Obstructive Sleep Apnea: A Summary of Clinical Practice Guidelines and the Adherence by Airway Focused Dentists and Orthodontists

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Abstract

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Introduction: The first aim of this study was to determine the published clinical guidelines regarding the involvement of dental professionals in screening, diagnosis, and treatment of Obstructive Sleep Apnea (OSA). The second aim was to determine whether airway focused dentists and orthodontists were adhering to published guidelines regarding their roles in the screening, diagnosis, and treatment of OSA. **Methods:** A summary of published guidelines for screening methods and treatment modalities was collated and those endorsed by 50% or more of the sources were considered the common guidelines. A survey was sent to airway focused general dentists (AFD), airway focused orthodontists (AFO) and non-airway focused orthodontists (non-AFO) to enquire about their practices for screening, diagnosis, and treatment of OSA. The results of the survey were then compared to the common clinical guidelines and the three groups of participants were compared to one another. **Results:** Various professional organizations published guidelines on the methods for screening, diagnosing, and treating patients for OSA. The common guidelines recommended screening patients for OSA and then, referring to a sleep

physician for diagnosis and treatment planning, when screening yields positive risk of OSA. Importantly, there were no clinical guidelines for preventing OSA. Some variation existed across the guidelines, including details of screening methods and treatment modalities. There was a response from 48 AFD, 41 AFO, and 78 non-AFO. Airway focused dentists and AFO screened and offered treatment for OSA at a higher frequency than non-AFO. Both AF dentists and orthodontists used radiographs for screening at a higher frequency than non-AFO. Additionally, AFD and AFO offered treatment to prevent and cure OSA. Airway focused dentists referred for tonsillectomy to prevent OSA at a significantly lower frequency that AFO, and AFD utilized maxillomandibular surgery and adenotonsillectomy at a lower frequency than AFO to cure OSA. Approximately half of AFD and AFO occasionally treated patients for OSA in collaboration with a sleep physician. None of the AFD completely adhered to the common guidelines for the steps taken from screening to treating patients for OSA. One AFO and one non-AFO completely adhered to the common guidelines for the above. **Conclusions:** Clinical guidelines from professional organizations on the management of OSA generally agree on the principles regarding screening, diagnosing, and treating OSA; however, they differ in some methods which may result in variations in the behavior of dentists and orthodontists. Few AFD and AFO consistently adhere to common guidelines for screening, treating, and practicing in collaboration with sleep physicians. Airway focused dentists and AFO provide preventative treatment which is not supported by the common guidelines.

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INTRODUCTION

Obstructive sleep apnea (OSA) is a breathing disorder that is rising among adults and children, with serious health consequences[1]. Obstructive sleep apnea is characterized by recurring episodes of partial or complete upper airway collapse, which disrupts breathing during sleep[2]. These disruptions can lead to frequent awakening from sleep and/or a decrease in the oxygen level in blood leading to poor quality, restless sleep[2]. There are anatomical and non- anatomical contributors to OSA[1,3,4]. Examples of anatomical contributors are enlarged tonsils and increased soft tissue in the neck leading to a narrow, crowded, or collapsible airway. One of the non-anatomical factors is an ineffective pharyngeal dilator muscle leading to upper airway collapse. Other non-anatomical contributors include a low arousal threshold which causes premature awakenings from even mild airway narrowing during sleep, and a high loop gain, which is an amplified ventilatory drive leading to hypocapnia (low levels of carbon dioxide). Often, there is an interaction between these different factors that create unstable control over breathing. Additionally, various risk factors are associated with OSA including male gender, increasing age, ethnicity (Hispanic, African American), obesity, genetic predisposition, side effects of medication influencing muscle tone of the airway, asthma, and endocrine disorders[5-7].

In adults, the prevalence of moderate to severe OSA is estimated to be 13% in men and 6% in women, while mild OSA affects approximately 14% of men and 5% of women[8]. There has been a rise in OSA among Americans by 14%-55% from 1988-1994 to 2007-2010[8]. This increase has been linked to the global increase in obesity and an aging population[8,9]. Furthermore, approximately 82% of OSA cases in men and 93% of OSA cases in women within the United States remain undiagnosed[10], which raises significant public health concerns as even mild OSA can be related to significant morbidity[10,11].

Obstructive sleep apnea has been linked to an increased risk of excessive daytime sleepiness[12,] myocardial infarction, congestive heart failure, stroke, diabetes mellitus and mortality[13,14]. Furthermore, cognitive impairment associated with sleep deprivation and hypoxemia (low levels of oxygen) resulting from OSA may arise, and includes deficits in attention, memory executive function, psychomotor

function, and language abilities[15]. Drivers with OSA are at a significantly higher risk of motor vehicle accidents, this risk was correlated with daytime sleepiness[16,17]. Additionally, OSA was revealed as an independent risk factor for hypertension[18], and untreated severe OSA increased the odds of fatal cardiovascular events by more than 3 times[19], OSA was also prevalent in 65.7% of patients admitted for an acute myocardial infarction[20]. Furthermore, those with untreated severe OSA have higher recurrence risk of atrial fibrillation[21]. In those who survive a stroke, there is a 75% increased risk of early death in those with moderate OSA compared to those who do not have OSA[22].

In pediatric patients, OSA is prevalent in up to 4% of the population in the United States[23,24]. Untreated OSA in children can be associated with excessive daytime sleepiness[25] and may lead to poor school performance, aggressive behavior, developmental delay, and difficulty in concentrating due hypoxemia and disrupted sleep relating to OSA[26,27]. Additional recognized morbidities include compromised ventricular function[28] and systemic hypertension[29]. These morbidities improved following treatment of OSA[26,27,29]. Studies have also indicated that nearly half of pediatric patients with mild to moderate obstructive sleep apnea (OSA) experience spontaneous remission[103]. Longitudinal observations have shown that OSA often does not persist from middle childhood into late adolescence[104]. Given the serious nature of OSA and its potential for severe consequences, proper screening and diagnosis are crucial for effective management of sequalae in adult and pediatric patients.

Screening and Diagnosis of OSA

Many professional organizations have published guidelines on screening, diagnosis, and treatment of OSA in adults and pediatric patients (Appendix I). The American Dental Association (ADA) recommend dentists to actively screen adult and pediatric patients for OSA[30]. In addition, the American Association of Orthodontists (AAO) recognizes the significant consequences of untreated OSA and recommends that orthodontists consider screening adult and pediatric patients[31]. However, there are conflicting guidelines, such as those made by the U.S. Preventive Services Task Force (USPSTF)[32]. The

guidelines by the USPSTF state that there is inadequate evidence to assess benefits versus harms of screening adults for OSA; thus, their guidelines recommend focused screening of at-risk individuals. These include adults presenting with signs and symptoms of OSA, patients with medical conditions that may trigger OSA, for example poorly controlled hypertension or cardiovascular disease, as well as those with specific occupations such as, commercial truck drivers and pilots. These guidelines by the USPSTF, however, do not apply to children, adolescents, or pregnant persons. Nonetheless, screening remains valuable in identifying patients who may be at risk for OSA and could benefit from further evaluation[35].

The dentist and orthodontists screening tools for adults include sleep questionnaires, such as, STOP-BANG, Epworth Sleepiness Scale (ESS) and Berlin (Appendix 1). Medical and family histories can also provide important insights to potential OSA risk factors including obesity, refractory blood pressure, cardiac illness[33] and a risk of diabetes[34]. Common symptoms reported by at risk patients are habitual snoring, restless sleep, excessive daytime sleepiness, witnessed gasping, morning headaches, and decreased focus[35].

A clinical examination of both hard and soft tissue is recommended to identify potential features that can be associated with OSA. Examples of these are neck circumference more than 17 inches in men and more than 16 inches in women, nasal deviation, and craniofacial characteristics such as retrognathia, an increased anterior facial height, a reduced SNB angle, short mandibular length, and clockwise rotation of the mandible, a maxilla deficient in length and transverse dimension. Additionally, an inferiorly positioned hyoid bone, large tongue and soft palate may be associated with OSA[36-39]. It is important to note that much of the evidence supporting these craniofacial clinical signs is heterogeneous and lacking longitudinal assessment. Furthermore, airway space is frequently evaluated using radiographic imagery, commonly lateral cephalometry and cone beam computed tomography (CBCT). Lateral cephalograms are not reliable for such measurements because they are two-dimensional and static. Similarly, even though CBCT provides detailed imaging, it is limited in the ability to provide imaging of the dynamic functions of the airway, because it only provides a snapshot of the moment it was taken. Moreover, the posture of the head at the time a CBCT is taken, tilted up or down, can significantly alter the measurements of the

minimum cross-sectional area of the upper airway[40]. Lastly, radiographic images are taken when the patient is awake and upright, so they do not accurately represent the airway dynamics that occur during sleep, when obstructive episodes typically manifest. In summary, the relationship between airway size/shape and respiratory function is poorly characterized by cephalometric radiographs and CBCT; therefore, they cannot be relied upon for screening OSA.

For screening pediatric patients, a similar approach is recommended. The Pediatric Sleep Questionnaire (PSQ) (Appendix I) may be utilized for screening. Additionally, family history of OSA and medical history of attention deficit hyperactivity disorder (ADHD), learning difficulties, hypertension, being underweight or overweight, craniofacial syndromes, reported habitual snoring, headaches on awakening, sleep enuresis (following a minimum of six month of continence) and witnessed gasping may raise concern for a risk of OSA[41]. Clinical examination to evaluate the presence of adenotonsillar hypertrophy, retrognathia, high arched palate and to obtain a Mallampati score has been recommended for screening[41].

When screening results suggest a clinical suspicion of OSA, it is essential for dentists and orthodontists to refer patients to a sleep physician for a comprehensive evaluation, diagnosis, and treatment planning because these aspects of OSA management fall outside the scope of their training[35]. Sleep physicians may conduct an overnight polysomnogram (PSG) to diagnose OSA. A polysomnogram is a sleep study that is considered the standard diagnostic test for obstructive sleep apnea[35]. It involves simultaneous recordings of multiple physiologic signals during sleep, including the electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG), and oxyhemoglobin saturation. Additionally, a PSG can detect the oronasal airflow and determine whether a complete cessation of airflow for at least ten seconds (apnea), or a reduction in airflow (hypopnea) occurs, both of which can be indicative of OSA. The Apnea Hypopnea Index (AHI) is then used to classify the severity of OSA as mild, moderate, and severe (Table 1) by combining the average number of apneas and/or hypopneas per hour of sleep[42]. Once a diagnosis is made and the underlying etiology and severity are determined, the sleep physician will recommend an appropriate course of action that may include various treatments discussed in the

following section.

Table 1. OSA severity determined by AHI

Severity of OSA	AHI for Adults	AHI for Children
Mild	5 to <15	1 to <5
Moderate	15 to <30	5 to <10
Severe	≥30	≥10

Treatment of OSA

Positive Airway Pressure

Positive Airway Pressure (PAP) therapy is the gold standard of treatment for OSA in adults. It functions by delivering positive air through a mask to keep the airway patent, promoting more restful sleep. Positive Airway Pressure is particularly recommended for patients with excessive sleepiness, impaired sleep-related quality of life or comorbid hypertention[43]. In pediatric patients, PAP is recommended when persistent OSA occurs after treatment with adenotonsillectomy or when surgical treatment of OSA is not desired or recommended[41,44]. Children may benefit from behavioral management to help with adherence to this treatment[45,46].

Mandibular Advancement Devices

Mandibular advancement devices (MAD) offer an alternative treatment for both adult and pediatric patients who cannot tolerate PAP therapy. These devices are reported to have a positive response in patients with mild to moderate OSA[47-49], as measured by the AHI. Mandibular advancement devices have been recommended in patients with specific phenotypes, such as low loop gain, a higher arousal threshold, and moderate pharyngeal collapsibility, because they are more likely to respond favorably to MAD [50-54]. Unfortunately, a clear and standardized clinical protocol for the optimal adjustment of MAD is lacking[55]. While MAD are effective, there are associated side effects following

their use. These devices cause occlusal changes (decreased overjet and overbite by retroclining upper incisors and proclining lower incisors), as well as mucosal dryness, hypersalivation, and dental discomfort[56,57]. Therefore, it is essential that patients are thoroughly informed, closely monitored, and managed accordingly.

Maxillary Expansion

Maxillary expansion is believed to be effective by enlarging the intranasal cavity, which reduces nasal resistance, enhances nasal airflow, reduces mouth breathing, and ultimately improves OSA[58-60]. On the other hand, an increase in the nasopharyngeal space does not necessarily equate to a reduction in the collapsibility of the nasopharyngeal airway, thus, individuals may remain susceptible to OSA. In addition, some researchers suggest that a narrow maxillary arch can alter the position of the tongue, leading to narrowing of the retroglossal airway. Therefore, increasing the transverse width of the maxilla may improve tongue positioning and enhance airway dimension[61]. Nevertheless, long-term stability of tongue position is not well documented, emphasizing the need for further research.

In the adult patients with skeletal maxillary transverse deficiency, several techniques are used to expand the maxilla such as surgically assisted rapid maxillary expansion (SARME), Lefort I osteotomy, and distraction osteogenesis maxillary expansion (DOME). These methods have been proposed to improve certain parameters related to OSA such as the AHI, Oxygen Desaturation Index (ODI), and/or Epworth Sleepiness Scale (ESS), and/or Nose Obstruction Symptom Evaluation (NOSE). It has been suggested that following evaluation by a sleep physician and in a collaborative multidisciplinary team, expansion can improve OSA in adult patients with maxillary transverse deficiency[62,63].

Maxillary expansion has also been reported to be an effective treatment for OSA in pediatric patients with high palatal vaults and constricted maxilla[64]. In addition, rapid maxillary expansion (RME) is considered when OSA persists after treatment with adenotonsillectomy for patients with a transverse maxillary deficiency[65]. However, when comparing the impact of RME to adenotonsillectomy, it was found that most of the improvement in the AHI were attributed to adenotonsillectomy. The changes

resulting from RME were marginal[66]. Therefore, the use of RME in treating OSA should be considered based on the severity of the condition and its underlying etiology. Furthermore, the effect of RME on airway dimensions has been described as limited and local, with changes decreasing further down the airway[67-69]. There is no data on the role of maxillary expansion for the prevention of OSA.

Myotherapy

The dilator muscle of the upper airway has a significant role in maintaining airway patency and this is where myotherapy plays a role. Both in adults and children, myotherapy includes oropharyngeal exercises consisting of isometric and isotonic exercises of the muscles of the tongue, soft palate, and lateral pharyngeal wall[70,71]. These muscles are used for functions such as swallowing, chewing, breathing and speech. There is research to support that myotherapy may serve as an adjunct treatment for OSA, because it was found to reduce AHI scores by up to 50% in adults and 60% in children. Additionally, improvements were seen in ESS, snoring and sleepiness.

Maxillomandibular Surgery

Surgical maxillomandibular advancements can be an effective alternative for adult patients with skeletal discrepancies that are unable to tolerate PAP, oral appliances or have severe OSA[31,72,73]. The surgery moves the anterior pharyngeal wall forward expanding the pharyngeal airway and can be highly successful at reducing AHI value postoperatively, thus, improving OSA. Patients must undergo a thorough orthodontic evaluation to assess skeletal and facial balance, because both the maxilla and mandible need to be advanced sufficiently to achieve significant improvements in airway volume.

Adenotonsillectomy

Adenotonsillar hypertrophy is the primary etiology for pediatric OSA, therefore, adenotonsillectomy is recommended as the first line of treatment for these patients[27,41]. This procedure has been proven effective in reducing obstructive events on a PSG. While adenotonsillectomy is generally safe, it is not without risk. Obstructive sleep apnea may not resolve completely if residual soft tissue

remains, there are other areas of obstruction, patient is obese or has underlying medical comorbidities[74]. Should OSA persist, multidisciplinary care including sleep physicians, dentists, otolaryngologists, and pulmonologists is recommended for optimal management[74].

Frenectomy

Lingual frenectomy is a procedure that aims to improve muscle function by releasing tongue ties (ankyloglossia), allowing the tongue to move more freely[75]. It has been proposed that ankyloglossia may predispose to OSA by contributing to upper airway collapse; thus, a lingual frenectomy has been speculated to help in the treatment of OSA[75]. The current evidence does not adequately demonstrate a cause-and-effect relationship between ankyloglossia and OSA. In 2020, the American Academy of Otolaryngology-Head and Neck surgery published a clinical consensus statement for ankyloglossia in children[76]. They stated that a significant number of children are undergoing unnecessary surgery of the lingual frenulum and that "buccal tie" release should not be performed. The statement also emphasized that ankyloglossia does not cause sleep apnea. Accordingly, it can be inferred that since ankyloglossia does not cause OSA, lingual frenectomy will not prevent or cure OSA. Therefore, dentists and orthodontists contributing to the care of patients with OSA should ensure their treatments are evidence based, effective and carefully evaluated for risks and benefits for each individual patient.

An emerging subgroup within the dental field, often referred to as "airway dentists," "forwardontics," or "orthotropics," focuses on the treatment of OSA. Many dental practices within this group advertise treatments for OSA on their websites, claiming to address various conditions such as ADHD, bruxism, and nocturnal enuresis by improving the airway through dental interventions. While some of these conditions may be associated with OSA[77-82], the evidence does not establish a clear cause-and-effect relationship[83-85]. Given the current literature, it is essential that these conditions are not used as diagnostic criteria or as a basis for promoting treatment without a thorough evaluation and recommendation by a sleep physician.

In view of the multifactorial nature of OSA, its rising prevalence and well documented associated

morbidity, a collaborative approach between the dentists and sleep physicians is essential, where dentists can contribute to the initial screening and subsequent adjunct treatment as recommend by the sleep physician. Currently, there is little known about the partnership between dental professionals and sleep physicians in the USA, as well as the current practice behavior of dentists and orthodontists who emphasize on airway therapy, i.e., "airway focused" dentists and orthodontists. Specifically, it remains unclear whether they routinely screen for OSA, focus on its prevention and/or treatment, or whether their practices align with established clinical practice guidelines.

The purpose of this study is to:

i. Identify and summarize the clinical guidelines for screening, prevention, and treatment protocols published by various dental/medical organizations for OSA.
ii. Assess and compare the practice behavior among AFD, AFO and non-AFO for screening, diagnosis and treating OSA patients, and compare them to the summarized clinical guidelines (i.e. "common guidelines").

MATERIALS AND METHODS

The study was approved by the Institutional Review Board (IRB) of the University of Washington (IRB ID: STUDY00019243).

Published Clinical Guidelines

In the spring of 2023, a Google web search was conducted to identify various organizations and societies that may have published clinical guidelines on OSA. The search utilized keywords "clinical guidelines OSA", "dental guidelines OSA", "OSA adult guidelines", "OSA children guidelines" and "OSA pediatric guidelines". Websites of organizations and societies that appeared in the search results were then reviewed for clinical guidelines on OSA and checked to have headquarters in the USA.

Additionally, a Google web search was conducted to identify the websites of professional organizations representing dentists, orthodontists, pediatric dentists, prosthodontists, and maxillofacial surgeons within the USA. These websites were searched for guidelines on OSA. Organizations or societies with clinical guidelines based solely on expert opinion or those lacking clinical guidelines were excluded from consideration. This search yielded guidelines from websites of the American Dental Association (ADA)[30], American Academy of Pediatric Dentistry (AAPD)[86], American Association of Orthodontists (AAO)[31], American College of Prosthodontics (ACP)[87], American Academy of Pediatrics (AAP)[41], American Academy of Dental Sleep Medicine (AADSM)[88], American Academy of Sleep Medicine (AASM)[35,44], National Sleep Foundation (NSP)[89], World Sleep Society (WSS)[90], and the Department of Veterans Affairs and the Department of Defense (VA/DoD)[91]. The guidelines from the organizations mentioned above regarding screening, diagnosis, treatment, and the dentist's role in each category were initially collected in a table (Appendix I). One organization was specific to adult patients (VA/DoD), two were specific to pediatric patients (AAPD, AAP), and the remaining organizations offered guidelines for both adult and pediatric patients. The guidelines that were endorsed by 50% or more of the organizations for adult patients and 50% or more of those for pediatric patients were considered the common guidelines for the purpose of this study. These common guidelines served as the basis for comparing the practice behaviors of AFD, AFO and non-AFO, to the guidelines. The websites of these organizations were revisited in the summer of 2024, and guidelines reviewed for updates just prior to applying the common guidelines for the comparisons of the AFD, AFO and non-AFO groups.

Study Sample

The study included a sample who met the following inclusion criteria: (1) general dentists that self-identify as airway focused dentists; (2) orthodontists; (3) must practice in the USA.

The American Sleep and Breathing Academy, The Breathe Institution, and the Airway Dentist Online Locator Tool were used to retrieve websites of general dentists and orthodontists offering airway

focused treatment. Additionally, a web search using keywords “airway dentists”, “airway dentistry”, “airway orthodontics” and “airway orthodontists”, was conducted to gather additional websites of general dentists and orthodontists that offered airway focused treatment. These websites provided information on demographics, e-mail addresses, and office contact numbers. These dentists and orthodontists formed the initial study sample of AFD and AFO, which was subsequently confirmed through the survey, where they self-identified as airway focused. The American Association of Orthodontists and the Angel Society Northwest Component were contacted to enquire about distributing the survey to their members practicing in the USA.

The survey was then e-mailed by the AAO to 2002 orthodontists and by the Angle Society Northwest Component to 50 orthodontists. Additionally, the survey was posted on Orthodontic Pearls, Orthopreneurs, and Women in Orthodontics Facebook groups, as well as directly sent to the e-mail addresses of 165 general dentists and 195 orthodontists, which were previously collected online from their websites.

Survey Study Procedure

The survey (Appendix II) was developed with questions on five categories: OSA screening, OSA diagnosis, OSA treatment, self-identification as an airway focused dentist or orthodontist, and demographic characteristics. As an incentive, participants were given the chance to win one of ten $100 Amazon gift cards for completing the survey. It was then administered on RedCap software.

To prevent duplicate responses, the survey initially asked respondents whether they had previously received and completed the survey. This step was necessary due to the potential overlap, as some orthodontists might be members of associations, have their emails retrieved from the websites collected, or belong to the Facebook groups where the survey was posted. If the respondents answered "yes," the survey was terminated. Following this, additional questions were used to verify most of the inclusion criteria, by confirming that respondents were either general dentists or orthodontists and practicing in the USA.

OSA Screening

Respondents' screening practices were assessed through a series of questions regarding whether they screened for obstructive sleep apnea (OSA), the specific age groups they screened (children, adolescents, or adults), and the methods they used for screening each group. The methods listed in the survey included medical history, questionnaires, clinical examination, and radiographic evaluation.

OSA Diagnosis

This section aimed to examine diagnostic practices for patients identified as at risk for obstructive sleep apnea (OSA) through screening. The survey included questions to assess whether respondents obtained a diagnosis of OSA and the methods they used to establish this diagnosis. For example, it inquired whether the diagnosis was based on screening results or provided by a sleep physician.

OSA Treatment

Respondents who offered treatment for OSA answered questions about therapeutic goals, including whether their aim was to prevent and/or cure OSA. Additional questions addressed the specific treatments offered and whether these were provided in collaboration with a sleep physician. The survey also evaluated how respondents assessed the success of their treatments.

Self-Identification

To identify airway-focused dentists and orthodontists, respondents were asked whether they considered themselves as such, which also served to confirm the final inclusion criteria for general dentists. This created four groups of participants: two consisting of AFD and AFO, the other two of non-AFD and non-AFO. Survey responses from non-AFD were excluded from the study, the remaining three groups were compared for differences in screening, diagnosing, and treating OSA.

Demographic Characteristics

The final section of the survey collected demographic information, including questions about the location and practice setting, years of experience, gender, ethnicity, and educational background related to OSA.

Statistical Methods

Sample Size Calculation

A study by Triggs et al. (2022)[105] found that 62 % of orthodontists screened for OSA and 38 % of orthodontists did not screen for OSA. Using these baseline proportions of 62% and 38%, the required sample size per group to detect a 24% difference in the frequency of screening between the two groups, with 80% power and a 0.05 significance level, is 33 participants per group.

Data Analysis

Continuous responses were summarized by the mean and standard deviation, frequency and percentage were used for categorical responses. Comparisons between the three groups of participants for continuous responses used one-way ANOVA and two-sample t test, and chi-square test and Fisher's exact test were used for categorical responses. For pairwise testing involving all three participant groups Holm's method was used to adjust the statistical significance (p-value) for the multiple testing. A significance level of 0.05 was used to determined statistical significance and R software (Version 4.4.1) was used for all analyses.

RESULTS

Clinical Practice Guidelines

The review of the guidelines showed there was a large overlap in the recommendations made the various organizations (Figure 1, Table2a-2d). The common guidelines included screening patients for OSA, and if screening indicated a potential risk for OSA, this was followed by referral to a sleep

physician for further evaluation, diagnosis through a PSG, and treatment planning. Additionally, the common guidelines recommended subsequent treatment be delivered through a multidisciplinary team, including a physician, dentist, and/or orthodontist. Follow up of treatment was advised to evaluate improvement in signs and symptoms or values of a repeat PSG and a referral back to a sleep physician if no improvement or worsening was observed. Notably, none of the common guidelines outlined the use of radiographs, evaluation of crowding, tongue position, ankyloglossia, or the assessment of frenal attachments as part of OSA screening. Furthermore, the common guidelines did not propose intervention aimed at preventing OSA.

In adults, the common guidelines for screening methods included medical history, OSA questionnaires, extraoral and intraoral exams. Relevant medical history (Table 2a) included obesity, cerebrovascular diseases, cardiovascular diseases, hypertension, difficulty controlling comorbidities, snoring, morning headaches, daytime sleepiness, reports of fragmented sleep, and whiteness gasping. The STOP-BANG and ESS questionnaires were the commonly recommended questionnaires (Table 2b). Clinical observations (Table 2c and 2d) indicative of a potential risk for OSA included a large neck circumference, retrognathia, and a deep narrow palate. Common treatments outlined included PAP, adenotonsillectomy, weight reduction, MAD, maxillomandibular surgery, and maxillary expansion (when transverse deficiency existed).

For the pediatric patients, common guidelines for screening methods included medical history, extraoral and intraoral exams. Relevant medical history (Table 2a) included craniofacial disorders, enuresis, overweight, ADHD, snoring, daytime sleepiness, morning headaches, and witnessed gasping. Clinical examination (Table 2c and 2d) assessing retrognathia, adenotonsillar hypertrophy, and a deep, narrow palate were identified as risk factors in the common guidelines. Treatments commonly outlined included, adenotonsillectomy, weight reduction, MAD, PAP, and maxillary expansion (when transverse deficiency existed).

There was limited information provided by some organizations regarding the potential risk factors to evaluate during screening, as well as treatment modalities for both pediatric and adult patients. As a

result, discrepancies emerged between the guidelines, leading to certain recommendations being excluded from the common guidelines.

Participants Survey Response

A total of 167 dentists and orthodontists responded to this survey. Of these, 48 were AFD (two dentists were excluded as they did not identify as AF), and 119 were orthodontists, 41 of which identified as AFO and 78 as non-AFO. Of the 165 general dentists invited to take the survey, 48 responded (response rate of 29.2%). Unfortunately, the response rate for orthodontists could not be determined. The survey was posted across several orthodontic Facebook groups, thus, it was not possible to determine overlapping memberships between the groups, members that are non-US orthodontists, and the number of bots or inactive accounts.

Participants Demographic Characteristics

Among the respondents who reported their gender, 45.5% were women. The average number of years in practice was 23.7, 20.7, and 16.5 years for AFD, AFO, and non-AFO, respectively. Most respondents reported working in private practice, primarily in suburban areas. Regarding educational background related to OSA, all AFD and AFO reported formal background in OSA, whereas 20.5% of non-AFO reported no formal background. Most respondents obtained their education through continuing education, followed by being self-taught (Table 3).

Participants Survey Screening Response

In summary of the responses on screening, it was found that 20.8% of AFD, 3.9% AFO, and 61.4% of non-AFO adhered to the common screening guidelines by excluding radiographs from their screening protocols. Regarding screening practices among respondents, a significant difference (P-value < 0.05) was observed in the frequency of screening between the three groups of participants (Table 4). Airway focused dentists (100%) screened for OSA at a significantly higher rate than AFO (87.8%), followed by

non-AFO (56.4%). Additionally, AFD (97.9%) screened adults at a significantly higher rate than AFO (80.5%), followed by non-AFO (43.6%). As for the screening methods employed (Table 5), medical history was most used across all three groups of participants. Airway focused dentists, however, utilized OSA-related questionnaires (95.8%) at a significantly higher rate than AFO (52.8%) and non-AFO (38.6%). Among the various questionnaires, the frequency of use of the ESS was not significantly different between AFD (63.0%) and AFO (31.6%) but was used at a significantly higher rate by AFD compared to non-AFO (5.9%). There was no significant difference between AFO and non-AFO in the use of the ESS questionnaires.

Furthermore, clinical exams and radiographs were more frequently utilized by AFD and AFO compared to non-AFO (Table 5). Among the various clinical observations made, bruxism and tooth wear were considered during an exam at a significantly higher rate by AFD (97.9%, 97.9%) followed by AFO (82.4%, 82.4%), then non-AFO (33.3%, 40.7%). Whereas AFD (83.3%) examined neck circumference at a significantly higher rate than AFO (44.1%) and non-AFO (37.0%). Other observations including tongue position, ankyloglossia, frenal attachments, and crowding were evaluated by AFD, AFO and non- AFO. However, AFD (93.8%, 91.7%) examined frenal attachments and crowding at a significantly higher rate than AFO (58.8%, 67.6%), followed by non-AFO (11.1%, 14.8%) (Table 6).

Participants Survey Diagnosis Response

Notably, AFD (4.2%) and AFO (16.7%) followed the common guidelines for both screening and the subsequent referral to a sleep physician for evaluation and diagnosis at a statistically significantly lower rate than non-AFO (45.5%). Among respondents who screened for OSA then referred at risk patients to a sleep physician, there was no significant difference between AFD (83.35%) and AFO (91.7%) or AFO and non-AFO (100%). However, AFD rereferred at a significantly lower rate than non-AFO. The remaining participants either educated patients and/or offered treatment without referral to a sleep physician. The majority of respondents, who obtained a diagnosis for OSA, did so through a sleep physician (Table 7).

Participants Survey Treatment Response

After evaluating the sample of respondents who offered treatment for OSA following screening, the number of non-AFO was too small for statistical analysis and, therefore, they were excluded from the analysis relevant to this section. In summary of OSA treatment responses, none of the AFD fully adhered to the common guidelines for treating OSA whereas 5.6% of AFO strictly adhered to the common guidelines. The lack of adherence was due to offering preventative treatment and certain curative treatments that do not abide by the common guidelines (frenectomies/frenotomies and myotherapy). Both AFD and AFO treated OSA at similar rates, with an aim to prevent and cure OSA (Table 8).

As for the various preventative treatments offered, AFD (21.1%) utilized adenotonsillectomy at a significantly lower rate than AFO (75%) (Table 9). Additionally, maxillomandibular surgery and adenotonsillectomy were offered significantly less to cure OSA by AFD (32.1%, 39.3%) compared to AFO (100%, 91.7%) (Table 10). Notably, 68.2% of AFD and 58.8% of AFO offered maxillary expansion for prevention and/or treatment only when there was an existing transverse deficiency. Furthermore, frenectomies, frenotomies and myotherapy were included in the treatment practices of AFD and AFO (Tables 9 and 10).

A collaborative approach with a sleep physician among AFD was evenly split: 50% always collaborated, while the other 50% occasionally collaborated with a sleep physician. As for AFO, 44.4% reported that they always collaborated with a sleep physician when treating OSA. The remaining AFO stated occasional collaboration. In addition, significantly less AFD (36.4%) assessed treatment success by evaluating improvements in airway space via radiographs compared to AFO (72.2%).

DISCUSSION

The first aim of this study was to identify and summarize clinical guidelines published by various professional organizations and societies then develop common guidelines on the screening and management of OSA. Secondly, the study sought to explore the practice behaviors of AFD and AF/non-AFO in screening and managing patients for OSA, and to assess any differences between these groups. These practice behaviors were also to be compared with the common published clinical guidelines. The review of the various common clinical guidelines revealed agreement on screening patients for OSA, including general methods of screening (health history, questionnaires clinical exams), referring to a sleep physician upon positive screening for OSA for further evaluation, diagnosis, and subsequent recommendation of treatment. The common guidelines outlined the need for a multidisciplinary team to manage a multifaceted disorder. Additionally, none of the common guidelines outlined recommendations for the prevention of OSA.

The differences, however, lay in the level of detail provided for the various aspects involved in screening patients, such as the different predisposing medical conditions, signs and symptoms and types of questionnaires, as well as the variety of treatments available. There is also a lack of clarity regarding whether information in a patient's medical history or observations during a clinical exam, in the absence of signs and symptoms, are sufficient to warrant a referral to a sleep physician for further evaluation. As a result, differences in practices may be a function of the specific guidelines to which individual dentists and orthodontists refer to.

Furthermore, OSA questionnaires are recommended by the common clinical guidelines and are simple, effective, and low-cost tools for screening. However, several studies have compared the reliability of sleep questionnaires in detecting OSA and found that not all are equally accurate as screening tools[92-94]. The STOP-BANG and Berlin questionnaires demonstrated high accuracy, while the Epworth Sleepiness Scale (ESS) was found unsuitable for OSA screening as it has low sensitivity and only measures daytime sleepiness. The review of common guidelines showed that ESS is, nonetheless, recommended by various

guidelines.

When comparing the respondents practice behaviors against the common guidelines for screening, results of the survey revealed that AFD and AFO screened at a higher rate compared with non-AFO. A possible explanation for the lower rate of screening by non-AFO may be associated with the higher rate of reported lack of education on OSA among these orthodontists. Furthermore, AFD and AFO stated that most of their knowledge on OSA came from continuing education, which could also indicate a greater interest in the topic and a stronger desire to incorporate OSA management into their practice, thus, screening for OSA more regularly. Additionally, all groups of participants reported low levels of education received during dental school and this may suggest a need for greater incorporation of OSA education into dental curricula to promote clinical practice that integrates correct management of OSA. The results of the present study aligned with a survey study on screening of OSA by orthodontists in the USA[105], which found that 62% of orthodontists screen for OSA. Screening was associated with a higher number of hours of continuing education. Their results also revealed that medical history was the most commonly used method for screening patients.

This study found that most participants managing patients for OSA did not adhere to the common guidelines. This non-compliance was primarily due to evaluating non-OSA related clinical features and the use of radiographs during screening. However, the deviation from the common guidelines was most notable when participants offered treatment, particularly preventative and certain curative interventions, which are not supported by the common guidelines.

Clinical exams are valuable for identifying risk factors of OSA, and the common guidelines recommend exams for screening. The results of this survey revealed that AFD and AFO rely more on clinical exams than non-AFO. Although, a trend was also detected where both AF participants tended to evaluate factors unrelated to OSA risk such as ankyloglossia, frenal attachments, and dental crowding. A systematic review by Chinnadurai et al.[95] found no significant impact of ankyloglossia on non-breastfeeding outcomes such as sleep-disordered breathing, malocclusion, narrow palate, crowding,

articulation, and dysphagia. While the literature does not establish a direct link between ankyloglossia, frenal attachment, crowding and OSA, some studies that lack strong evidence due to small sample sizes and methodological shortcomings[96-98], report positive association to OSA. This conflicting evidence can lead to misinterpretation of a causal relationship and may contribute towards dentists and orthodontists identifying these clinical features as risk factors of OSA. Therefore, it is essential to critically evaluate the literature to ensure the evidence is adequate before applying it in practice.

The absence of a role of radiographs in evaluating OSA is consistent across the common guidelines reviewed in this study. However, both AFD and AFO are utilizing radiographs. This may be due to the ready availability of radiographic imaging, a lack of awareness regarding the guidelines, and/or the superfluous research incorporating radiographs in assessing OSA in their methodologies. This use of radiographs for OSA screening purposes leads to unnecessary exposure to radiation and an inaccurate assessment of OSA risk.

Following screening, a patient found at risk for OSA should be referred to a sleep physician. The survey showed that a small subset of AFD and AFO are diagnosing OSA based solely on screening, which can lead to misdiagnosis or delays in the necessary evaluation and management by a sleep physician, if OSA is indeed present. This also suggests that some dentists and orthodontists may be operating outside the scope of their training.

Airway focused dentists and airway focused orthodontists reported offering treatment aimed at preventing and curing OSA. Although the common guidelines did not recommend preventative treatment, they also do not explicitly restrict it, potentially leaving this aspect to be open to interpretation. A tendency towards using maxillary expansion as the primary preventative treatment was observed. However, OSA is a multifaceted condition, and its development is not solely a result of anatomical features. Therefore, offering dental treatments aimed at altering anatomical dimensions, such as maxillary expansion, may not prevent the onset of OSA. Eckert et al.[99] explains a phenotypic approach to OSA, outlining the importance of understanding anatomical causes and non-anatomical factors (phenotypes)

that lead to OSA to overcome the "one-size fits all" strategy in its' treatment. This can be applied to the dental profession, where caution is needed to avoid applying a universal approach that could lead to the delivery of unnecessary treatment, which can be costly, time-consuming, and potentially uncomfortable for patients.

The practice behaviors of AFD and AFO are similar in incorporating maxillary expansion to cure OSA. However, over a third of both AFD and AFO use expansion for patients in the absence of a transverse discrepancy. These patients need careful management, as unnecessary expansion can harm periodontal tissue or lead to a posterior buccal crossbites. Furthermore, the role of maxillary expansion in treating OSA remains controversial. While the common guidelines support its' use when a transverse discrepancy is present, meaning there is an orthodontic need for expansion, recent literature suggests limited benefits from maxillary expansion compared to other options, such as adenotonsillectomy or watchful waiting in pediatric patients[66,100].

Furthermore, both AFD and AFO reported offering frenectomies/frenotomies and myotherapy as treatments for OSA. However, these interventions are not outlined in the common guidelines, indicating that they are not adhering to the guidelines. Additionally, while lingual frenectomy is generally considered a safe and well-tolerated procedure, it carries potential risks, including airway obstruction, injury to salivary structures, oral aversions, and scarring[76]. Furthermore, there are reports of lingual frenectomies causing posterior tongue collapse, which can worsen OSA[101]. Regarding myotherapy, a 2020 Cochrane review by Rueda et al.[107] concluded that myofunctional therapy may reduce daytime sleepiness and increase sleep quality on the short term, however, it was found that the evidence for benefit of myofunctional therapy in treating OSA was moderate to very low due to a lack of blinding, incomplete outcome data, and imprecisions.

The treatment of OSA should involve close collaboration with a sleep physician to ensure patients receive comprehensive care from professionals who are trained to manage sleep breathing disorders, and dentists and orthodontists may also receive guidance on the recommended treatment, as per the common guidelines. However, only half of AFD and AFO, that treat patients for OSA, reported occasionally

working as part of a team with a sleep physician. This fact raises concerns over the effectiveness of the treatment offered, as it may not address the underlying cause(s) of OSA, and if left unresolved, it could lead to significant and harmful consequences for patients.

There are limitations to this study. Although the survey was distributed to multiple platforms online to maximize accessibility and reach, the small sample size and self-selection to participate may not adequately represent the broader population, potentially decreasing its generalizability. Additionally, the small sample size of orthodontists prohibited the ability to investigate the treatment behaviors among the non-AFO subgroup. On the other hand, the response rate by AFD is relatively high for survey studies assessing practicing clinicians, therefore, the results of this study may be considered representative of the greater population of AFD. While the questions were designed to allow for a wide range of responses, it is possible that the survey did not capture all the practices used by respondents. Additionally, since participants self-identified as "airway-focused," the accuracy of their responses could be influenced their subjective interpretation of what “airway-focused" entails. Despite these limitations, the survey design effectively enabled respondents to categorize their answers based on three distinct age groups, providing a structure that closely aligns with clinical practice. Furthermore, the initial study sample of AFD and AFO was selected based on three criteria: (1) publicizing OSA-related treatments on their websites; (2) membership in breathing/airway groups; and/or (3) inclusion in the Online Airway Locator Tool. This was later confirmed by participants self-identifying as airway-focused. Of the fifty general dentists who participated in the survey, forty-eight identified as airway-focused dentists, indicating that the initial sample accurately represented airway-focused dentists based on the selection criteria by this study. Since the survey did not inquire about how orthodontists were invited to participate (via AAO, direct email from investigator, or Facebook groups), it was not possible to analyze this relationship.

In summary, there may be a misconception that treatments offered to patients can cure OSA. The goal of treatments is to mitigate the downstream sequelae of OSA, which have been well documented in terms of reducing mortality and to improve patients’ quality of life[106]. With the increasing prevalence of

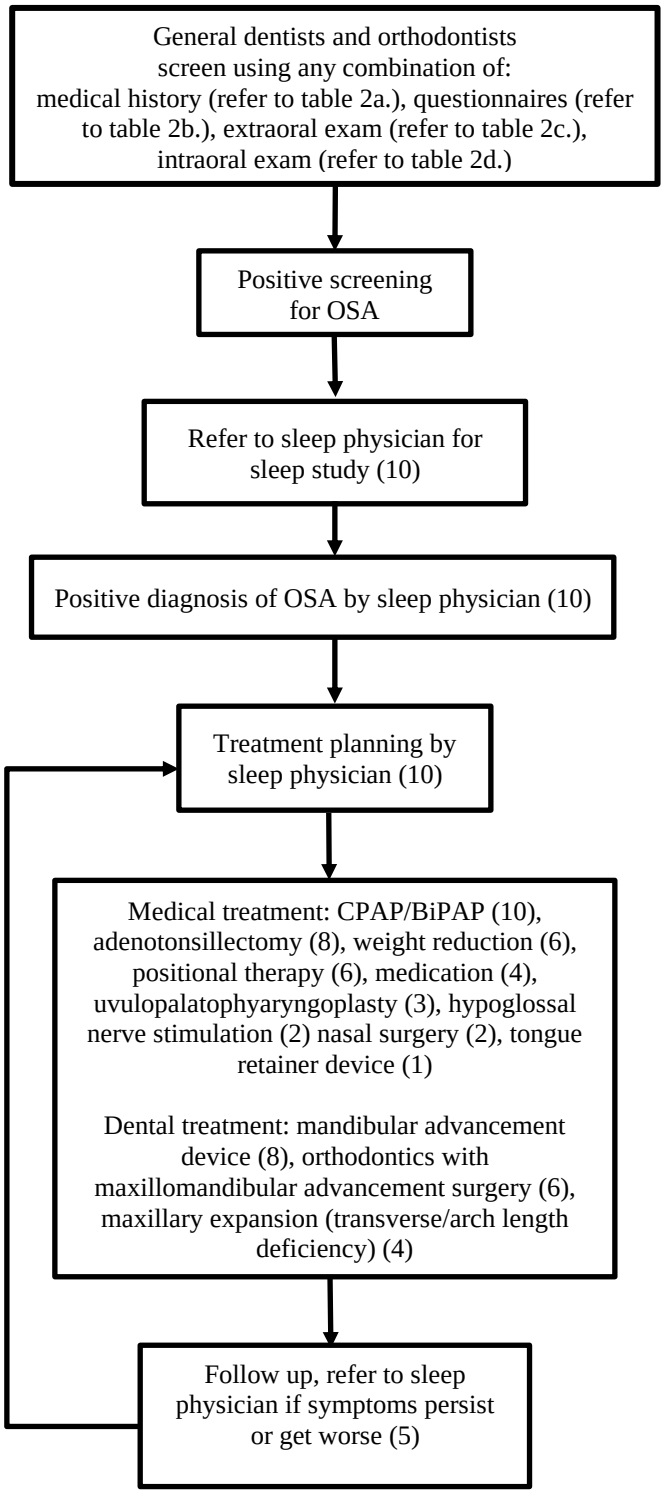
OSA, the risk of misinformation on social media[102], along with the popularity of documentaries and podcasts on breathing and sleep, awareness of this topic and likely diagnosis may continue to rise. Therefore, the responsibility of dentists and orthodontists, whether AF or non-AF, to further expand their knowledge on OSA to effectively educate patients may become more important than ever.

CONCLUSIONS:

1. Clinical guidelines agree on many protocols for managing OSA. The common guidelines recommend screening patients, referring patients with positive screening to a sleep physician for further evaluation, diagnosis with a sleep study and treatment planning, a multidisciplinary team to deliver treatment and the follow up on treatment. The common guidelines do not recommend the use of radiographs for evaluating OSA, treatment for preventative intervention, screening, or treatment of ankyloglossia, frenal attachments, or the use of myotherapy for treating OSA.
2. Airway focused dentists and AFO screened and treated OSA at a higher frequency than non-AFO and acted inconsistently with the common guidelines at a higher frequency than non-AFO. Additionally, there was a lack of consistent collaboration with sleep physicians for diagnosis and treatment.

FIGURES AND TABLES

Summary of clinical guidelines for the management of OSA (Figure 1).



Note: Numbers in parentheses indicates the number of organizations, out of 10, that recommend this guideline

Table 2a. Summary clinical guidelines for medical history for OSA screening.

	Number of organizations recommending guideline (out of 10)					
	1	2	3	4	5	6
Medical History	Hypothyroidism	Older age	Sleeping head hyperextended	Enuresis	Daytime sleepiness	Overweight
	Abnormal nasal morphology	Male gender	Fatigue	Attention deficient disorder	Witnessed gasping	Cardiovascular, cerebrovascular disease
	Rhinitis	Awakening with dry mouth	Alcohol consumption	Learning problems	Morning headaches	Snoring
	Smoking	Frequent nocturnal awakenings			Fragmented sleep	
	Seizures	Diabetes			Craniofacial disorders	
	Cyanosis	Mouth breathing			Hypertension	
	Ethnicity	Bruxism			Difficulty controlling medical comorbidities	
	Acromegaly	Congestion				
	Diaphoresis	TMD				
		Family history of OSA				
		Impaired growth				
		Long-term opioid use				

Table 2b. Summary of clinical guidelines for questionnaires for OSA screening.

	Number of organizations recommending guideline (out of 10)				
	1	2	4	5	6
Questionnaires	Kushida	PSQ	Berlin	ESS	STOP-BANG
		FTP			

Table 2c. Summary of clinical guidelines for extraoral exam for OSA screening.

	Number of organizations recommending guideline (out of 10)		
	1	3	5
Extraoral Exam	Steep mandibular plane angle	Dolichocephalic facial type	Retrognathia
	Low hyoid		Large neck circumference
	Midface deficiency		

Table 2d. Summary of clinical guidelines for intraoral exam for OSA screening.

	Number of organizations recommending guideline (out of 10)			
	1	2	4	5
Intraoral Exam	Anterior open bite	Pharyngeal crowding	Mallampati Score	Enlarged tonsil/adenoids (Brodsky Scale)
	Enamel erosion associated with gastroesophageal reflux	Macroglossia		Narrow and deep palate
	Tooth wear associated with bruxism			

Table 3. Demographic characteristics of AFD, AFO and non-AFO (gender, age, ethnicity, practice setting, practice location, years of practice, education on OSA).

DEMOGRAPHIC CHARACTERISTICS	AFD N = 48	AFO N = 41	Non-AFO N = 78	p-value[1]
Gender				
Female	27 (57.4%)	17 (42.5%)	32 (41.6%)	0.194
Male	20 (42.6%)	23 (57.5%)	45 (58.4%)	
Unknown	1	1	1	
Age				
25 to 35	3 (7.9%)	8 (19.5%)	22 (28.2%)	
36 to 45	11 (28.9%)	9 (22.0%)	17 (21.8%)	
46 to 55	12 (31.6%)	8 (19.5%)	17 (21.8%)	
56 to 65	7 (18.4%)	8 (19.5%)	13 (16.7%)	
66 and over	5 (13.2%)	7 (17.1%)	9 (11.5%)	
Prefer not to answer	0 (0.0%)	1 (2.4%)	0 (0.0%)	
Unknown	10	0	0	
Ethnicity				
White, non-Hispanic	33 (71.7%)	35 (87.5%)	51 (72.9%)	
Asian or Asian Indian	3 (6.5%)	2 (5.0%)	11 (15.7%)	
Black or AA	2 (4.3%)	0 (0.0%)	3 (4.3%)	
Hispanic or Latino	1 (2.2%)	1 (2.5%)	0 (0.0%)	
Middle Easter or NA	1 (2.2%)	0 (0.0%)	4 (5.7%)	
Other	6 (13.0%)	0 (0.0%)	1 (1.4%)	
Mixed	0 (0.0%)	2 (5.0%)	0 (0.0%)	
Unknown	2	1	8	
Practice Setting				
Private practice, solo	35 (72.9%)	23 (56.1%)	42 (53.8%)	0.090
Private practice, group	12 (25.0%)	13 (31.7%)	23 (29.5%)	0.769
Dental service organization	2 (4.2%)	0 (0.0%)	2 (2.6%)	0.579

(CONTINUED)

Table 3. (cont.) Demographic characteristics of AFD, AFO and non-AFO (gender, age, ethnicity, practice setting, practice location, years of practice, education on OSA).

DEMOGRAPHIC CHARACTERISTICS	AFD N = 48	AFO N = 41	Non-AFO N = 78	p-value[1]
Community clinic	0 (0.0%)[B]	6 (14.6%)[A]	15 (19.2%)[A]	0.006
Academic institution	0 (0.0%)	4 (9.8%)	4 (5.1%)	0.094
Hospital	0 (0.0%)	1 (2.4%)	2 (2.6%)	0.610
Other	0 (0.0%)	0 (0.0%)	0 (0.0%)	>0.999
Practice Location				0.523
Rural	8 (16.7%)	5 (12.2%)	6 (7.7%)	
Urban	17 (35.4%)	13 (31.7%)	20 (25.6%)	
Suburban	20 (41.7%)	19 (46.3%)	40 (51.3%)	
Rural & Suburban	1 (2.1%)	3 (7.3%)	5 (6.4%)	
Urban & Suburban	2 (4.2%)	1 (2.4%)	7 (9.0%)	
Years in Practice				
Mean (SD*)	23.7 (12.0)	20.7 (14.2)	16.5 (13.5)	
Education on OSA				
Dental school	1 (2.1%)[B]	9 (22.0%)[A]	10 (12.8%)[A,B]	0.011
Residency training	NA	16 (39.0%)	38 (48.7%)	0.339
Continuing education	48 (100.0%)[C]	36 (87.8%)[A]	38 (48.7%)[B]	<0.001
Self-taught	13 (27.1%)[B]	17 (41.5%)[A]	14 (17.9%)[B]	0.022
No background on OSA	0 (0.0%)[A]	0 (0.0%)[A]	16 (20.5%)[B]	<0.001

Uppercase superscript letters indicate significant group differences at a 0.05 significance level
[1]Fisher's exact test; Pearson's Chi-squared test, *SD: Standard Deviation

Table 4. Reported frequency of screening for OSA by AFD, AFO and non-AFO

SCREEN FOR OSA	AFD N = 48	AFO N = 41	Non-AFO N = 78	p-value[1]
1 or more ages	48 (100.0%)[C]	36 (87.8%)[A]	44 (56.4%)[B]	<0.001
Children	42 (87.5%)[A]	35 (85.4%)[A]	40 (51.3%)[B]	<0.001
Adolescents	42 (87.5%)[A]	32 (78.0%)[A]	34 (43.6%)[B]	<0.001
Adults	47 (97.9%)[C]	33 (80.5%)[A]	34 (43.6%)[B]	<0.001

Uppercase superscript letters indicate significant group differences at a 0.05 significance level,
[1]Pearson's Chi-squared test

Table 5. Reported screening methods for OSA used by AFD, AFO and non-AFD

SCREENING METHODS	AFD N = 48	AFO N = 36	Non-AFO N = 44	p-value[1]
Medical history	48 (100.0%)	35 (97.2%)	41 (93.2%)	0.143
OSA questionnaire	46 (95.8%)[B]	19 (52.8%)[A]	17 (38.6%)[A]	<0.001
Clinical exam	48 (100.0%)[A]	34 (94.4%)[A]	27 (61.4%)[B]	<0.001
Radiographic evaluation	38 (79.2%)[A]	31 (86.1%)[A]	17 (38.6%)[B]	<0.001

Uppercase superscript letters indicate significant group differences at a 0.05 significance level,
[1]Pearson's Chi-squared test

Table 6. Reported guideline-adherent and non-adherent clinical exam observations used for screening OSA by AFD, AFO and non-AFD

OBSERVATIONS IN A CLINICAL EXAM	AFD N = 48	AFO N = 34	NON-AFO N = 27	P-VALUE[1]
Adherent to Guidelines				
Retrognathic mandible	47 (97.9%)	34 (100.0%)	26 (96.3%)	0.723
Constricted maxilla	47 (97.9%)	33 (97.1%)	24 (88.9%)	0.161
Brodsky scale	20 (41.7%)	8 (23.5%)	6 (22.2%)	0.111
Bruxism	47 (97.9%)[C]	28 (82.4%)[A]	9 (33.3%)[B]	<0.001
Tooth wear	47 (97.9%)[C]	28 (82.4%)[A]	11 (40.7%)[B]	<0.001
Dolichofacial profile	38 (79.2%)	25 (73.5%)	19 (70.4%)	0.672
Neck circumference	40 (83.3%)[B]	15 (44.1%)[A]	10 (37.0%)[A]	<0.001
BMI	41 (85.4%)[B]	22 (64.7%)[A,B]	12 (44.4%)[A]	<0.001
One or more of above observations	48 (100.0%)	34 (100.0%)	27 (100.0%)	>0.999
Non-Adherent to guidelines				
Tongue position	46 (95.8%)[B]	30 (88.2%)[A,B]	17 (63.0%)[A]	<0.001
Ankyloglossia	44 (91.7%)[A]	25 (73.5%)[A]	7 (25.9%)[B]	<0.001
Frenal attachments	45 (93.8%)[C]	20 (58.8%)[A]	3 (11.1%)[B]	<0.001
Crowding	44 (91.7%)[C]	23 (67.6%)[A]	4 (14.8%)[B]	<0.001
One or more of above observations	47 (97.9%)[A]	32 (94.1%)[A]	18 (66.7%)[B]	<0.001

Uppercase superscript letters indicate significant group differences at a 0.05 significance level,
[1]Fisher's exact test; Pearson's Chi-squared test

Table 7. Reported methods used to obtain a diagnosis for OSA by AFD, AFO and non-AFO

METHODS TO OBTAIN A DIAGNOSIS	AFD N = 48	AFO N = 36	NON-AFO N = 44	P-VALUE[1]
Signs and symptoms	6 (12.5%)[A,B]	12 (33.3%)[A]	4 (9.1%)[B]	0.009
Questionnaire	6 (12.5%)	7 (19.4%)	3 (6.8%)	0.244
Clinical evaluation	5 (10.4%)[B]	13 (36.1%)[A]	2 (4.5%)[B]	<0.001
Radiographic evaluation	5 (10.4%)[A]	10 (27.8%)[A]	2 (4.5%)[B]	0.011
Diagnosis by sleep physician	45 (93.8%)[B]	26 (72.2%)[A]	35 (79.5%)[A,B]	0.027
Do not obtain diagnosis	4 (8.3%)	8 (22.2%)	11 (25.0%)	0.085

[1]Fisher's exact test; Pearson's Chi-squared test

Table 8. Reported treatment intention to cure and/or prevent OSA by AFD and AFO

TREATMENT INTENTIONS	AFD N = 22	AFO N = 18	P-VALUE[1]
Cure OSA	20 (90.9%)	12 (66.7%)	0.110
Prevent OSA	21 (95.5%)	16 (88.9%)	0.579
Only cure OSA	1 (4.5%)	2 (11.1%)	0.579
Only prevent OSA	2 (9.1%)	6 (33.3%)	0.110
Prevent and cure OSA	19 (86.4%)	10 (55.6%)	0.040

[1]Fisher's exact test; Pearson's Chi-squared test

Table 9. Reported treatment methods used to prevent OSA by AFD and AFO

TREATMENT METHODS TO PREVENT OSA	AFD N = 38	AFO N = 16	P-VALUE[1]
Maxillary expansion	33 (86.8%)	15 (93.8%)	0.657
Adenotonsillectomy	8 (21.1%)	12 (75.0%)	<0.001
LAUP, UPPP or RFA*	7 (18.4%)	1 (6.3%)	0.411
Mandibular advancement device	27 (71.1%)	14 (87.5%)	0.301
Frenectomy	26 (68.4%)	10 (62.5%)	0.673
Frenotomy	22 (57.9%)	9 (56.3%)	0.911
Myotherapy	29 (76.3%)	11 (68.8%)	0.735

[1]Fisher's exact test; Pearson's Chi-squared test
*LAUP: Laser-Assisted Uvulopalatoplasty, UPPP: Uvulopalatopharyngoplasty, RFA: Radiofrequency Ablation

Table 10. Reported guideline-adherent and non-adherent treatment methods used to cure OSA by AFD and AFO

TREATMENT METHODS TO CURE OSA	AFD N = 28	AFO N = 12	P-VALUE[1]
Adherent to guidelines			
Maxillary expansion	24 (85.7%)	11 (91.7%)	>0.999
Tonsillectomy	11 (39.3%)	10 (83.3%)	0.011
Positional therapy	14 (50.0%)	4 (33.3%)	0.332
Mandibular advancement Devices	23 (82.1%)	8 (66.7%)	0.411
LAUP, UPPP or RFA*	7 (25.0%)	2 (16.7%)	0.697
Maxillomandibular Surgery	9 (32.1%)	12 (100.0%)	<0.001
One or more of above treatments	28 (100.0%)	12 (100.0%)	>0.999
Non-Adherent to guidelines			
Frenectomy	20 (71.4%)	8 (66.7%)	>0.999
Frenotomy	17 (60.7%)	7 (58.3%)	>0.999
Myotherapy	21 (75.0%)	8 (66.7%)	0.704
None	0 (0.0%)	0 (0.0%)	>0.999
One or more of above treatments	28 (100.0%)	12 (100.0%)	>0.999

[1]Fisher's exact test; Pearson's Chi-squared test
*LAUP: Laser-Assisted Uvulopalatoplasty, UPPP: Uvulopalatopharyngoplasty, RFA: Radiofrequency Ablation

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APPENDIX I

Organization	Screening	Diagnosis	Prevention	Treatment	Dental role
American Dental Association (ADA)	Health history, oral exam, STOP-BANG[1], Berlin questionnaire, ESS[2], NoSAS[3], SACS[4]	Primary or Sleep medicine physician, PSG or HST[7]	N/A	Behavioral modification, positional therapy, PAP[8], Oral appliance	Screen, refer for diagnosis, OA in collaboration with physician and long term follow up of OA
American Academy of Pediatric Dentistry (AAPD)	Clinical exam, Mallampati, FTP[5], STOP-BANG, Berlin questionnaire, ESS	Various medical specialist, PSG	N/A	CPAP, weight reduction, positional therapy, RME -Mx transverse deficiency, MAD[9]- for class II	Screen, refer, provide adjunct treatment as part of collaborative role with physician, recognize associated craniofacial anomalies, aware if inappropriate diagnosis of ADHD
American Association of Orthodontists (AAO)	Medical and dental history Questionnaire: STOP-BANG, ESS, FTP, Kushida index, Berlin, PSQ[6] Oral exam, Modified Mallampati, Brodsky Scale	Sleep physician, PSG, HSAT	N/A	PAP, Positional therapy, weight reduction medication, surgery – tonsillectomy, adenoidectomy, nasal surgery. Oral appliances, RME-maxillary transverse deficiency, MMA[10]surgery-underlying sagittal skeletal discrepancy unable to tolerate or adhere to PAP or OA	Multidisciplinary approach Attentive to clinical features of patients with genetic syndromes that affect craniofacial morphology no indication in the literature that prophylactic application of maxillary expansion prevents the future development of OSA
American College of Prosthodontics (ACP)	Oral exam Questionnaires: ESS, STOP-BANG, Berlin	Sleep physician, PSG	N/A	CPAP, MAD, TRD[11] Children: Adenotonsillectomy-adenotonsillar hypertrophy, Maxillary expansion and orthodontic/surgical correction of malocclusion	Screen, refer, multidisciplinary approach with prescription of oral appliances with long term follow up of OA
American Academy of Pediatrics (AAP)	All children/adolescents for snoring	PSG Alternatives when PSG is not available	N/A	Adenotonsillectomy-adenotonsillar hypertrophy, CPAP, weight loss, intranasal corticosteroids	Reevaluate postoperatively
American Academy of Dental Sleep Medicine (AADSM)	Exam anatomic factors associated with OSA, nocturnal and daytime symptoms. medical and family history Adult: EPSS, Berlin, STOP-BANG, Enamel erosion associated with gastroesophageal reflux, sleep bruxism, pharyngeal crowding is associated	Physician (Dx and treatment plan)	N/A		Qualified dentists treat diagnosed patients, identify risk modifiers, work with other health care providers to manage through evidence-based practices. Patient education Screen and refer to physician Provide OA when prescribed and referred by a physician then have physician reassessment, dentists- long-term management, verify efficacy of OA
American Academy of Sleep Medicine (AASM)	Questionnaires and prediction algorithms not to be used to diagnose OSA in adults	Board-certified sleep medicine physician, PSG, HST for uncomplicated adult patient, if inconclusive or negative or clinically inconclusive then PSG is needed. Follow up PSG: recurrent or persistent symptoms, assess response to treatment with non-PAP interventions.	N/A	CPAP, BPAP[12], OA, weight reduction, topical nasal corticosteroids	OA delivery

[CONTINUED]

Organization	Screening	Diagnosis	Prevention	Treatment	Dental role
National Sleep Foundation	Sleep physician	PSG, HST	N/A	Lifestyle changes-weight loss, reduce alcohol, quitting smoking. Positional therapy Nasal sprays CPAP	MAD, surgery when lifestyle changes or OA does not help-nose, tongue, palate, bones of face,neck,jaw ex tonsillectomy, uvulopalatophyaryngoplast, Nerve stimulator for those with symptomatic heart failure
World Sleep Society (WSS)	AASM endorsed	AASM endorsed	N/A	AASM endorsed on PAP	AASM endorsed
The Department of Veterans Affairs and the Department of Defense	STOP-BANG stratify risk for OSA	HST- high pretest probability of OSA and no significant medical comorbidities PSG-significant co morbidities repeat testing with an HSAT or PSG if a patient has a high pretest probability for OSA and an initial nondiagnostic HSAT.	N/A	PAP-mild to moderate symptomatic OSA Evaluation for Hypoglossal nerve stimulation intolerant to PAP with AHI 15-65 & have body mass index <32 kg/m^2	MAD if PAP not tolerated by qualified dentists, for mild to moderate OSA Evaluation for maxillomandibular advancement surgery for those with severe OSA who are also intolerant to PAP treatment or are not a candidate for alternative treatments

STOP-BANG[1]: Snoring, Tired during the day, Observed stop breathing during the sleep, High blood pressure, BMI, Age, Neck circumference, Gender, ESS[2]: Epworth Sleepiness Scale, NoSAS[3]: Neck, Obesity, Snoring, Age, Sex score SACS[4]: Sleep Apnea Clinical Score, FTP[5]: Fried Tongue Position, PSQ[6]: Pediatric Sleep Questionnaire, HST[7]: Home Sleep Test, PAP: Positive Airway Pressure[8], MAD[9]: Mandibular Advancement Devices, MMA[10]: Maxillary Mandibular Advancement, TRD:[11] Tongue Retaining Device, BPAP[12]: Bi-level positive airway pressure

APPENDIX II

Survey

Note: The survey sent to general dentists was the same as that sent to orthodontists except for exclusion of the question asking, general dentists, if they are board certified.

Researchers from the University of Washington are conducting this study to learn how orthodontists who work with children, adolescents and/or adults perceive and manage Obstructive Sleep Apnea (OSA). We are interested in the perspectives of any orthodontist practicing in the United States of America.

Participation in this study involves completing a questionnaire about the ways you might screen and treat your patients for OSA. Your responses will be anonymous and confidential. The questionnaire will take approximately 10 minutes or less to complete.

Selecting "Yes" below and submitting the questionnaire will be considered your consent to participation. Taking part in research is always optional. If you decide not to participate in this study, there will be no consequences.
Documentation of IRB exemption is on file. This study is funded by the University of Washington Alumni Association.

As a thank you for your time, at the end of the questionnaire you will be able to enter a drawing for a chance to win one of ten $100 Amazon gift cards.

If you have questions before, during, or after participation, you may contact the Principal Investigator, Mariam Mustafa at mmustafa@uw.edu.

Thank you for your willingness to participate and

your valuable perspective! I consent to

participation.

◯ Yes ◯ No

Have you completed this questionnaire before? Yes No

Are you an Orthodontists? Yes No

Do you practice in the United States of America? Yes No

YOU ARE ELIGIBLE TO TAKE THIS SURVERY, THANK YOU FOR YOUR INTEREST

Do you screen patients for Obstructive Sleep Apnea (OSA)?
(Select all that apply)

- Yes, children (0-12 years)
- Yes, adolescents (13 -17 years)
- Yes, adults (18 years and above)
- No, I do not screen for OSA

My screening for children (0-12 years) includes
(Select all that apply)

- Medical history
- OSA-specific questionnaire
- Clinical exam
- Radiographic evaluation
- None of the above

The questionnaires I use for children (0-12 years) include
(Select all that apply)

- STOP-BANG ESS
- FTP
- Kushida index
- Berlin
- PSQ
- None of the above

Observations that are relevant to OSA during a clinical exam of children (0-12 years) include
(Select all that apply)

- Retrognathic mandible
- Constricted maxilla
- Brodsky Scale
- Tongue position
- Ankyloglossia
- Frenal attachments
- Crowding
- Bruxing
- Tooth wear
- Dolichofacial profile
- Neck circumference
- Body Mass Index
- None of the above

Radiographs I use for evaluating airway for children (0-12 years) include

(Select all that apply)

- Cone-beam Computed Tomography (CBCT)
- Lateral Cephalometric Radiograph
- None of the above

My screening for adolescents (13-17 years) includes
(Select all that apply)

- Medical history
- OSA-specific questionnaire
- Clinical exam
- Radiographic evaluation
- None of the above

The questionnaires I use for adolescents (13-17 years) include
(Select all that apply)

- STOP-BANG ESS
- FTP
- Kushida index
- Berlin
- PSQ
- None of the above

Observations that are relevant to OSA during a clinical exam of adolescents (13-17 years) include (Select all that apply)

- Retrognathic mandible
- Constricted maxilla
- Brodsky Scale
- Tongue position
- Ankyloglossia
- Frenal attachments
- Crowding
- Bruxing
- Tooth wear
- Dolichofacial profile
- Neck circumference
- Body Mass Index
- None of the above

Radiographs I use for evaluating airway in adolescents (13-17 years) include (Select all that apply)

- Cone-beam Computed Tomography (CBCT)
- Lateral Cephalometric Radiograph
- None of the above

My screening for adults (18 years and above) include (Select all that apply)

- Medical history
- OSA-specific questionnaire
- Clinical exam
- Radiographic evaluation
- None of the above

The questionnaires I use for adults (18 years and above) include (Select all that apply)

- STOP-BANG ESS
- FTP
- Kushida index
- Berlin
- PSQ
- None of the above

Observations that are relevant to OSA during a clinical exam of adults (18 years and above) include (Select all that apply)

- Retrognathic mandible
- Constricted maxilla
- Brodsky Scale
- Tongue position
- Ankyloglossia
- Frenal attachments
- Crowding
- Bruxing
- Tooth wear
- Dolichofacial profile
- Neck circumference
- Body Mass Index
- None of the above

Radiographs I use for evaluating airway for adults (18 years and above) include (Select all that apply)

- Cone-beam Computed Tomography (CBCT)
- Lateral Cephalometric Radiograph
- None of the above

Which signs and symptoms are relevant for a diagnosis of OSA? (Select all that apply)

- Snoring
- Arousal from sleep/gasping or choking
- Witnessed pauses in breathing
- Frequent nocturnal awakening
- Nonrestorative sleep
- Morning headaches
- Excessive daytime sleepiness
- Reported difficulty focusing
- Mood disturbances
- Tooth wear
- Bruxism
- ADHD
- High arched palate
- Retrognathic mandible

- Enlarged tonsils
- Crowding
- Chronic upper airway infections
- Asthma
- Chronic ear infections
- None of the above

How do you obtain a diagnosis of OSA? (Select all that apply)

- Based on presenting signs and symptoms
- Based on response to questionnaire
- Based on clinical evaluation
- Based on radiographic evaluation
- Based on a diagnosis by a sleep physician
- I do not obtain a diagnosis for OSA

On suspicion/diagnosis of OSA, what action do you take?
(Select all that apply)

- Patient education
- Referral to physician
- Offer treatment
- No action

For children (0-12 years), my treatment is intended to (Select all that apply)

- Prevent OSA
- Cure OSA
- I do not offer treatment to this age group

Treatment I offer for prevention of OSA in children (0-12 years) includes
(Select all that apply)

- Maxillary expansion
- Lingual frenectomy for ankyloglossia
- Frenotomies
- Myotherapy
- Tonsillectomy and/or adenoidectomy
- Laser-Assisted Uvulopalatoplasty (LAUP) and/or Uvulopalatopharyngoplasty (UPPP) and/or Radio Frequency Ablation (RFA)
- Mandibular advancement devices
- None of the above

Treatment I offer to cure OSA in children (0-12 years) includes
(Select all that apply)

- Maxillary expansion
- Lingual frenectomy for ankyloglossia
- Frenotomies
- Myotherapy
- Tonsillectomy and/or adenoidectomy
- Positional therapy
- Mandibular advancement devices
- Laser-Assisted Uvulopalatoplasty (LAUP) and/or Uvulopalatopharyngoplasty (UPPP) and/or Radio Frequency Ablation (RFA)
- Maxillary mandibular advancement surgery
- None of the above

In children, maxillary expansion is offered only when there is a maxillary transverse deficiency and/or arch length deficiency? Yes No

For adolescents (13-17 years), my treatment is intended to (Select all that apply)

- Prevent OSA
- Cure OSA
- I do not offer treatment to this age group

Treatment I offer for prevention of OSA in children (0-12 years) includes
(Select all that apply)

- Maxillary expansion
- Lingual frenectomy for ankyloglossia
- Frenotomies
- Myotherapy
- Tonsillectomy and/or adenoidectomy
- Laser-Assisted Uvulopalatoplasty (LAUP) and/or Uvulopalatopharyngoplasty (UPPP) and/or Radio Frequency Ablation (RFA)
- Mandibular advancement devices
- None of the above

Treatment I offer to cure OSA in adolescents (13-17years) includes
(Select all that apply)

- Maxillary expansion
- Lingual frenectomy for ankyloglossia
- Frenotomies

- Myotherapy
- Tonsillectomy and/or adenoidectomy
- Positional therapy
- Mandibular advancement devices
- Laser-Assisted Uvulopalatoplasty (LAUP) and/or Uvulopalatopharyngoplasty (UPPP) and/or Radio Frequency Ablation (RFA)
- Maxillary mandibular advancement surgery
- None of the above

In adolescents, maxillary expansion is offered only when there is a maxillary transverse deficiency and/or arch length deficiency? Yes No

For adults (18 years and above), my treatment is intended to (Select all that apply)

- Prevent OSA
- Cure OSA
- I do not offer treatment to this age group

Treatment I offer for prevention of OSA in adults (18 years and above) includes (Select all that apply)

- Maxillary expansion
- Lingual frenectomy for ankyloglossia
- Frenotomies
- Myotherapy
- Tonsillectomy and/or adenoidectomy
- Laser-Assisted Uvulopalatoplasty (LAUP) and/or Uvulopalatopharyngoplasty (UPPP) and/or Radio Frequency Ablation (RFA)
- Mandibular advancement devices
- None of the above

Treatment I offer to cure OSA in adults (18 years and above), includes (Select all that apply)

- Maxillary expansion
- Lingual frenectomy for ankyloglossia
- Frenotomies
- Myotherapy
- Tonsillectomy and/or adenoidectomy
- Positional therapy
- Mandibular advancement devices
- Laser-Assisted Uvulopalatoplasty (LAUP) and/or Uvulopalatopharyngoplasty (UPPP) and/or Radio Frequency Ablation (RFA)
- Maxillary mandibular advancement surgery

- None of the above

In adults, maxillary expansion is offered only when there is a maxillary transverse deficiency and/or arch length deficiency? Yes No

What constitutes successful treatment of OSA? (Select all that apply)

- Improvement of signs and symptoms
- Complete resolution of signs and symptoms
- Improvement of airway volume on a lateral cephalometry or CBCT
- Improvement in parameters with a Polysomnography (PSG)
- Improvement in parameters with a Home Sleep Test (HST)
- None of the above

The treatments I offer are in collaboration with a sleep physician

- Never
- Occasionally
- Always

Do you consider yourself an airway-focused clinician?

Yes No

Where did you learn about OSA? (Select all that apply)

- Dental school
- Residency training
- Continuing education course
- Self taught
- I have no background in OSA

In which state are you currently practicing?

In which setting is your practice located? (Select all that apply)

Rural area

Urban area

Suburban

Other

Which of the following describes where you practice primarily? (Select all that apply)

- Private practice, solo
- Private practice, group
- Dental service organization Community clinic
- Academic institution (e.g, dental school)
- Hospital
- Other

Number of years practicing as an orthodontist?

Are you board certified in orthodontics? Yes No

How many days per week do you practice clinically?

With what gender do you identify?

- Women
- Man
- Non-binary
- A gender not listed here
- Prefer not to answer

What age range do you fall in?

25 to 35
36 to 45
46 to 55
56 to 65
66 and over
Prefer not to answer

With what race or ethnicity do you identify? (Select all that apply)

- American Indian or Alaska Native
- Asian or Asian Indian
- Black or African American
- Hispanic or Latino
- Middle Eastern or North African
- Mixed
- Native Hawaiian or other Pacific Islander
- White
- Other
- Prefer not to answer

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