percent prevalence of childhood asthma.[6] Also, this study's 11.9 percent prevalence for SDB aligns with previous estimates of the 12 percent to 15 percent range[5] and may be at the low end of the range, since the PSQ screening tool is a less-sensitive proxy for a confirmed diagnosis of SDB with polysomnography. This finding highlights the need for dentists to increase awareness of the high prevalence of SDB and routinely screen pediatric patients with SDB, as recommended by the American Academy of Pediatrics[2] and the AAPD.[8] Any child identified as high-risk for SDB should be referred to their primary care physician, since these children may be at higher risk of developing growth delay, hyperactivity, attention deficits, and learning disabilities.[2] Apneic episodes during periods of critical childhood development may lead to permanent neurocognitive deficits, underscoring the importance of early diagnosis and treatment of SDB.[2] Pediatric SDB are conditions that require a clear diagnostic definition in pediatric patients and include physiology and sequelae that differ from that of adult OSA.[14]

Following a definitive SDB diagnosis, these patients may be evaluated by a multidisciplinary care team including, but not limited to, pediatricians, otolaryngologists, orthodontists, and speech therapists. The AAPD recommends that dentists screen patients for snoring and sleep-related breathing disorders,[8] with results from this study demonstrating opportunities for dentists to identify children at risk for SDB at the peak ages of prevalence from seven to eight years and slightly lower prevalence beyond age eight, since children have more frequent visits to dentists compared to physicians after nine years of age.[15] Screening and referrals, therefore, are important services dentists can provide because they routinely see a large number of pediatric patients at frequent intervals.

Dentists must also ensure optimal orofacial growth and development for the referred children and collaborate with the physician for interprofessional care. The AAPD guidelines advise that "the dentist work with the physician to determine if adjunctive options (e.g., rapid palatal expansion, orthodontic treatment) are advised as part of a multidisciplinary treatment effort. If a dentist decides to treat OSA with an intraoral appliance, it is strongly encouraged that the patient be reassessed throughout treatment for symptoms of OSA to determine if the treatment is working."[8]

The major strengths of this study are its sample size of 1,000 subjects and geographic diversity, due to the fact that it encompassed seven U.S. states. These strengths lead to greater generalizability of this study's results and conclusions compared to findings from a single and isolated clinic population. The primary limitation of this study is that the PSQ does not provide a definitive diagnosis of SDB, although it is a reliable and valid screening tool used to identify patients at high risk for developing such disorders. Another limitation is that a majority of child patients at federally qualified health centers are beneficiaries of the Medicaid program, which serves as a proxy for low family income. Hence, the results may not be generalizable to the entire population, since children in low-income families may have other social determinants of health that act as confounding variables, such as race, low socioeconomic status, single caregiver, and crowded home.[16,17]

As additional research is gathered to support the dentist's role in screening patients for a suspected SDB diagnosis, further studies are necessary to follow the referrals made from dentists to primary care physicians and examine the percentage of definitive diagnoses and success of consequent treatment. As well, future studies should examine the predictive validity of the clinical indicators of SDB identified in this study, including age, ASA status, anterior overjet, ADHD, and obesity. Additional studies are needed to conclude whether other clinical findings and comorbidities may be associated with SDB and the long-term impact of oral appliance therapy in mitigating SDB symptoms. Future studies might also reinforce the significance of dentists possessing a knowledge of the physiology and sequelae of SDB, at the level of the pediatrician, to ensure an efficient referral process and participate in the multidisciplinary approach to care for these children.

Conclusions

Based on this study's results, the following conclusions can be made:

1. The prevalence of suspected sleep-disordered breathing was identified in 11.9 percent of the sample population studied with a Pediatric Sleep Questionnaire score of eight or greater.
2. Dentists should routinely screen children with the PSQ tool, cross-reference clinical indicators such as age, ASA status, anterior overjet, ADHD, and obesity, and optimize orofacial growth and development.
3. Dentists have an opportunity for interprofessional collaboration with primary care physicians by referring high-risk children to the physicians for further diagnosis and treatment.

Acknowledgments

The authors wish to thank the individuals at NYU Langone Hospitals, New York City, N.Y., USA, who supported this study: Dr. Jay Balzer, a dental public health specialist and mentor, and the former Advanced Education in Pediatric Dentistry residents, Dr. Jeffrey Chang, Dr. Gurjote Dhaliwal, Dr. Krystal Kazemba, Dr. Yun Kim, Dr. Scarlet Kim, Dr. Supriya Koirala, Dr. Nikita Kuppanda, Dr. Naomi La, Dr. Weston Milne, Dr. Tiffany Rangel, Dr. Rohit Sethi, Dr. Jennifer Sylvian, Dr. Michelle Yang, and Dr. Jenna Yu.

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