The Relationship between Obstructive Sleep Apnea (OSA) and Periodontal Disease

by

Faaria Hussain

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Faaria Hussain

has met the thesis requirements
for the degree of
Master of Public Health

Approved by:

Marshare Penny

Marshare Penny, Dr.P.H.
Professor
Committee Chair

Lindsay Fahnestock

Lindsay Fahnestock, Dr.P.H.
Assistant Professor
Committee Member

M. Wigginton

Melissa Wigginton, Dr.P.H.
Associate Professor
Committee Member

Abstract

Periodontal disease is becoming an increasingly pervasive public health concern for the United States population. Over 64.7 million American adults have some form of periodontal disease, and an estimated 22 million Americans suffer from sleep apnea. Current literature has defined the link between both diseases, but the long-term prognosis and links to other systemic diseases remain to be investigated. This study aimed to find an association between periodontal disease and obstructive sleep apnea, and if found, whether gender and race influences the relationship. A cross-sectional study was conducted using data from the 2017-2018 National Health and Nutrition Examination Survey (NHANES) standardized questions regarding oral health and sleep disorders. The sample consisted of 192 participants aged 17 and older. A Chi-square test of independence and two Cochran-Mantel-Haenszel tests of independence were used to test the hypotheses. No significant association was found between periodontal disease and obstructive sleep apnea. Neither gender nor racial/ethnicity were found to influence the relationship between periodontal disease and obstructive sleep apnea. Results of these findings have public health implications for clinical practice and program implementation geared toward improving oral health.

Keywords: periodontal disease, sleep apnea, gender, race

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Introduction

Overview of Literature

Periodontal disease and obstructive sleep apnea are highly prevalent in both developed and developing countries, affecting approximately 20-50% of the global population (Nazir, 2017). In the United States, the growing pervasiveness of periodontal disease in individuals ranging from adolescents to adults makes it a prominent public health concern. The following literature will examine the anatomy of the diseases and how gender and ethnicity contribute to the likelihood of contracting both diseases.

Periodontal Disease

Periodontal disease is a bacteria-induced inflammatory gum disease that damages soft and hard tissue that support the teeth (Pihlstrom et al., 2005). Often overlooked by individuals because of common oral hygiene symptoms, periodontal disease affects approximately 64.7 million Americans aged 30 and older, making it the leading oral health disease in the nation (American Academy of Periodontology, 2019).

Common, but largely preventable, periodontal disease is caused by poor oral hygiene. It is characterized as a local infection and subsequent inflammatory response in the supporting structures of the teeth and tissues (Famili, 2015). The bacterial proliferation leads to the destruction of periodontal connective tissue, ligaments, and the alveolar bone (Billings, 2015). Periodontal manifestation depends on both the bacterial pathogen and the host response, often resulting in inflammation. The host response may be aggravated by stress or other chronic inflammatory illnesses (Billings, 2015). Symptoms of the disease include increased bleeding from the gums, bad breath, changes in the positioning of the teeth in the jaws, lengthening of the teeth (gum recession), loose teeth or loss of teeth, and increased pain or sensitivity (Mayo Clinic,

2020). To determine if individuals show signs periodontal disease, dentists rely on a visual assessment of the patient's overall oral condition in addition to charting pocket depths with a periodontal probe (American Academy of Periodontology, 2019). To measure pocket depth, a probe is placed beneath the gum line at several sites throughout the oral cavity. The American Academy of Periodontology (2019) defined a healthy mouth with a pocket depth between 1 and 3 millimeters (mm). Clinically, pockets deeper than 4 mm indicate periodontal disease.

Globally, periodontal diseases are responsible for a vast burden of diseases (Teufer, 2019). According to the Global Burden of Disease Study, periodontal diseases were responsible for 3.5 million years lived with disease or disability worldwide (Vos et al., 2015). The bacteria culpable for periodontal diseases enter the bloodstream through gum tissue and can potentially affect other parts of the human body (Mayo Clinic, 2020). Several research studies have suggested that periodontal disease is connected to heart disease, diabetes, respiratory disease, and rheumatoid arthritis. Researchers believe that inflammation is the basis for the link between these systemic diseases (Kim and Amar, 2006). While periodontists are experts in treating oral inflammation, additional research needs to be conducted to determine how treating periodontal disease can reduce the risk for other inflammatory diseases and disorders (Hasturk & Kantarci, 2015; Kim & Amar, 2006).

Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) is a condition associated with a systemic inflammatory response, in which an individual has repetitive episodes of transient oxygen desaturation during sleep (Ryan et al., 2005). Being the most common form of sleep–disordered breathing, it is estimated to affect 18 million individuals in the U.S (Barsh, 2009). It is categorized as a disorder that occurs when throat muscles relax, leading to an episodic collapse of the upper airway during

sleep by cessation or reduction of airflow that causes intermittent hypoxia and fragmented sleep (Famili, 2015; American Sleep Apnea Association, 2020). OSA is currently diagnosed with an overnight sleep diagnostic test known as a polysomnogram (PSG), the gold standard of the diagnosis (Loke et al., 2015). The main outcome used to define OSA severity is the apnea-hypopnea index (AHI). This index represents the number of breathing stoppages (apneas) and periods of reduced airflow (hypopneas) lasting greater than 10 seconds that result in a brief awakening (arousal) or reduced oxygenation per hour of sleep (Osman et al., 2018). While severity cutoffs can vary, mild sleep apnea is typically defined as mild 5–15, moderate 15–30, and severe more than 30 respiratory events (Osman et al., 2018). An apneic event is defined as minimum 10-second interval between breaths, with a neurologic arousal, a blood oxygen desaturation of 3% to 4% or greater, or both arousal and desaturation (Loke et al., 2015).

Most people with OSA are either undiagnosed, misdiagnosed, or untreated; this can be attributed to a lack of awareness of the disorder (Osman et al., 2018). Other potential barriers to seek treatment include stigma related to some of the features of the disease such as snoring, access to polysomnography (PSG), and availability of diagnostic services (Osman et al., 2018). In addition, primary care physicians may not be prompted to explore an early diagnosis of OSA, especially if patients do not present with subjective sleepiness risk factors (Osman et al., 2018). Left untreated, the cost of OSA are substantial and can have life-shortening consequences: high blood pressure, heart disease, stroke, automobile accidents caused by falling asleep at the wheel, diabetes, depression, and other ailments.

Periodontal Disease and Obstructive Sleep Apnea

The relationship between periodontal disease and obstructive sleep apnea had gone uninvestigated until Gunaratnam's and colleagues' seminal study exploring a link between the

two (Famili, 2015). Sleep apnea is associated with an elevated inflammatory response. Therefore, the presence of obstructive sleep apnea was hypothesized to be linked to increased risk of periodontal disease, which prompted studies for further testing and evidence (Ahmad et al., 2013). Research conducted by Seo and colleagues reported higher prevalence of OSA in patients with periodontitis, supporting the hypothesis of association (Seo et al., 2012). Mouth breathing and intermittent decrease in oxygenation of tissues during sleep in combination with deteriorated daily life comfort may create a predisposition to periodontal disease in OSA patients (Nizam et al., 2014).

Interleukin (IL)-1β, and IL-33 are associated with both acute and chronic inflammation. Increased levels of IL-1β were detected in saliva, gingival tissue, and gingival crevicular fluid (GCF) of patients with periodontitis (Nizam et al., 2014). The prominent biologic effect of IL-33 is the induction of T-helper 2 cytokines and anti-inflammatory activity (Nizam et al., 2014). The salivary changes in the oral cavity increase the ability of microorganisms to colonize the mouth in patients with heavy mouth breathing (Dentistry iQ, 2014). Shared risk factors for periodontitis and OSA include being of the male sex, older age, obesity, oral breathing, cigarette smoking, and alcohol consumption (Ahmed et al., 2013).

Periodontal Disease – Obstructive Sleep Apnea and Gender

Previous research conducted suggested that OSA and periodontal disease is greater among males than females (Alam et al., 2012; Desvarieux et al., 2004; Sanders et al., 2016). According to the Centers for Disease Control and Prevention ([CDC] 2017) women outshine men when it comes to self-care. Research examining gender differences by Furuta and colleagues found that women tend to be better practitioners of preventative care as they are almost twice as likely to have received a regular dental check-up in the past year and schedule

recommended treatment following check-ups (Furuta et al., 2011). Women in the study also had better indicators of periodontal health, including lower incidence of dental plaque, calculus, and bleeding on probing; all of which can be used as markers of periodontal disease (American Academy of Periodontology, 2011). Women also gravitate towards an aesthetic appeal, being twice as likely to notice missing teeth on another person than men. Approximately, 74% of women would be embarrassed by a missing tooth, a possible consequence of periodontal disease, compared to 57% of men (American Academy of Periodontology, 2011).

Similar to the periodontal diagnosis, more men suffer from OSA than women. Men tend to be referred to sleep medicine centers more often than women, suggesting a discrepancy regardless of having similar symptoms when they are witnessed to have more frequent sleep apneic episodes (Lin et al., 2009). Men are also noted to have OSA when sleeping supine and higher non-rapid eye movement (NREM) sleep cycles (Rundo, 2019). Although men are generally at a higher risk of developing OSA, once women reach menopause, they possess a similar risk as men. Studies suggested that postmenopausal women with lower levels of hormones results in greater risk of OSA (O'Connor et al., 2000). OSA is also less severe in women compared with men of similar body mass index (BMI) (Rundo, 2019). Along with larger BMI's, men are more likely to have a neck circumference greater than 16 inches, a strong indicator of OSA (Hines, 2019). There are a number of pathophysiological differences to suggest why men are more prone to the disease than women (Lin et al., 2009). Although the exact mechanisms are unknown, differences in obesity, upper airway anatomy, breathing control, hormones, and aging are all thought to play a role in an individual's development of OSA (Lin et al., 2009).

Periodontal Disease – Obstructive Sleep Apnea and Racial/Ethnicity

"Race" is a multi-dimensional construct inherently associated with several difficult-to-measure exposures that can directly or indirectly affect periodontal health (Weatherspoon et al., 2016). This being the case, the burden of periodontal disease is not equally distributed in the population. Stress is among the exposures captured by race, which can potentially explain the racial/ethnic disparities in periodontal disease (Weatherspoon et al., 2016). Black and Hispanic Americans may be exposed to greater levels of stressors in today's society, including discrimination and lower socioeconomic status in comparison to their white counterparts (Williams & Mohammed, 2009). Exposure to stress has been shown to be a risk factor for periodontitis.

Varying cultural practices can also be contributors to the disease (Sanders, Essick, Beck et al., 2015). Dental caries and periodontal disease can be linked to ethnicity and country of origin even among immigrants of all income and educational levels who have lived in the United States for many years. Ethnicity is a significant factor among those whose oral health is already at-risk due to smoking habits or by having systemic health conditions known to contribute to oral infections (Cruz, 2007). The differences are rooted in the immigrant's country of origin where early cultural influences can set the stage for oral health problems later in life (Cruz, 2007). Some ethnic groups may be more prone to tooth decay because their traditional foods are high in refined carbohydrates, while other groups may be less susceptible to decay because refined carbohydrates are almost absent from their diets (Cruz, 2007). Other factors include oral health practices and environmental influences as in the case of developing countries that don't have a fluoridated water supply to provide protection against tooth decay (Cruz, 2007). Heredity can

also be a factor as some ethnic groups may be more susceptible to decay-causing oral bacteria (Cruz, 2007).

Sleep disorders can also be disproportionately experienced among racial groups and ethnicities. The Sleep Heart Health Study found a slightly increased risk of moderate to severe OSA in Blacks (20%) and American Indians (23%) compared with Whites (17%) (Young et al., 2002). Another Multi-Ethnic Study of Atherosclerosis Sleep showed the prevalence of OSA was 30% in Whites, 32% in Blacks, 38% in Hispanics, and 39% in Chinese individuals (Chen et al., 2015). These differences among racial groups may be due to variations in craniofacial anatomy (Rundo, 2019). OSA arises from a combination of pathophysiological and anatomical factors resulting in the narrowing of the upper airway at the level of the pharynx (Johal et al., 2007). Different ethnicities have their own unique cranial facial structures that can naturally make an individual more or less susceptible from developing OSA. A previous study by the Northern Sydney Central Coast Area Health Service (2009) revealed that subjects with OSA have a shorter and retruded jaw, smaller enclosed area within the mandible, wider and flatter mid and lower face, and more soft tissues or fat deposition on the anterior neck without the influence of obesity (Hui, 2009). These traits are often more common in minority populations compared to others (Cruz, 2007).

Purpose of the Study

The purpose of this study was to examine the relationship between periodontal disease and Obstructive Sleep Apnea. More specifically, this study sought to find if this potential relationship is influenced by race and ethnicity or gender.

Research Questions

The study answered the following research questions:

1. Is there a relationship between obstructive sleep apnea and periodontal disease?
2. Does ethnicity influence the relationship between obstructive sleep apnea and periodontal disease?
3. Does gender influence the relationship between obstructive sleep apnea and periodontal disease?

Hypotheses

The first research question hypothesized that there is a relationship between obstructive sleep apnea and periodontal disease. The second and third research hypotheses, that the relationship between obstructive sleep apnea and periodontal disease is influenced by gender and race/ethnicity.

Method

Design

A cross-sectional study was conducted to explore the relationship between periodontal disease and obstructive sleep apnea, and the influence gender and race has on the relationship. This study used secondary data from the 2017- 2018 National Health and Nutrition Examination Survey (NHANES). The NHANES is one of a series of health-related programs conducted by the National Center for Health Statistics (NCHS) to provide information on the health and nutritional status of the non-institutionalized civilian resident population of the United States (CDC, 2017). NHANES is unique in collecting person-level demographic, health, and nutrition information from personal interviews and a standardized physical examination in a mobile examination center (MEC) (CDC, 2017).

Procedures

The 2017-2018 NHANES data are collected from health interviews conducted in respondents' homes followed by an examination with a study team of physicians, medical, and health technicians as well as dietary and health interviewers in MECs (CDC, 2017). The NHANES interview includes demographic, socioeconomic, dietary, and health-related questions (CDC, 2017). The examination component consists of medical, dental, and physiological measurements as well as laboratory tests administered by highly trained medical personnel (CDC, 2017). To assess population differences, staff participated in cultural competency training to help them recognize and respect cultural differences (CDC, 2017). Confidential and administrative data are not released, resulting in some variables having been recoded to further protect participants' confidentiality (CDC, 2017).

Participants

The 2017-2018 NHANES dataset consists of a nationally representative sample of more than 5,000 participants (CDC, 2017). The target population for this study included all adults aged 18 years and older who responded to the questionnaire. The original dataset consisted of 9,543 participants. For the purpose of this study, only individuals who responded to the questions on the oral health and sleep disorders questionnaires were selected, and missing responses were excluded from the dataset. This resulted in a sample size of 1,513. The sample size was calculated using G* Power Software Version 3.1 for three statistical tests, including one Chi-square test of independence and two Mantel-Haenszel Chi-square tests. It was determined that the Mantel-Haenszel Chi-square test required the greatest number of participants with a statistical power of 0.80, an alpha coefficient of 0.05, and a moderate effect size, which produced a sample size of 192. As a result, a sample size of 192 participants was determined necessary to answer each research question.

Independent Variable

The independent variables included sleep disorders, gender, and ethnicity. The first variable, sleep disorders, was measured by the question SLQ040 –"In the past 12 months, how often did (you/SP) snort, gasp, or stop breathing while (you were/s/he was) asleep?" The responses included seven options, "0-Never", "1-Rarely (1-2 nights a week)," "2-Ocassionally (3-4 nights a week)," "3-Frequently (5 or more nights a week)," "7- Refused," and "9-Don't Know." Response options "1-Rarely (1-2 nights a week)," "2-Ocassionally (3-4 nights a week)," and "3-Frequently (5 or more nights a week)" were collapsed and recoded into "1-Yes." The response option "0-Never" was recoded into "2-No," and the remaining responses, "7- Refused" and "9-Don't Know" were recoded as "999- Missing."

The second independent variable, gender, was measured by the question RIAGENDR. Responses included two options coded as "male" and "female." The third independent variable, ethnicity, was measured by the question RIDRETH3. The variable was recoded from six levels into two categories. "Mexican American," "Other Hispanic," "Non-Hispanic Black," "Non-Hispanic Asian," and "Other Race – Including Multi-Racial" were collapsed and recoded into a category called "Minority." While "Non-Hispanic White" became a single category of "Non-Minority."

Dependent Variable

The dependent variable for the study was periodontal disease. The variable was measured by question OHAROCDG, "Gum disease/problem." The oral health examination was conducted by dental examiners who were dentists (D.D.S./D.M.D.) licensed in at least one U.S. state in the MECs. The examiners answered the question "gum disease" with "1-Yes" or "2-No" after assessing the gum line and oral cavity of the NHANES participants. Individuals who were not examined by the oral health professionals were coded as "Missing" in the dataset.

Data Analysis

A Chi-square test of independence was conducted to answer the first research question exploring the relationship between OSA and periodontal disease. A Cochran-Mantel-Haenszel Chi-square test was performed for the second and third research questions to analyze whether ethnicity and gender influenced the relationship between periodontal disease and OSA.

Results

The sample from this study included data from the 2017-2018 NHANES. The purpose of the study was to determine if there was a relationship between obstructive sleep apnea and periodontal disease and to analyze whether ethnicity and gender influenced that relationship.

Demographics

Survey participants *(n* = 192) were mostly male (61.5%), and most classified themselves as Non-Hispanic Black (30.7%) and Non-Hispanic White (27.6%). Participants were categorized in four age groups with the vast majority falling in the 40-59 (32.3%) and 60 and older age (33.3%) categories. The average age was 49.3 years. Most of the participants reported being married (44.6%) and most had completed a high school education or higher (65.2%). Among the 192 participants, the most reported income ranged from $20,000 to $44,999 (48.2%). In terms of education, only 8.2% of survey participants had received a college degree.

Major Findings

A Chi-square test of independence was performed to explore the relationship between OSA and periodontal disease. While it was hypothesized that a relationship between the two diseases existed, no significant association was found (X^2 (1) = .014, p > .05). Obstructive sleep apnea and periodontal disease appear to be independent events (see Table 1).

Table 1
Relationship between Obstructive Sleep Apnea (OSA) and Periodontal Disease (n=192)

Variable	Gum Disease		Adjusted OR (95% CI)
	Yes	No	
Sleep			
Yes	52 (27.1%).	1 (0.6%)	.540 (.150 – 1.938)
No	136 (70.8%).	3 (1.5%)	

Note. N = Total Number, % = Valid Percent; OR, odd ratio; CI, confidence interval. Chi-square test was used to assess the relationship between obstructive sleep apnea and periodontal disease. *p*=.906

A Cochran-Mantel-Haenszel test of independence was used to explore whether gender had an influence on the relationship of OSA and periodontal disease. Gender was not found to influence the association between OSA and periodontal disease (Male ($X^2(1) = .031$, $p > .05$; Female ($X^2(1) = .350$, $p > .05$) (see Table 2).

Table 2
Bivariate Association between Obstructive Sleep Apnea and Periodontal Disease with the Influence of Gender (n = 192)

Variable		Gum Disease		
Sleep Trouble		Yes N (%)	No N (%)	Adjusted OR (95% CI)
Male	Obstructive Sleep Apnea	33 (17.2.%)	1 (0.6%)	.805 (.071 – 9.181)
	No Obstructive Sleep Apnea	82 (42.7%)	2 (1.04%)	
Female	Obstructive Sleep Apnea	19 (9.9%)	0 (0.0%)	1.019 (.983 – 1.056)
	No Obstructive Sleep Apnea	54 (28.1%)	21 (0.6%)	

Note. N = Total Number, % = Valid Percent; OR, odd ratio; CI, confidence interval. Chi-square test was used to assess the relationship between obstructive sleep apnea, periodontal disease and gender. *Male p=1.00 & Female p=1.00*

A Cochran-Mantel-Haenszel test of independence was used to explore whether ethnicity had an influence on the relationship of OSA and periodontal disease. Race/ethnicity was not found to influence the association between OSA and periodontal disease (Racial/Ethnic Minority ($X^2(1) = .736$, $p > .05$; Non-Minority ($X^2(1) = .387$, $p > .05$) (see Table 3).

Table 3

Bivariate Association between Obstructive Sleep Apnea and Periodontal Disease with the influence of Ethnicity (n=192)

Variable		Gum Disease		
Racial/Ethnic Minority		Yes N (%)	No N (%)	Adjusted OR (95% CI)
Yes	Obstructive Sleep Apnea	37 (19.3.%)	0 (0.0%)	1.020 (.992 – 1.048)
	No Obstructive Sleep Apnea	100 (52.1%)	2 (1.0%)	
No	Obstructive Sleep Apnea	15 (7.8%)	1 (0.5%)	.417 (.024 – 7.107)
	No Obstructive Sleep Apnea	36 (18.8%)	1 (0.5%)	

Note. N = Total Number, % = Valid Percent; OR, odd ratio; CI, confidence interval. Chi-square test was used to assess the relationship between obstructive sleep apnea, periodontal disease and gender. *Minority p=1.00 & Non-Minority p=.517*

Discussion

The study analysis results did not present significance for any of the three research questions. Even with lack of association, study limitations, and contradictions to previous literature, the findings lead to certain public health implications that can improve oral health.

Summary of Major Findings

This study aimed to find an association between obstructive sleep apnea and periodontal disease. However, there was no association found. The results from this study contradict the initial Gunaratnam's and colleagues' (2008) study, which found that a relationship existed between the two diseases. A study conducted by Seo and colleagues (2012) also found an association between sleep apnea and periodontal disease, while this study did not. In a study done by Nizam (2014), it was found that mouth breathing and intermittent decrease in oxygenation of tissues during sleep in combination with high levels of physical activity may create a predisposition to periodontal disease in OSA individuals. In addition, salivary changes in the oral cavity increase the ability of microorganisms to colonize the mouth in individuals with heavy mouth breathing, which is a common characteristic of OSA patients.

The lack of association in this research study may have resulted from an uneven distribution of the sample size as well as how periodontal disease was identified. With regard to sample size, very few participants reported a lack of gum disease resulting in imbalanced data. The definition of periodontal disease may have influenced the amount of responses captured. The periodontal disease variable may have been measured differently compared to the measurement in other studies. When examining the relationship between the two diseases, Nizam and colleagues (2014) studied severe forms of periodontal disease instead of those that were mild or in the early stages. The NHANES data questionnaire does not specify the stage of periodontal

disease; instead, the variable captured gum disease that was visible when the participant was examined.

The findings for second and third research questions noted that gender and ethnicity did not influence the association between OSA and periodontal disease. These findings are inconsistent with Alam's and associates' (2012) whose research suggested that OSA and periodontal disease are greater among males than females (Alam et al., 2012). It also contradicted research conducted by Furuta and colleagues (2011), which found that women tend to be better practitioners of preventative care as they are more likely to follow up with treatment and procedures. In this study, the majority of respondents were male (61.5%) than females (38.5%), thus leading to an unequal representation of gender in the study.

Ethnicity was initially thought to be a significant factor in oral health outcomes due to various cultural differences. A study done by Cruz (2007) showed that immigrants from Puerto Rico, Haiti and India are more prone to tooth decay because their traditional foods are high in refined carbohydrates. The same study also found that developing countries have an absence of fluoridation in the water supply, a practice which provides protection against tooth decay (Cruz, 2007). The findings of this study contradict the results Cruz obtained. The lack of association with regard to ethnicity in this research study could be due to under sampling of other minority populations. The participants were largely made up of Non-Hispanic Black, Non-Hispanic White, or Mexican American, while Non-Hispanic Asians, Native Americans, Pacific Islanders, or other multi-racial individuals were underrepresented. Furthermore, in a 2019 study, differences in sleep disorder outcomes among racial groups were found to be due to variations in craniofacial anatomy (Rundo, 2019). Each ethnicity has unique cranial facial structures that can naturally make an individual more or less susceptible from developing OSA in their lifetime.

However, in this study sleep disorders were also disproportionately experienced among racial groups and ethnicities, contradicting the results of Rundo's study. Gender and ethnicity had no bearing on the relationship of OSA and periodontal disease; therefore, these findings do not appear to align with previous research.

Public Health Implications

The results of these findings have public health implications for clinical practice and program implementation. Although, there is no association between OSA and periodontal disease, it is imperative to prevent periodontal disease since it is pervasive in the current United States population (NHANES, 2018). Among the 192 participants surveyed, 188 (97.9%) responded to having periodontal disease. Oral healthcare is not consistently taught to the public; therefore, diseases progresses without attention. Educating the population on the risks, signs, and symptoms with cultural and linguistic appropriateness would create inclusivity, eliminating the barriers of fear and lack of education that often overwhelm patients.

Furthermore, patients need to be screened earlier and more frequently to assess the disease and avoid further damage. Bi-annual dental screenings result in more patient interaction and consistent assessment, allowing the tracking of disease progression rather than annual visits, which are completed with more or less minimal effort to fill insurances quotas. The majority of the study participants reported an income of $45,000 or less, the threshold for government assisted medical care. Individuals who qualify for subsidized dental care can have their insurance(s) implement mandatory periodontal visits and procedures in a calendar year. Certain benchmarks of treatment already exist, such as, oral cancer screenings and regular teeth cleaning. Catching the disease early would allow individuals to live healthier, pain free lives and reduce the risks of developing other systemic diseases that can be detrimental to one's health.

Study Limitations

One limitation of this study was the under representation of minority groups, education levels, and income brackets. In this study, a majority (66.2%) of the participants made less than $45,000 and over (69%) had received a high school diploma/GED equivalent or less. Only 8.2% completed a college degree or more. The under-representation of these groups did not allow for diversity within the results to examine if education and income levels have an influence on the diseases studied. Having a larger pool of participants from various backgrounds would allow for a more comprehensive representation of the population, resulting in more generalizable findings that are less skewed to certain demographics.

A second limitation of this study was the recall bias. Recall bias is an error that occurs when participants do not remember previous events; therefore the accuracy of their answer may be flawed. Since the sleep of the participants was not monitored by a health professional, they had to answer the questionnaire based solely on their own opinion and/or feedback from their partner or spouse. This could result in false or flawed responses.

Another limitation was the cross-sectional nature of the study. Cross-sectional studies are used to examine the differences between groups; however, the outcome and exposures of the participants are measured at the same point in time (Setia, 2016). It is difficult to determine the progression of the disease without observing it over a period of time. This study would have benefited from a longitudinal design, using primary data, where the questions could be tailored to the patients' sleep patterns, oral health, and stage of periodontal disease. It would also allow for sufficient time to track the participants' health outcomes, ensuring more significant and accurate results specific to the study and its variables.

Future Direction

Future research should continue to examine the relationship between periodontal disease and obstructive sleep apnea. Studies should also have equal representation from diverse communities as well as different education levels and income levels to better examine the distribution of these populations and determine the impact of these variables on periodontal disease and OSA. Research should also be conducted using a longitudinal study design with primary data specific to certain regional areas where the diseases are prevalent. This would allow the primary investigators to observe the participants over a period of time and properly assess the health outcomes of the given population.

Conclusion

Periodontal disease and sleep apnea are heavily prevalent diseases impacting the health of the American population. Due to the late manifestation of the symptoms of the two diseases, a majority of individuals go undiagnosed until the later stages. Therefore, it is imperative to bridge the misconception of periodontal disease symptoms and not overlook sleep apnea as a routine distress. A stronger awareness of the potential ramifications of the combination of the two health conditions can be gained by providing better oral health care for individuals.

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Appendix A: Tables

Table 4
Demographic Description of 2017-2018 NHANES Sample (n=192)

Variable	n	%
Gender		
Male	118	61.5%
Female	74	38.5%
Race/Ethnicity		
Non-Hispanic Black	59	30.7%
Non-Hispanic White	53	27.6%
Mexican American	34	17.7%
Other Hispanic	16	8.3%
Non-Hispanic Asian	15	7.8%
Other Race-Including Multi-Racial	15	7.8%
Age		
17 - 25	21	10.9%
26 - 39	45	23.4%
40 - 59	62	32.3%
60 and Older	64	33.3%
Annual Household Income		
$0 to $4,999	9	5.4%
$5,000 to $9,999	10	6.0%
$10,000 to $14,000	11	6.6%
$15,000 to $19,999	20	12.0%
$20,000 to $24,999	21	12.7%
$25,000 to $34,999	18	10.8%
$35,000 to $44,999	21	12.7%
$45,000 to $54,999	8	4.8%
$55,000 to $64,999	10	6.0%
$65,000 to $74,999	8	4.8%
$20,000 and Over	3	1.8%
Under $20,000	8	4.8%
$75,000 to $99,999	10	6.0%
$100,000 and Over	9	5.4%
Marital Status		
Married	82	44.6%
Widowed	11	6.0%
Divorced	22	12.0%
Separated	6	3.3%
Never Married	44	23.9%
Living with Partner	19	10.3%
Education Level		
Less than 9th grade	18	9.8%
9-11th grade (Includes 12th grade No Diploma)	46	25.0%
High School Graduate/GED or Equivalent	63	34.2%

Some College or AA degree	42	22.8%
College Graduate or Above	15	8.2%