Sleep Disordered Breathing and Oral Health in Children

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Abstract

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Purpose: To assess the oral health status and Oral Health Related Quality of Life (OHRQoL) of children at risk for SDB (SDB 1) in comparison to those not at risk for SDB (SDB 0).

Methods: This cross sectional study recruited consecutive children between the ages of 8 to 17 years from a university-based pediatric dental clinic. Caregivers completed the Pediatric Sleep Questionnaire (PSQ) to stratify risk of SDB. Children and their Caregivers completed the Child Oral Health Impact Profile (COHIP) to measure the OHRQoL. A dental exam was conducted and dental caries, periodontal status, oropharyngeal soft tissue features, and dental occlusion were recorded. DMFS, dmfs, PPD (pocket probing depth), parent COHIP score, child COHIP score, and BOP (bleeding on probing) were compared between children at risk for SDB (SDB 1) and those not at risk for SDB (SDB 0).

Results: 123 children were enrolled (11.5 □ 2.7 years, female =48%). 49% were classified as being at high risk for SDB. There was a significant association between SDB and all six outcomes. The SDB 1 group had an average of 12.03 (P<0.001) more DMFS, 6.15 (P<0.001) more dmfs, and 30.22 (P<0.001) times the odds of BOP. Being at risk for SDB was associated with a poorer OHRQoL, with an average parent COHIP score of 15.50 (P<0.001) points greater and child COHIP score of 13.02 (P<0.001) points greater.

Conclusion: The results from this study suggest that the impact of SDB on the oral health and Oral Health Related Quality of Life (OHRQoL) in children is profound and far-reaching. Given the significant association between SDB and all six outcomes, it is critical practitioners closely monitor the oral health of their pediatric SDB patients.

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DEDICATION

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Chapter 1. INTRODUCTION

Sleep disordered breathing (SDB) is an umbrella term that comprises a group of disorders characterized by abnormal respiratory pattern and ventilation. SDB ranges from its least severe form, primary snoring, all the way to the most severe and common form, obstructive sleep apnea (OSA). OSA is characterized by a partial or complete collapse of the upper airway during sleep, resulting in partial or complete cessations of breathing (hypopnea, apnea). This results in disruption of normal sleep architecture and oxygen desaturation [1,2]. SDB is relatively uncommon in children with a prevalence of approximately 2%-5% [3–5].

There has been extensive research documenting the systemic, social, and behavioral consequences of SDB in children, particularly with OSA. It is well appreciated that SBD/OSA in children is associated with: cardiomyopathy, BP dysregulation, elevated sympathetic activity, vascular pathology, metabolic disorders, impaired autonomic reflexes, epilepsy, gastroesophageal reflux, history of childhood cancer, ADHD, severe neurocognitive impairment, and behavior problems. This leads to increased medical expenses and reduced quality of life for children and parents[6–18]. Most of these complications can resolve or improve with an adenotonsillectomy, the first-line SDB treatment[19]. However, tragically, many children go undiagnosed and the associated morbidities remain or increase in severity.

In addition to systemic complications, children with SDB often show a wide range of oral manifestations. These include: adenoid hypertrophy, tonsillar hypertrophy, macroglossia, thick soft palate, reduced posterior airway space, reduced sagittal nasopharyngeal and oropharyngeal dimensions, narrow dentoalveolar width, increased overjet, reduced overbite, and malocclusion[7,20–27]. Many of these oral manifestations are associated with oral disease, including

dental caries and periodontal disease. For example, studies have shown that malocclusion is associated with dental caries[28,29]. Compounding this problem, many SDB patients are mouth breathers, which leads to xerostomia. The literature has concretely shown that xerostomia and salivary gland dysfunction drastically increase caries risk[30]. Therefore, it can be hypothesized that oral manifestations found in children with SDB likely have significant and far-reaching consequences on their oral health.

Despite the fact that oral diseases in children can result in systemic disease, reduced quality of life, adverse social consequences, severe economic burdens, and family stress, there are no studies linking SDB with poor oral health in the pediatric population[6–18]. Therefore, it is paramount that we investigate the oral health status of children with SDB. The purpose of this research is to assess the oral health and oral health-related quality of life in children and adolescents at risk for SDB compared with an unaffected control group (children not at risk for SDB).

Objectives:

1) Assess the oral health status of children at risk for SDB.
2) Assess the Oral Health Related Quality of Life (OHRQoL) of children at risk for SDB.

Hypotheses

H1: Children at risk for SDB have poor oral health compared to healthy subjects.

H2: Children at risk for SDB have poor oral health-related quality of life (OHRQoL) compared to healthy subjects.

Chapter 2. METHODS

2.1 STUDY DESIGN

In this cross-sectional study, patients at the pediatric dental clinic at University of Washington for were approached during routine dental check-ups between October 2016 and January 2017. Inclusion criteria required that the subject was 8 to 17 years old at the time of enrollment, in good overall health, and did not have active orthodontic treatment within the last year. Children and their caregivers were also required to be fluent in English. The study was approved by the University of Washington Institutional Review Board with written informed consent/assent obtained from each participant and/or their legal representative.

2.2 QUESTIONNAIRES

After consenting/assenting to participate, caregivers were asked to complete the Pediatric Sleep Questionnaire (PSQ) to determine whether their child was at risk for SDB[41]. This validated questionnaire consists of 22 items forming three distinct domains: snoring, daytime sleepiness, and related behavioral disturbances, an overall score of ≥8 indicates positive SDB symptoms. The subjects' oral health related quality of life (OHRQoL) was assessed based on the answers given by the children and their caregivers to the COHIP questionnaire[42]. This questionnaire consists of 35 items forming 5 conceptually distinct domains: oral health (oral symptoms such as teeth pain, sensitivity, and oral sores), functional well being (the child's ability to perform specific everyday activities), social/emotional well being (peer interactions and mood states), school environment (assignments associated with the school environment) and self-image (positive feelings about self). The COHIP uses Likert-type scales where "Never" = 0; "Once or

twice" = 1; "Sometimes" = 2; "Often"= 3; and "Very often" = 4. For some items, the scale was reversed so that higher scores consistently indicated poor oral health. A subscore for each of the five COHIP domains and an overall total COHIP score were calculated. For the overall scores, higher scores reflect worsened OHRQoL. Patient demographics such as age, sex, parental education, were gathered as a part of the COHIP questionnaire completed by the caregivers.

2.3 DENTAL EXAM

The clinical examinations were carried out by a dentist (BT) using a dental mirror and a ball-ended periodontal probe. The examiner was was blinded to results of the PSQ. Craniofacial features and dental occlusion were recorded. Soft palate morphology was classified according to the Mallampati classification[43]. Tonsil size was classified according to the Brodsky score[44] .The recorded variables for dental occlusion included molar occlusion (normal (I), mesial (II) or distal (III)), overjet (in millimeters), overbite (percentage), and crowding[45]. The diagnosis of dental caries was based on the detection of carious lesions at the cavitation stage, as recommended by the World Health Organization (WHO). DMFS and dmfs indices (decayed, missing, and filled surfaces; lower-case letters for primary teeth, upper-case for permanent teeth) were used[46]. The periodontal examination was performed for the Ramfjord index teeth (teeth number: 3, 9/F, 12/I, 19, 25/P, 28/S), separate recordings were made for the four smooth surfaces of these teeth, and an average tooth score was then recorded[47]. Two periodontal indices were measured to assess periodontal status: 1) Bleeding on probing recorded after stimulating the region where gingiva and teeth come to contact to each other by a periodontal probe; and 2) Probing depth, "defined as the distance between the gingival margin and the bottom end of the periodontal pocket"[28].

2.4 DATA ANALYSIS

Six different outcomes were used to compare the oral health status between SDB 1 (children at risk for SDB, + or positive) and SDB 0 (children not at risk for SDB, - or negative) participants. Five continuous outcomes were measured: DMFS, dmfs, PPD (pocket probing depth), COHIP (child oral heath impact profile) parent, and COHIP child. One categorical outcome was measured, BOP (bleeding on probing).

The unadjusted difference between the means for the continuous outcomes was calculated with a t-test allowing for unequal variances. The unadjusted odds ratio for the categorical outcome was calculated with a Fisher's exact test. The adjusted difference between the means for the continuous outcomes was calculated with linear regression. The adjusted odds ratio for the categorical outcome was calculated with logistic regression. For all six outcomes a regression analysis was used to adjust for confounders. Confounders adjusted for included: age, smoking, gender, ethnicity, education, income, insurance, obesity, Mallampati classification, Brodsky score, overjet, and overbite. Data analysis was performed using The R Project for Statistical Computing.

Chapter 3. RESULTS

3.1 DESCRIPTIVE STATISTICS

A total of 123 patients were enrolled. Mean age was 11.5 ± 2.7 years, and females constituted 48% of the sample. Body Mass Index (BMI) for age was greater than the 85th percentile, indicating overweight/obesity, in 13% of participants. Overall, 17% of children had health problems, 9% came from homes with smoking, 45% reported snoring, 50% had daytime sleepiness, and 76% behavioral symptoms. Approximately half of the children were SDB+ based on PSQ score. All children with SDB (100%) suffered from behavioral symptoms, 90% were snorers and the most frequently reported symptom was waking up with dry mouth (100%). The frequencies of demographic and health-related variables assessed by SDB status are given in Table 1.

Unadjusted DMFS, dmfs, PPD, and BOP (Tables 3 and 4):

There was a significant association between SDB and DMFS ($P<0.001$). The mean difference in DMFS between SDB 1 and SDB 0 was 12.03 (95% CI: 7.70-16.36). There was a significant association between SDB and dmfs ($P<0.001$). The mean difference in dmfs between SDB 1 and SDB 0 was 6.15 (95% CI: 3.15-9.14). There was a significant association between SDB and PPD ($P<0.001$). The mean difference in PPD between SDB 1 and SDB 0 was 1.74 (95% CI: 1.38-2.10). There was a significant association between SDB and BOP ($P<0.001$). The odds of BOP in SDB 1 were 30.22 times the odds in SDB 0 (95% CI: 10.32-104.70).

Adjusted DMFS, dmfs, PPD, and BOP (Tables 5 and 6):

There was a significant association between SDB and DMFS (P<0.001). The mean difference in DMFS between SDB 1 and SDB 0 was 9.27 (95% CI: 3.82-14.71). There was a significant association between SDB and dmfs (P<0.001). The mean difference in dmfs between SDB 1 and SDB 0 was 5.25 (95% CI: 2.62-7.88). There was a significant association between SDB and PPD (P<0.001). The mean difference in PPD between SDB 1 and SDB 0 was 1.67 (95% CI: 1.20-2.15). There was a significant association between SDB and BOP (P<0.001). The odds of BOP in SDB 1 was 363.70 times the odds in SDB 0 (95% CI: 13.29-9953.84).

Unadjusted Parent COHIP and Child COHIP (Table 3):

There was a significant association between SDB and parent COHIP score (P<0.001). The mean difference in parent COHIP score between SDB 1 and SDB 0 was 15.50 (95% CI: 10.55-20.46). There was a significant association between SDB and child COHIP score (P<0.001). The mean difference in child COHIP score between SDB 1 and SDB 0 was 13.02 (95% CI: 9.01-17.04). Overall and individual COHIP scores for the 5 domains are given in Table 2.

Adjusted Parent COHIP and Child COHIP (Table 5):

There was a significant association between SDB and parent COHIP score (P<0.001). The mean difference in parent COHIP score between SDB 1 and SDB 0 was 7.89 (95% CI: 3.33-12.45).There was a significant association between SDB and child COHIP score (P<0.001). The mean difference in child COHIP score between SDB 1 and SDB 0 was 8.81 (95% CI: 4.86-12.76).

Regression Analysis: DMFS, dmfs, PPD, BOP, COHIP Parent, and COHIP Child:

We adjusted for the following confounders: age, smoking, gender, ethnicity, education, income, insurance, obesity, Mallampati classification, Brodsky score, overjet, and overbite. In the regression analysis, age was calculated using groups that differ in age by 1 year. Education was categorized as less than high school, high school diploma, college degree, and post-graduate or professional, with less than high school serving as the reference group. Income was categorized as less than 39.99K, 40-59.99K, 60-79.99K, and 80K or more, with less than 39.99K serving as the reference group. Insurance was categorized as state sponsored, private, other government programs, and don't have coverage. Patients with state sponsored insurance served as the reference group. Weight was categorized as normal, overweight, and obese, with normal serving as the reference group. Mallampati classification was categorized as class I, class II, and class III, with class I serving as the reference group. Brodsky score was categorized as grade 0, grade I, grade II, and grade III, with grade 0 serving as the reference group. Overjet was categorized as ≤1mm, >1-≤3mm, >3-≤6mm, and >6mm, with ≤1mm serving as the reference group. Overbite was categorized as ≤0%, >0-≤30%, >30%-≤50%, and >50%, with ≤0% serving as the reference group.

Adjusted DMFS Regression Analysis (Table 7):

There was a significant association between DMFS and SDB, age, income, and overbite. The SDB 1 group was found to have an average of 9.27 more DMFS. Age also had a positive association with DMFS, but not nearly as much as SDB. Greater overbite was negatively associated with DMFS.

Adjusted dmfs Regression Analysis (Table 8):

There was a significant association between dmfs and SDB, age, education, weight, Mallampati classification, and Brodsky score. The SDB 1 group was found to have an average of 5.25 more dmfs. Higher Mallampati classification and greater Brodsky score were both associated with increased dmfs. Surprisingly, higher education was found to have a positive relationship with dmfs, older age negative, and increased weight negative.

Adjusted PPD Regression Analysis (Table 9):

There was a significant association between PPD and SDB, sex, insurance, and Brodsky score. The SDB 1 group was found to have an average PPD of 1.67mm greater than the SDB 0 group. Male sex was associated with greater PPD and the only statistically significant negative association was found with greater Brodsky score.

Adjusted COHIP Parent Regression Analysis (Table 10):

There was a significant association between parent COHIP score and SBD, weight, and Mallampati classification. The SDB 1 group was found to have an average parent COHIP score of 7.89 points greater than the SDB 0 group. Overweight and higher Mallampati classification were also associated with greater COHIP parent scores.

Adjusted COHIP Child Regression Analysis (Table 11):

There was a significant association between child COHIP score and SDB, age, weight, Mallampati classification, and overjet. The SDB 1 group had an average child COHIP score of

8.81 points greater than the SDB 0 group. Overweight, older age, higher Mallampati classification, and increased overjet were all associated with greater child COHIP scores.

Adjusted BOP Regression Analysis (Table 12):

There was a significant association between BOP and SDB, insurance, and weight. The SDB 1 group was found to have 363.70 times the odds of BOP.

Chapter 4. DISCUSSION

The literature is ripe with well-designed studies showing the relationship between SDB and poor systemic health in children[6–18]. In spite of this well understood association, there is virtually no data concerning the relationship between SDB and oral health in children. This is a critical question that needs to be answered and our study was the first of its kind to investigate this association. We hypothesized that SDB has a profound negative impact on oral health in children. As anticipated, SDB (the predictor) was associated with all six outcomes: DMFS, dmfs, PPD, BOP, and Oral Health Related Quality of Life (child COHIP and parent COHIP).

The Oral Health Related Quality of Life (OHRQoL) was measured by the child and parent COHIP scores, with the higher the score the poorer the OHRQoL. SDB was found to have a significant impact on the OHRQoL for children and adults (higher child and parent COHIP scores). Given that SDB is associated with dental caries, PPD, and BOP, this comes as no surprise, and further validates the association of SDB and poor oral health. In the regression analysis both child and parent COHIP scores were associated with weight. We do not know why this relationship exists, but increased risk of SDB and adverse health outcomes secondary to obesity is likely a contributing factor[31,32]. Obesity and caries have been shown to coexist in

children of low socioeconomic status[33]. Surprisingly, there was no association between the child and parent COHIP scores and education, income, or insurance. We were anticipating that education less than high school, income less than 39.99K, and state sponsored insurance would be associated with higher COHIP scores, but no such relationship was noted. A possible explanation for this was our sample size. There were limited numbers of patients in each of the respective categories, insufficient to draw definitive conclusions. A final notable association was found between child and parent COHIP scores and Mallampati classification. Higher scores (poorer OHRQoL) were associated with higher Mallampati classification. This is perhaps due to these patients being at increased risk for SDB, which in turn puts them at greater risk for oral health complications[34].

Our analysis showed that there is a significant association between SDB and dental caries in the primary and permanent dentitions. The relationship between SDB and dental caries, although not clearly understood, may be secondary to sharing common risk factors. For example, it is well established in the literature that dry mouth is associated with dental caries and OSA[35]. Oksenberg et al found that the incidence of dry mouth upon awakening is twofold higher in OSA patients versus primary snorers and increases linearly from mild, moderate, to severe OSA[36]. Given the increased degree of dry mouth that accompanies the severity of OSA, the association noted between SDB and dental caries comes as no surprise. Future studies should compare the association between pediatric dental caries and mild, moderate, and severe OSA respectively.

Another important finding of our study was that SDB is associated with the periodontal status (BOP and PPD). As with dental caries, this relationship is likely the result of shared risk factors. In addition to dental caries, dry mouth is associated with gingival disease. Mizutani et al reported that xerostomia was related to gingival disease in young adults via the accumulation of

dental plaque[37]. Gingival inflammation secondary to xerostomia may explain our findings that children with SDB have greater BOP and PPD. As well, all of the SDB patients in our study were mouth-breathers, and chronic gingivitis and periodontitis are frequently found in mouth-breathers[38].

Of the multiple confounders that we adjusted for in the regression analysis, we were anticipating many would be associated with caries in the primary and adult dentition (dmfs and DMFS). However, only age and overbite were associated with both. Also of note, we only found an association between low socioeconomic status and dental caries in the permanent dentition. Based on previous studies that concretely show the relationship between low socioeconomic status and dental caries in the primary dentition, we speculate our findings are related to a small sample size[33,39,40].

This study was subject to the inherent limitations common to all cross-sectional studies. Our results showed strong associations between SDB and all six outcomes, but we can only extrapolate as far as associations due to the study design. Future studies need to be properly designed and carried out to definitively determine causality. This article can serve as a stepping-stone that future researchers can use when developing studies that address this.

Our hope from this study is that medical and dental practitioners will be alerted to pay careful attention to the oral health of their SDB patients, understanding that they are at an increased risk for a number of oral health problems. As the oral health consequences of SDB become more commonly recognized by the medical community, diagnosis and appropriate interventions can begin earlier, minimizing social, financial, systemic, and oral health complications.

Chapter 5. CONCLUSION

The results from this study suggest that the impact of SDB on the oral health and Oral Health Related Quality of Life (OHRQoL) in children is profound and far-reaching. Given the significant association between SDB and all six outcomes, it is critical practitioners closely monitor the oral health of their pediatric SDB patients.

5.1 CONFLICT OF INTEREST

The authors have no conflicts of interest.

Table 1: Characteristics of the study population

Sociodemographic Variables n (%)		SDB-	SDB+
Age (years)	Mean ±SD	11.5±2.8	11.8±2.6
Race/Ethnicity	American Indian or Alaskan	6 (10)	0 (0)
	Asian	9 (15)	6 (10)
	Black or African American	8 (13)	3 (5)
	Hispanic or Latino	3 (5)	15 (25)
	White	26 (43)	26 (40)
	Other	8 (14)	13 (20)
Caregiver's educational level	Less than high school	2 (3)	5 (9)
	High school diploma	19 (32)	8 (13)
	College degree	31 (52)	31 (52)
	Postgraduate degree	8 (14)	19 (27)
Family income	Less than 39.99K	28 (47)	27 (44)
	40K-59.99K	16 (26)	21 (32)
	60K- 80K or more	16 (26)	15 (25)
Dental Insurance	Private	11 (18)	10 (17)
	State Sponsored	40 (67)	44 (68)
	Government programs	8 (13)	9 (15)
	None	1 (1)	0 (0)
Gender	Male	30 (50)	33 (55)
	Female	30 (50)	30 (45)
Weight	Normal	51 (85)	57 (91)
	Overweight	3 (5)	2 (2)
	Obesity	6 (10)	4 (7)
Smoking In the household	Yes	7 (88)	5 (8)
	No	53 (12)	58 (92)
Health Problems	Yes	12 (20)	9 (14)
	No	48 (80)	54 (86)

Snoring*	Yes	54 (90)	2 (2)
	No	6 (10)	61(98)
Sleepiness*	Yes	56 (93)	6 (10)
	No	4 (7)	57 (90)
Behavioral Symptoms *	Yes	60 (100)	33 (52)
	No	0 (0)	30 (48)

* Indicate P value <0.05, the level of significance was set at $p < 0.05$

Table 2. Comparison of Overall and Subscale COHIP Scores for SDB+ vs. Control Groups

	COHIP Item	SDB- n=63	SDB+ n=60	P-value
COHIP/Child	Overall COHIP	10.3±9.4	25.9±16	<0.001
(Mean±SD)	Oral health	6.2±4.6	13.5±6.3	<0.001
	Functional well being	0.6±1.8	3.3±4.0	<0.001
	Social well Being	1.4±2.9	2.9±4.0	0.019
	School environment	0.4±1.4	0.9±1.6	0.08
	Self image	1.7±2.5	5.3±5.0	<0.001
COHIP/Caregiver	Overall COHIP	11.6±9.2	24.5±12	<0.001
(Mean±SD)	Oral health	8.1±5.7	15.5±5.4	<0.001
	Functional well being	1.0±1.9	2.8±3.0	<0.001
	Social well Being	0.7±1.9	2.0±4.0	0.02
	School environment	0.4±0.8	1.1±1.6	0.11
	Self image	1.4±2.5	3.1±3.0	<0.001

The level of significance was set at $p < 0.05$

Table 3- Unadjusted Continuous Outcomes

Outcome	Mean SDB-	Mean SDB+	Difference in Means	95% CI, Lower	95% CI, Upper	p-value
DMFS	3.65	15.68	12.03	7.7	16.36	P<0.001
dmfs	2.9	9.05	6.15	3.15	9.14	P<0.001
PPD	0.4	2.14	1.74	1.38	2.1	P<0.001
COHIP Parent	10.37	25.87	15.5	10.55	20.46	P<0.001
COHIP Child	11.49	24.52	13.02	9.01	17.04	P<0.001

Table 4- Unadjusted Categorical Outcome

Outcome	Proportion SDB-	Proportion SDB+	SDB Odds Ratio	95% CI, Lower	95% CI, Upper	p-value
Bleeding	0.22	0.9	**30.22**	10.32	104.7	P<0.001

Table 5- Adjusted Continuous Outcomes

Outcome	Difference in Means	95% CI, Lower	95% CI, Upper	p-value
DMFS	9.27	3.82	14.71	P<0.001
dmfs	5.25	2.62	7.88	P<0.001
PPD	1.67	1.2	2.15	P<0.001
COHIP Parent	7.89	3.33	12.45	P<0.001
COHIP Child	8.81	4.86	12.76	P<0.001

Table 6- Adjusted Categorical Outcome

Outcome	SDB Odds Ratio	95% CI, Lower	95% CI, Upper	p-value
Bleeding	**363.7**	13.29	9953.84	P<0.001

Table 7- Adjusted DMFS Regression Analysis

Predictor/Confounder	Difference in Means	95% CI, Lower	95% CI, Upper	p-value	Overall p-value
Intercept	41.81	11.96	71.66	0.006	
SDB	9.27	3.82	14.71	P<0.001	
Age	1.4	0.67	2.14	P<0.001	
Smoking	-0.85	-4.57	2.87	0.66	
Male Gender	2.25	-1.06	5.55	0.18	
American Indian/Alaska Native:White	2.18	-6.78	11.13	0.63	0.26
Asian:White	-5.81	-10.66	-0.96	0.02	
Black/African American:White	-5.92	-11.98	0.13	0.06	
Hispanic/Latino:White	-3.73	-8.06	0.59	0.09	
Other:White	-0.39	-5.58	4.81	0.88	
High School Diploma:Less Than High School	-6.47	-16.85	3.91	0.22	0.16
College Degree:Less Than High School	-9.98	-20.38	0.42	0.06	
Post-Graduate or Professional:Less Than High School	-11.29	-22.07	-0.51	0.04	
40K-59.99K:Less than 39.99K	-4.57	-8.63	-0.5	0.03	0.03
60K-79.99K:Less than 39.99K	-6.23	-11.58	-0.87	0.02	
80K or More:Less than 39.99K	0.67	-4.14	5.49	0.78	
Private:State Sponsored	-1.07	-5.16	3.03	0.61	0.07
Other Government Programs:State Sponsored	2.72	-2.51	7.95	0.31	
Don't Have Coverage:State Sponsored	-33.53	-50.76	-16.3	P<0.001	
Overweight:Normal	-1.47	-9.32	6.38	0.71	0.64
Obesity:Normal	2.96	-4.16	10.08	0.42	
Class II Mallampati:Class I Mallampati	0.72	-3.74	5.19	0.75	0.91
Class III Mallampati:Class I Mallampati	-0.58	-10.07	8.92	0.91	
Score I Brodsky:Score 0 Brodsky	-12.61	-25.46	0.24	0.05	0.06
Score II Brodsky:Score 0 Brodsky	-11.01	-23.72	1.7	0.09	
Score III Brodsky:Score 0 Brodsky	-8.89	-22.51	4.73	0.2	
(1,3] Overjet:[0,1] Overjet	-8.68	-19.35	1.99	0.11	0.21
(3,6] Overjet:[0,1] Overjet	-3.69	-6.76	-0.63	0.02	
(6,infinity) Overjet:[0,1] Overjet	-3.84	-10.19	2.52	0.24	
(0%,30%] Overbite:(-infinity%,0%] Overbite	-29.76	-45.2	-14.33	P<0.001	0.02
(30%,50%] Overbite:(-infinity%,0%] Overbite	-30.21	-46.16	-14.25	P<0.001	
(50%,infinity%) Overbite:(-infinity%,0%] Overbite	-31.2	-46.71	-15.68	P<0.001	

Table 8- Adjusted dmfs Regression Analysis

Predictor/Confounder	Difference in Means	95% CI, Lower	95% CI, Upper	p-value	Overall p-value
Intercept	-0.61	-16.52	15.31	0.94	
SDB	5.25	2.62	7.88	P<0.001	
Age	-1.55	-1.98	-1.13	P<0.001	
Smoking	-2.29	-6.11	1.53	0.24	
Male Gender	1.19	-0.94	3.33	0.27	
American Indian/Alaska Native:White	-1.46	-6.84	3.92	0.59	P<0.001
Asian:White	4.58	-0.24	9.4	0.06	
Black/African American:White	9.89	3.43	16.36	0.003	
Hispanic/Latino:White	4.64	0.99	8.28	0.01	
Other:White	-0.33	-3.6	2.94	0.84	
High School Diploma:Less Than High School	8.41	0.14	16.69	0.05	0.05
College Degree:Less Than High School	7.94	-0.01	15.88	0.05	
Post-Graduate or Professional:Less Than High School	9.29	1.01	17.56	0.03	
40K-59.99K:Less than 39.99K	-0.13	-2.88	2.62	0.93	0.4
60K-79.99K:Less than 39.99K	0.02	-3.36	3.4	0.99	
80K or More:Less than 39.99K	-3.17	-7.13	0.8	0.12	
Private:State Sponsored	0.33	-2.27	2.92	0.81	0.51
Other Government Programs:State Sponsored	-0.67	-3.86	2.52	0.68	
Don't Have Coverage:State Sponsored	12.26	3.56	20.95	0.006	
Overweight:Normal	-9.58	-17.28	-1.88	0.01	0.002
Obesity:Normal	-5.04	-9.2	-0.88	0.02	
Class II Mallampati:Class I Mallampati	1.3	-1.15	3.75	0.3	0.04
Class III Mallampati:Class I Mallampati	7.69	3.11	12.27	0.001	
Score I Brodsky:Score 0 Brodsky	5.88	1.28	10.48	0.01	0.005
Score II Brodsky:Score 0 Brodsky	4.16	-0.04	8.36	0.05	
Score III Brodsky:Score 0 Brodsky	10.98	4.59	17.37	P<0.001	
(1,3] Overjet:[0,1] Overjet	0.48	-6.41	7.38	0.89	0.62
(3,6] Overjet:[0,1] Overjet	-0.61	-3.74	2.52	0.7	
(6,infinity) Overjet:[0,1] Overjet	-3.29	-6.88	0.31	0.07	
(0%,30%] Overbite:(-infinity%,0%] Overbite	7.6	-0.3	15.5	0.06	0.04
(30%,50%] Overbite:(-infinity%,0%] Overbite	2.88	-5.2	10.95	0.49	
(50%,infinity%) Overbite:(-infinity%,0%] Overbite	7.68	-0.59	15.96	0.07	

Table 9- Adjusted PPD Regression Analysis

Predictor/Confounder	Difference in Means	95% CI, Lower	95% CI, Upper	p-value	Overall p-value
Intercept	2.66	-0.01	5.32	0.05	
SDB	1.67	1.2	2.15	P<0.001	
Age	0.03	-0.03	0.1	0.33	
Smoking	-0.21	-0.56	0.13	0.23	
Male Gender	0.42	0.11	0.74	0.009	
American Indian/Alaska Native:White	0.02	-0.95	0.99	0.97	0.93
Asian:White	-0.2	-0.72	0.31	0.44	
Black/African American:White	0.24	-0.45	0.93	0.5	
Hispanic/Latino:White	0.04	-0.39	0.47	0.85	
Other:White	0.05	-0.42	0.52	0.83	
High School Diploma:Less Than High School	-0.83	-2	0.35	0.17	0.15
College Degree:Less Than High School	-1.08	-2.29	0.13	0.08	
Post-Graduate or Professional:Less Than High School	-1.1	-2.35	0.14	0.08	
40K-59.99K:Less than 39.99K	-0.3	-0.67	0.07	0.12	0.41
60K-79.99K:Less than 39.99K	-0.29	-0.73	0.16	0.21	
80K or More:Less than 39.99K	-0.09	-0.76	0.58	0.8	
Private:State Sponsored	0.47	-0.05	0.98	0.08	0.02
Other Government Programs:State Sponsored	0.62	0.14	1.09	0.01	
Don't Have Coverage:State Sponsored	-1.27	-2.65	0.1	0.07	
Overweight:Normal	-0.24	-1.07	0.59	0.57	0.48
Obesity:Normal	-0.37	-0.95	0.22	0.22	
Class II Mallampati:Class I Mallampati	-0.19	-0.55	0.17	0.31	0.37
Class III Mallampati:Class I Mallampati	0.3	-0.39	0.99	0.39	
Score I Brodsky:Score 0 Brodsky	-0.78	-1.66	0.1	0.08	0.03
Score II Brodsky:Score 0 Brodsky	-0.85	-1.69	-0.01	0.05	
Score III Brodsky:Score 0 Brodsky	-0.07	-1.09	0.95	0.89	
(1,3] Overjet:[0,1] Overjet	-0.96	-2.13	0.22	0.11	0.32
(3,6] Overjet:[0,1] Overjet	0.17	-0.18	0.52	0.34	
(6,infinity) Overjet:[0,1] Overjet	-0.04	-0.92	0.84	0.93	
(0%,30%] Overbite:(-infinity%,0%] Overbite	-1.06	-2.31	0.19	0.09	0.4
(30%,50%] Overbite:(-infinity%,0%] Overbite	-1.31	-2.69	0.06	0.06	
(50%,infinity%) Overbite:(-infinity%,0%] Overbite	-0.89	-2.23	0.45	0.2	

Table 10- Adjusted Parent COHIP Regression Analysis

Predictor/Confounder	Difference in Means	95% CI, Lower	95% CI, Upper	p-value	Overall p-value
Intercept	27.64	-3.4	58.68	0.08	
SDB	7.89	3.33	12.45	P<0.001	
Age	0.75	-0.07	1.56	0.07	
Smoking	5.81	-4.55	16.17	0.27	
Male Gender	2.77	-1.43	6.97	0.2	
American Indian/Alaska Native:White	11.73	-4.15	27.61	0.15	0.12
Asian:White	1.38	-5.64	8.4	0.7	
Black/African American:White	-3.11	-15.45	9.23	0.62	
Hispanic/Latino:White	-6.28	-12.82	0.25	0.06	
Other:White	0.13	-6.17	6.43	0.97	
High School Diploma:Less Than High School	-7.7	-19.87	4.46	0.21	0.49
College Degree:Less Than High School	-9.23	-20.62	2.17	0.11	
Post-Graduate or Professional:Less Than High School	-10.28	-23.1	2.54	0.12	
40K-59.99K:Less than 39.99K	-3.86	-9.2	1.49	0.16	0.13
60K-79.99K:Less than 39.99K	1.65	-4.19	7.48	0.58	
80K or More:Less than 39.99K	4.35	-3.44	12.14	0.27	
Private:State Sponsored	-4.76	-10.34	0.82	0.09	0.45
Other Government Programs:State Sponsored	-1.77	-7.87	4.33	0.57	
Don't Have Coverage:State Sponsored	-5.51	-24.17	13.15	0.56	
Overweight:Normal	26.33	8.64	44.02	0.004	P<0.001
Obesity:Normal	-0.04	-8.51	8.43	0.99	
Class II Mallampati:Class I Mallampati	2.86	-1.51	7.23	0.2	0.001
Class III Mallampati:Class I Mallampati	22.45	10.28	34.62	P<0.001	
Score I Brodsky:Score 0 Brodsky	-4.28	-16.51	7.95	0.49	0.55
Score II Brodsky:Score 0 Brodsky	-2.96	-14.02	8.09	0.6	
Score III Brodsky:Score 0 Brodsky	1.87	-12.74	16.49	0.8	
(1,3] Overjet:[0,1] Overjet	-5.31	-16.87	6.24	0.37	0.28
(3,6] Overjet:[0,1] Overjet	1.93	-4.26	8.12	0.54	
(6,infinity) Overjet:[0,1] Overjet	8.4	-0.3	17.1	0.06	
(0%,30%] Overbite:(-infinity%,0%] Overbite	-13.73	-30.33	2.87	0.1	0.38
(30%,50%] Overbite:(-infinity%,0%] Overbite	-14.26	-30.68	2.16	0.09	
(50%,infinity%) Overbite:(-infinity%,0%] Overbite	-17.8	-34.91	-0.69	0.04	

Table 11- Adjusted Child COHIP Regression Analysis

Predictor/Confounder	Difference in Means	95% CI, Lower	95% CI, Upper	p-value	Overall p-value
Intercept	3.68	-19.27	26.64	0.75	
SDB	8.81	4.86	12.76	P<0.001	
Age	0.7	0.08	1.31	0.03	
Smoking	4.67	-1.3	10.65	0.13	
Male Gender	0.57	-2.59	3.72	0.72	
American Indian/Alaska Native:White	1.45	-10.77	13.66	0.82	0.01
Asian:White	-6.43	-10.81	-2.05	0.004	
Black/African American:White	-8.95	-17.98	0.09	0.05	
Hispanic/Latino:White	-9.59	-15.3	-3.89	P<0.001	
Other:White	-1.8	-6.93	3.32	0.49	
High School Diploma:Less Than High School	-2.32	-13.19	8.54	0.68	0.08
College Degree:Less Than High School	-8.56	-19.25	2.13	0.12	
Post-Graduate or Professional:Less Than High School	-7.28	-18.87	4.31	0.22	
40K-59.99K:Less than 39.99K	0.61	-3.62	4.84	0.78	0.36
60K-79.99K:Less than 39.99K	3.76	-2.38	9.9	0.23	
80K or More:Less than 39.99K	4.19	-0.76	9.14	0.1	
Private:State Sponsored	1.83	-1.97	5.64	0.34	0.6
Other Government Programs:State Sponsored	-1.3	-7.05	4.45	0.66	
Don't Have Coverage:State Sponsored	-10.83	-25.79	4.14	0.16	
Overweight:Normal	19.04	7.25	30.83	0.002	P<0.001
Obesity:Normal	-2.07	-7.03	2.88	0.41	
Class II Mallampati:Class I Mallampati	2	-1.49	5.49	0.26	0.001
Class III Mallampati:Class I Mallampati	17.62	9.41	25.83	P<0.001	
Score I Brodsky:Score 0 Brodsky	-2.07	-9.8	5.67	0.6	0.7
Score II Brodsky:Score 0 Brodsky	-1.03	-7.67	5.6	0.76	
Score III Brodsky:Score 0 Brodsky	-4.83	-13.69	4.04	0.29	
(1,3] Overjet:[0,1] Overjet	0.92	-10.36	12.21	0.87	0.01
(3,6] Overjet:[0,1] Overjet	6.47	0.95	11.99	0.02	
(6,infinity) Overjet:[0,1] Overjet	7.27	0.68	13.86	0.03	
(0%,30%] Overbite:(-infinity%,0%] Overbite	6.29	-6.46	19.03	0.33	0.27
(30%,50%] Overbite:(-infinity%,0%] Overbite	10.51	-2.22	23.23	0.11	
(50%,infinity%) Overbite:(-infinity%,0%] Overbite	9.91	-3.42	23.24	0.15	

Table 12- Adjusted BOP Regression Analysis

Predictor/Confounder	Odds Ratio	95% CI, Lower	95% CI, Upper	p-value	Overall p-value
Intercept	33.01	0	3257990.69	0.55	
SDB	363.7	13.29	9953.84	P<0.001	
Age	0.77	0.47	1.27	0.31	
Smoking	0.37	0.01	22.55	0.63	
Male Gender	9.53	0.62	146.68	0.11	
American Indian/Alaska Native:White	23823378	89060.34	6372683313	P<0.001	0.18
Asian:White	0.55	0.07	4.2	0.57	
Black/African American:White	2.82	0.07	116.47	0.58	
Hispanic/Latino:White	0.01	0	12.95	0.21	
Other:White	0.36	0.05	2.84	0.33	
High School Diploma:Less Than High School	0.32	0	21143.78	0.84	0
College Degree:Less Than High School	0.03	0	653.8	0.49	
Post-Graduate or Professional:Less Than High School	0.02	0	89.28	0.36	
40K-59.99K:Less than 39.99K	0.21	0.02	1.79	0.15	0.21
60K-79.99K:Less than 39.99K	0.53	0.04	6.27	0.61	
80K or More:Less than 39.99K	0.04	0	1.37	0.07	
Private:State Sponsored	44.09	2.51	775.01	0.009	0.005
Other Government Programs:State Sponsored	24.8	1.52	405.05	0.02	
Don't Have Coverage:State Sponsored	17029085.6	300700.25	964381482.5	P<0.001	
Overweight:Normal	4.37	0.02	1100.59	0.6	0.04
Obesity:Normal	0.01	0	0.21	0.002	
Class II Mallampati:Class I Mallampati	0.09	0.01	1.55	0.09	0.07
Class III Mallampati:Class I Mallampati	15.58	1.19	204.4	0.04	
Score I Brodsky:Score 0 Brodsky	1.29	0	402.27	0.93	0.07
Score II Brodsky:Score 0 Brodsky	3.4	0	3283.29	0.73	
Score III Brodsky:Score 0 Brodsky	1089101988	114018.94	1.04E+13	P<0.001	
(1,3] Overjet:[0,1] Overjet	1.14	0	30294.92	0.98	0.59
(3,6] Overjet:[0,1] Overjet	1.58	0.29	8.51	0.6	
(6,infinity) Overjet:[0,1] Overjet	0.12	0	7.75	0.31	

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