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Investigating the Oral Health of Individuals with Depression: Finding from the 2015-2016 National Health and Nutrition Examination Survey (NHANES)

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ABSTRACT

Investigating the Oral Health of Individuals with Depression: Finding from the 2015-2016
National Health and Nutrition Examination Survey (NHANES)

by

Bayan Ali M Almohaimeed

December 11, 2019

Background: Recent studies have shown an association between oral disease (e.g. periodontal) and depression. However, most of these studies did not examine depression in association with other critical oral health outcomes such as preventative dental care and dental care access, as well as oral health-related quality of life. Therefore, the study aims to investigate the association between depression with indicators of oral health taking into account sociodemographics and chronic disease indicators (CDI).

Methods: The data were obtained from 2015-2016 NHANES. Our independent variable is depression status, which was measured using the Patient Health Questionnaire-9 (PHQ-9). The dependent variables are oral health outcomes (oral health condition, oral ache, periodontal disease, bone loss, dental care, dentist visit, feeling bad and having difficulty because of oral health, and using dental floss). Covariates included sociodemographics and CDI such as current smoking, diabetes, and body mass index.

Results: A total of 5,992 respondents 18+ years old were included. The sample mean age was 47.22 (45.97-48.46). Out of 5,992 respondents 49.67% were females. The prevalence of depression was 5.48%, and greater among females (65%) than males (34%); higher among individuals with low income (42%) than others (p value <.0001). After adjusting for sociodemographics and CDI, participants with depression were more likely to report fair/poor oral condition [aOR=2.18 (1.33-3.57)], oral pain [aOR=2.87 (1.86-4.44)], and difficulty accessing needed dental care [aOR=2.78 (2.00-3.86)] than others. Having depression was associated with poor oral health perceptions [aOR=2.26 (1.51-3.38)], and having difficulty at job/school because of their oral health [aOR=2.96 (1.64-5.33)].

Conclusion: The present study provides empirical evidence on the association between depression with oral health outcomes, including access to dental care.

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BY

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Bayan Ali M Almohaimeed

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TABLE OF CONTENTS

AUTHOR’S STATEMENT	IV
TABLE OF CONTENTS	V
LIST OF TABLES	VI
CHAPTER I: INTRODUCTION	1
1.1 RESEARCH QUESTIONS	2
1.2 HYPOTHESIS.....	3
CHAPTER II: LITERATURE REVIEW	4
2.1 ORAL DISEASE	4
2.2 DISPARITY AND ORAL HEALTH.....	5
2.3 DENTAL CARE COST:	6
2.5 DENTAL CARIES	7
2.6 PERIODONTAL DISEASE	8
2.7 TOOTH LOSS.....	9
2.8 ORAL HEALTH AND SMOKING	10
2.9 ORAL HEALTH AND DIABETES	10
2.10 DEPRESSION AND ORAL HEALTH	11
2.11 LITERATURE REVIEW REFERENCES.....	13
CHAPTER III: MANUSCRIPT	26
3.1 INTRODUCTION	26
3.2 METHODS	28
3.3 MEASURES.....	28
3.3.1 <i>Independent variable</i>	28
3.3.2 <i>Dependent variables</i>	29
3.3.3 <i>Sociodemographic variables and CDI</i>	30
3.3.4 <i>Statistical Analysis</i>	31
3.4 RESULTS: DESCRIPTIVE STATISTICS.....	32
3.5 DISCUSSION	34
3.6 LIMITATIONS.....	36
3.7 IMPLICATIONS FOR PUBLIC HEALTH PROFESSIONALS AND DENTISTS.....	37
3.8 CONCLUSION.....	38
REFERENCES.....	44

LIST OF TABLES

Table 1. Sociodemographic Characteristics of persons with and without depression and chronic disease indicators NHANES 2015-2016.....	39
Table 2. Association between oral health outcomes of persons with and without depression.	41
Table 3. Multivariate analysis for depression and Chronic disease indicators by preventive measures and clinical presentation of oral health outcome.	42
Table 4. Multivariate analysis for depression and Chronic disease indicators by self-reported participant's subjective prospective about oral health.	43

CHAPTER I: INTRODUCTION

Oral health is a vital part of our overall health, as the American Dental Association (ADA) believes that poor oral health can lead to inferior body health states (Oral Health, 2019). In the last few years, public health professionals shed light over oral health and disease as a public health concern. Health professionals' main goal is to explore the epidemiology of oral disease and to expose the underlining causes. According to the Center of Disease Control and Prevention (CDC), the statistic of oral disease shows a huge increase in oral diseases prevalence among American's adults. In the United States, untreated dental caries was present in thirty percent of the population, and more than forty-five percent of adults aged 30 years and older have periodontitis (Dye, et al., 2015; Eke, et al., 2015).

The importance of having optimum oral health has been indicated to improve mental and physical health. However, poor oral health can cause a decrease in life quality and affect work performance and productivity. On the other hand, the cost of oral care and treatment is very high, which can be a burden to the country's economy. Oral disease is a public health problem, and in order to resolve it, we must first comprehend the underlining causes. Over the past few decades, researchers have been studying oral and dental disease risk factors, and they have been observing the trends of oral and dental disease. Researchers' efforts were focused on the biological and behavioral aspects that affect oral and dental health, but they were few studies considering the effect of mental health as an oral disease risk factor. For example, depression, anxiety, and dentist phobia were found to be the most common mental disorders that affect negatively on oral health.

Depression is a widespread mental disorder that become the focus of health professionals in the United States. (Depression, 2018). Depression can cause mental and physical illnesses that lead to lesser life quality. Lately, studies hypothesize that there is a relationship between depression and physiological and behavioral precursors of oral disease (Dumitrescu, et al., 2009). They believe that depression can affect oral health behaviors like brushing and flossing, which result in undesirable oral health outcomes like cavities and periodontal disease. There are only a few studies in the United States that focus on this subject, which encouraged us to take the opportunity and dive deep to explore this relationship.

This study aims to investigate depression and oral health outcomes among U.S adults and to identifies the relationship between depression and oral health outcomes from 2015 to 2016 using the National Health and Nutrition Examination Survey (NHANES).

1.1 Research Questions

Our research questions are: what is the prevalence of oral health outcomes among U.S. adults with and without depression between 2015-2016 using The National Health and Nutrition Examination Survey (NHANES)? Does depression have a significant impact on an individual's oral health (investigating depression's influence on participants' oral health across age, gender, race, marital status, country of birth, education, and income)?

1.2 Hypothesis

For this research, we hypothesize that adults with depression have poor oral health compared to others with no depression taking into account the sociodemographic data like age, gender, race, marital status, country of birth, education, income, and chronic disease indicators (CDI).

CHAPTER II: LITERATURE REVIEW

2.1 Oral disease

Oral disease is one of the most common noncommunicable diseases in the world (Petersen, et al., 2005; Beaglehole, et al., 2009). Oral disease is considered an epidemic health-problem (Petersen, et al., 2005; Beaglehole, et al., 2009). Oral diseases include dental caries, periodontal diseases, tooth loss, and oral cancer. In the United States, untreated dental caries was present in 30 percent of the population, and more than forty-five percent of adults older than 30 years old have a sign of a periodontal problem (Dye, et al., 2015; Eke, et al., 2015). The sizable number of oral diseases has a significant impact on the health care system and the country's economic status. Since the cost of dental treatment is high, not all people can afford it, and according to the World health organization (WHO) around 5% of developed country total health care cost is on dental treatments (Oral health , 2018).

Oral disease can affect people physically by causing pain, discomfort, and even in extreme cases, death. Additionally, it can affect their mentality and decrease their quality of life. It can cause a loss of confidence which leads to stress and anxiety. Studies have linked oral disease to many chronic illnesses: cardiovascular disease (CVD), respiratory disease, diabetes, and cancer (Oral health and noncommunicable diseases, 2018). Moreover, a study by Griffin et al. found that people with chronic illnesses have a higher risk of having oral diseases than others (Griffin, et al., 2009). Recent studies have established an association between oral disease and psychological disorders such as depression, anxiety, post-traumatic stress disorder (PTSD), and phobias but insufficient data was available (Kisely, et al., 2016). Oral and dental disease has numerous causes

and risk factors. Behavioral risk factors are considered one of the most essential causes of oral and dental disease, and these include smoking, high sugar diet, and induced gastroesophageal reflex. A diet containing high sugar intake and sticky food increases the risk of having dental caries and negatively affects the oral bacterial flora (Moynihan, 2005). On the other hand, the consumption of adequate fluoride through water, food, or prescription tablets can help strengthen the enamel, which is the outer surface of the tooth, for children who still developing their permanent teeth (Carey, 2014; Rozier, et al., 2010) Despite fluoride's benefits, it can be harmful if it's taken excessively (DenBesten, & Li, 2011).

Poor oral hygiene is another contributing factor to oral and dental disease. The optimum oral hygiene routine consists of brushing twice a day and flossing once a day. Moreover, using fluoride enhanced mouthwash can decrease or control plaque, periodontitis, halitosis or bad breath, and tooth decay. There are different types of mouth rinse and toothpaste; some of them are used for therapeutic purposes or just for cosmetic. In some cases, patients with chronic diseases or mental disorders find it difficult or don't prioritize practicing basic oral care.

2.2 Disparity and oral health

Oral health disparity is a major issue facing public health professionals and human rights advocates. Having access to dental and oral treatments depends on social and demographic status, and inequality in health care access can be a considerable barrier for these people. Oral health disparity can be impacted by age, income, and race/ethnicity. Low-income children have the highest dental caries rate and the lowest dentist visits comparing to high-income children. Furthermore, race has played a significant role over the years on dental health access. Children

from minority groups face a great disparity regarding access to medical and dental care (Flores, & Lin, , 2013). A study found that the elderly visits the dentist fewer times than other age groups despite having compromised oral health condition (Petersen, et al., 2010). According to the Center for Disease Control and Prevention (CDC), American adults between the age of 33 and 44 who are black, non-Hispanics, and Mexican have almost twice the number of untreated teeth caries than American adults who are white, non-Hispanics (Oral Health, n.d.). In 2016, a study by Jin et al. have linked oral diseases to people socioeconomic status, sugar intake, and smoking (Jin, et al., 2016).

2.3 Dental care cost:

The cost of dental treatment is very high. In 2010, the global burden of dental disease was estimated to be more than 440 billion dollars and the cost of dental care around \$300 billion. There are more than \$140 billions of indirect expense that oral diseases have caused (Listl, et al., 2015). In high-income countries, over twenty percent of health expenses are for dental treatment and care (Oral health , 2018). Studies have discussed different ways to decrease dental care cost. One study suggests expanding the Affordable Care Act's children's dental care coverage to prevent and maintain oral disease before it becomes complicated and expensive (Nasseh, et al., 2013). Many Americans face a financial barrier to get dental care. The Affordable Care Act (ACA) has reduced these barriers and made health care more accessible and affordable, yet many American adults are not covered by the ACA dental care insurance plan. In 2013, more than 10 percent of children and one-third of nonelderly adults had no dental insurance in the United States (Nasseh, et al., 2013). According to the National Health Interview Survey in 2014, 12% of adults ages 19 to 64 reported

they did not receive necessary dental care because of the high cost. This is compared to 7% of people ages 65 and older and 4% of children (Vujicic, et al., 2016).

2.4 Losing workday and missing school

Poor oral health has great impact on work and school attendance and students' academic performance. A study concluded that children with dental ache are more likely to miss school than others, and children who attended school with dental pain or discomfort have shown to exhibit inferior performance than their classmates (Jackson, et al., 2011; Seirawan, et al., 2012). A study by Kelekar & Naavaal investigated the time lost during work or school for dental visits among adults in the United States and found that generally more than 300 million hours are lost to dental care visits and 90 million hours for emergency dental care. Those statistics results suggest an inequality in hours lost to dental care among different races and levels education; higher education is associated with increased amount of planned dental visits. For example, Hispanic adults and non-Hispanic white adults are more likely to visit the dentist regularly as opposed to other race groups (Kelekar, U. & Naavaal, 2018).

2.5 Dental caries

Dental caries, also known as tooth decay or cavities, are the destruction of susceptible dental hard tissues by a bacterial acidic by-product. Tooth decay is a multifactorial disease. This process starts with the formation of dental plaque by the bacteria biofilm within the outer surface of the tooth. The oral bacteria digests carbohydrates in order to produce acid and cause dental caries. The risk factors of dental caries can be physical or biological such as root and crown shape

and mineral composition. Also, the salivary flow factor, based on its fluoride content, plays a large role on the susceptibility of getting dental caries (Silk, 2014; Marsh, et al., 2009).

Dental caries can cause pain, discomfort, and difficulty eating. Also, they may cause inflammation on the surrounding gingival tissue, tooth loss, and abscesses (Laudenbach, & Simon, 2014). Selwits et al. stated, “Dental caries results from an ecological imbalance in the physiological equilibrium between tooth minerals and oral microbial biofilms” (Selwitz, et al., 2007). Caries can affect tooth enamel, dentin, and cementum. The carious cavity can vary in color from yellow to black, and they can be on the crown of the tooth (coronel caries) or the root of the tooth (root caries) (Fejerskov, 1997; Thylstrup, & Fejerskov, 1994). Dental decay can be caused by the interaction of bacterial acid and saliva which can cause demineralization to the teeth; cavities as the result. Demineralization is the earliest stage of dental caries and it can be prevented by applying fluoride to the affected tooth using fluoride tooth paste or fluoride varnish. In the United States, Community Water Fluoridation program, which is the process of adjusting the amount of fluoride in the drinkable water, believed to prevent over one-fourth of tooth decay incidents among children and adults (Division of Oral Health, National Center for Chronic Disease Prevention and Health Promotion, 2019).

2.6 Periodontal disease

Periodontal disease is the eleventh most common disease in the world (GBD 2016 Disease and Injury Incidence and Prevalen & Looker, 2017). It is an infection that affects the gingiva, supporting connective tissue, and the alveolar bone (Sanz, et al., 2017; Williams, 1990). Dental plaque microbiology in relation with periodontitis has been studied extensively. Oral bacteria

produce plaque, subgingival or supragingival, which has been found to cause periodontal disease. The research found more than 300 types of bacteria in dental plaque that caused periodontitis (Jin, et al., 2016; Kassebaum, et al., 2014a; Christersson, et al., 1991). Periodontal disease can be treated chemically by using antibacterial, or mechanically by removing dental plaque using brushing and flossing. In some cases, people may need to visit the dentist office to remove the harden part of dental plaque which called calculus. Periodontal disease can cause bad breath, persistence bad taste, pain discomfort, and eating difficulties. Also, it can cause gingival redness, gingival swelling, tooth sensitivity, and in advance cases, tooth loss. There are many risk factors for periodontal disease such as poor oral hygiene, smoking, diabetes and poor diet (Maintaining and improving the oral health of young children, 2014; Chapple, et al., 2013). There is some medication that reduces the salivary flow, which in results increase the chance of getting periodontitis. In addition, some diseases like the immune deficiency virus AIDS compromise the immunity and enhance oral cavity bacterial growth and causes periodontists (Tonetti, et al., 2017; Eke et al., 2012). In the United State, more than forty-five percent of adults aged 30 years and older have periodontitis and around seventy percent of adults 65 years and older. Periodontitis increases with age (Eke, et al., 2015).

2.7 Tooth loss

In the last decade, tooth loss has been declining among adults in the United States (Kassebaum, et al., 2014). Tooth loss can be defined as the process of tooth falling out due to dental or periodontal disease. Tooth loss can be a neutral process when the primary teeth are replaced by permanent teeth in children (Nowak, et al., 2019) or it can occur because of an injury or oral and dental trauma. Tooth decay and periodontal disease are the leading cause of tooth loss

(Marcus, et al., 1996); (Burt, et al., 1990). In developed countries, edentulism or tooth-loss, among the elderly population, is one of the primary causes of Years Lived with Disability (YLD) (GBD 2016 Disease and Injury Incidence and Prevalence & Looker, 2017). Studies suggest an association between tooth loss and socioeconomic status. For example, low income and low education level were found to be strongly associated with tooth loss (Matsuyama, et al., 2019; Buchwald, et al., 2013).

2.8 Oral health and Smoking

Tobacco can be used in two ways inhalation, smoked tobacco, and chewing tobacco (Al-Ibrahim, & Gross, 1990). People mostly use tobacco as smoked. In the United States, fourteen percent of people at 18 years old and older smokes tobacco (Smoking & Tobacco Use, 2019). Tobacco smoking has been proven to negatively impacts people health. Smoking is associated with cardiovascular disease, respiratory disease, cancer, and death. Smoking adversely affects people oral and dental health. It causes dental caries, periodontal disease, gingival recession, tooth loss, and cancer (Agnihotri, & Gaur, 2014; Benedetti, et al., 2013; Warnakulasuriya, et al., 2010; Banihashemrad, et al., 2009; Winn, 2001). Also, smoking slows the healing process after having oral surgery (Balaji, 2008). Studies found that smokers have a weak sense of smell and taste and they also have lower salivary flow and buffer ability (Rad, et al., 2010).

2.9 Oral health and diabetes

Diabetes mellitus is a widespread chronic disease worldwide. According to the World Health Organization (WHO) diabetes is one of the leading causes of death globally and around 400 million people have the disease (Diabetes., 2018). Diabetes mellitus is a chronic disease that affect

the insulin production from the pancreases or the ability of the body to efficiently use the insulin (Alberti & Zimmet, 1998). Diabetes have been linked to increase the risk of having dental caries, moderate to severe periodontal disease (Liu, et al., 2018; Sima & Glogauer , 2013), teeth loss, and xerostomia (Lamster, et al., 2008; Soell, et al., 2007; Moore, et al., 2001). Another study found that diabetes reduced the effectiveness of saliva to maintain healthy oral flora which increase the risk of having dental caries (Collin, et al., 1998).

2.10 Depression and oral health

The American psychiatric association defined depression as” a medical illness that negatively affects how you feel, the way you think, and how you act” (American Psychiatric Association, 2013). In the last few years, depression was a prevalent disorder in the United States (Weinberger, et al., 2018). According to the CDC, during 2013-2016, around 8 percent of American adults, age 20 and higher, suffers from depression (Depression, 2018). Depression sign and symptoms vary between people. It can be mild, moderate, or severe. Studies believe that depression can cause a loss of interest in life, family, and friends. Also, it can affect people quality of life, such as self-care activity like teeth brushing and flossing (Barbosa, et al., 2018). Like many psychological disorders, depression effect people physical health and well-being. Depression has been linked to many chronic diseases such as diabetes, cancer, cardiovascular disease (CVD) (Clarke, et al., 2009) and respiratory disease (Lawrence, et al., 2010). A study by Pan A. proved that the relationship between depression and diabetes is bidirectional (Pan, et al., 2010). In 2016, a cohort study showed that depression is associated with hormonal contraception use among women (Skovlund, et al., 2016).

A study done by Elter et al. in United State 2002, discussed the relationship between depression and periodontal disease. After adjusting for gender, smoking, antidepressant use, physical health, and baseline oral health, they concluded that after one-year depression affected periodontal health adversely (Elter, et al., 2002). However, a study done in 2003 by Persson et al. found out that there is no relation between periodontal disease and depression, after adjusting for sociodemographic and health factor associated with a periodontal disease like smoking, (Persson, et al., 2003). Using the Behavioral Risk Factor Surveillance System (BRFSS) Anxiety and depression module (PHQ-8), Okoro et al in 2012 concluded that there is a relation between tooth loss and depression and anxiety (Okoro, et al., 2012). In 2014, Saman et al. studied the association of depression and partial and full edentulism patients. The study result was after controlling for confounders like SES and race/ethnicity, that chronic depression is associated with partial and full edentulism (Saman, et al., 2014). On the other hand, depression medication usage believed to cause side effects like dry mouth and change in the oral normal flora, which increase the risk of having dental caries (Bardow, et al., 2011); (Lalloo, et al., 2013).

Using the National Health and Nutrition Examination Survey (NHANES) 2015-2016 will allow us to obtain depression statistic and oral health status and outcomes data for the U.S. adults population. Also, it will help us to understand the relationship between depression and oral health outcomes and take into account sociodemographics and chronic disease indicators (CDI).

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CHAPTER III: MANUSCRIPT

3.1 Introduction

Depression is a widespread mental disorder that has become the focus of health professionals in the United States (Depression, 2018). The American Psychiatric Association defined depression as “a medical illness that negatively affects how you feel, the way you think, and how you act” (American Psychiatric Association, 2013). Since 2005, depression has been a prevalent disorder in the United States (Weinberger, et al., 2018). According to the Center of Disease Control and Prevention (CDC), during the years from 2013 to 2016, around 8 percent of American adults, age 20 and higher, suffered from depression (Prevalence of Depression Among Adults Aged 20 and Over: United States, 2013–2016, 2018). Depression signs and symptoms vary between individuals and can be mild, moderate, or severe. Studies show that depression can cause a loss of interest in life, family, and friends (Depression, 2018). Also, it can affect individuals’ quality of life, such as self-care activities like teeth brushing and flossing (Barbosa, et al., 2018). Like many psychological disorders, depression affects individuals’ physical health and well-being and has been linked to many chronic diseases such as diabetes, cancer, cardiovascular disease (CVD) and respiratory disease (Lawrence, et al., 2013; Lawrence, et al., 2010; Clarke, & Currie, 2009).

Recent studies have shown an association between depression and oral disease like periodontal disease, dental caries but little data were available (Kisely, et al., 2016). Oral disease is considered an epidemic health-problem (Petersen , et al., 2005). In the United States, untreated dental caries was present in thirty percent of people, and more than forty-five percent of adults

older than thirty years old have at least one sign of a periodontal problem (Dye, et al., 2015). A study conducted by Elter et al. in the United States in 2002, discussed the relationship between depression and periodontal disease. After adjusting for gender, smoking, antidepressant use, physical health, and baseline oral health, they concluded that after one year depression affected periodontal health adversely (Elter, et al., 2002). However, a study done in 2003 by Persson et al. found that there is no relation between periodontal disease and depression after adjusting for sociodemographic data and health factors associated with periodontal disease like smoking (Persson, et al., 2003). Using the Behavioral Risk Factor Surveillance System (BRFSS) Anxiety and Depression Module (PHQ-8), Okoro et al. concluded in 2012 that there is a relation between tooth loss and depression and anxiety (Okoro, et al., , 2012). In 2014, Saman et al. studied the association of depression with partial and full edentulism patients. The study results found that after controlling for confounders like socioeconomic status (SES) - for example, race or ethnicity - chronic depression was associated with partial and full edentulism (Saman, et al., 2014).

Contemporary studies hypothesize that there is a relationship between depression and oral disease. However, most of these studies did not examine depression in association with other essential oral health outcomes such as preventative dental care measures and dental care access, as well as oral health-related quality of life. Therefore, the present study aims to investigate oral health outcomes among U.S adults and to identify the relationship between depression and oral health outcomes from 2015 to 2016 using the National Health and Nutrition Examination Survey (NHANES).

3.2 Methods

In this cross-sectional study, we used secondary data. The data were obtained from the 2015-2016 National Health and Nutrition Examination Survey (NHANES). The NHANES's goal is to evaluate the health and nutritional status of American adults and children. The survey contains an interview and an examination. NHANES is a large, well-characterized program of the National Center for Health Statistics (NCHS) at the Center for Disease Control and Prevention (CDC).

Our independent variable was depression status, and the dependent variables include oral health outcomes. Data included in the study were the participants' sociodemographic data like age, gender, race, marital status, income, country of birth, and education. We also included current smoking, diabetes, and body mass index. For oral and dental health analysis, we used Oral Health Questionnaire (OHQ). Furthermore, depression was measured using the Patient Health Questionnaire-9 (PHQ-9). All eligible adult participants, 18 years and older, with complete data were included in the study, and children were excluded. 5,992 participants were eligible for the study.

3.3 Measures

3.3.1 Independent variable

For depression, we used Patient Health Questionnaire-9 (PHQ-9). It is a nine-item depression screening tool developed in 2002 by Kroenke and Spitzer, which were used to assess the occurrence of depression symptoms for the past two weeks of the survey (Kroenke, et al. ,

2002; Kroenke, et al., 2001). For each question of the nine-item instrument, the responses were broken down into four categories, and each category was assigned a numerical value: 0 for "not at all," 1 for "several days," 2 for "more than half the days," and 3 for "nearly every day." The PHQ_9 incorporates DSM-IV depression diagnostic criteria (Spitzer, et al., 1999). A participant's total score is based on the sum of the points in each item ranging from 0 to 27. Major depression and depression severity can be assessed using pre-defined cut-point references. For this study, we used a score of ≥ 10 points since this cut-point had a sensitivity of 88% and a specificity of 88% for major depression (Kroenke, et al., 2001). The Patient Health Questionnaire-9 (PHQ-9) depression screener was coded into SAS, and the final score was calculated for each participant. Depression status was dichotomized into "depression group" for participants with ≥ 10 points and "non-depression group" for participants who have a score of < 10 points.

3.3.2 *Dependent variables*

For oral health outcomes, we used the Oral Health Questioner (OHQ). This questioner contains participants' answers to oral health questions, which we used to evaluate oral health outcomes. The questions included information about participants' oral health conditions (Excellent, Very good, Good, Fair, and Poor). Also, we included other important variables that can present an idea about the participants' oral and dental health states, such as present dental ache, periodontal disease, and bone loss. Also, we reported participants' life quality measures such as if the participants ever felt bad or embarrassed because of oral health, and if they missed work or had difficulty at the job because of dental pain. Moreover, we included participants' dental care access, dentist visits, and flossing as an oral hygiene behavior measure.

3.3.3 *Sociodemographic variables and CDI*

For sociodemographic data, age and gender were included. The age means, median, and interquartile range were calculated for individuals with and without depression. Also, for race/ethnicity we categorized participants' race/ethnicity into three categories: Non-Hispanic White, Non-Hispanic Black, and Other Race. The Multi-Racial category was included under Other Race. For marital status, we have two categories: Married or Living with Partner (category one) and Divorced, Separated, Widowed, or Never married (category two). For country of birth, we have two classifications; participants' who were born in the U.S and other countries. Family income was classified into three categories: less than \$25,000; \$25,000 to less than \$55,000; and more than \$55,000. Participants who responded with other, unsure, or declined to answer were considered as missing, which were excluded from the analysis.

For participants' chronic disease indicators, we included current smoking, diabetes, and BMI. For current smoking, it was defined as participants who reported that they have smoked 100 cigarettes and are currently smoke "everyday" or "someday". For diabetes, we included "yes" for having diabetes and "no" for not having diabetes. Also, we included BMI, as smoking, diabetes, and BMI can all be possible mediators. The BMI was separated into four categories; underweight (BMI \leq 18.49), Normal (BMI 18.5 – 24.99), Overweight (25 -29), and Obese (BMI \geq 30). We also added a new variable called "CDI-count", which represent the number of CDI including depression, the participants' have had. The CDI-count has four categories: 0 or no CDI, 1 CDI, 2CDI, and 3 or more CDI.

3.3.4 *Statistical Analysis*

Data analyses were completed using Analytics Software Solutions (SAS) version 9.4 software. Univariate, bivariate, multivariate and weighted frequency were calculated. Logistic regression was performed to investigate the differences between individuals with and people who without depression.

Bivariate and multivariate analyses to compare participants' sociodemographics, chronic disease indicators, and oral health outcomes for individuals with and without depression were conducted. The Wilcoxon rank-sum test for a continuous variable like age and chi-square for categorical variables and weighted percentages were reported. We used the Full sample 2-year MEC exam weight; for cluster, we used the Masked variance pseudo-PSU, and for strata, we used the Masked variance pseudo-stratum. Weighted frequencies, adjusted odds ratio, 95% confidence intervals (CIs), and p-values were presented; we used a p-value of 0.05 for statistical significance.

3.4 Results: Descriptive Statistics

A total of 5,992 participants who were over 18 years old were included, and missing data were excluded. Table 1. shows participants' sociodemographic characteristics and chronic disease indicators for individuals with and without depression. Out of 5,992 participants 334 (5.48%) were having depression; their mean age was 48.82 [CI 95%: (45.99-51.65)], and their median was 50.03 [CI 95%: (34.48-61.53)]. For gender, 65.54% [CI 95%: [57.97-73.11)] of females had depression which is higher than males' 34.46% [CI 95%: (26.89-42.03)]; higher among individuals with low income of less than \$25,000 (42.81%) than others (p value <.0001). For marital status, 54.92% [CI 95%: (45.44-64.40)] of individuals who were, "divorced/ separated/ widowed/ never married," had depression, as did around 45.08% [CI 95%: (35.60-54.56)] of those who were "married/ living with a partner." Gender, marital status, family income, and education level were significantly associated with depression (p-value <.0001). On the other hand, chronic disease indicators such as current smoking were higher among individuals with depression (45.43%) while for individuals without depression the percentage was lower (16.66%).

Table 2. shows the oral health outcomes, dental care access, and behaviors among participants with and without depression. For oral health condition across the depression group, 44.51 % [CI 95% (35.53-53.50)] reported "good/very good/ excellent" oral health and 55.49% [CI 95%: (46.50-64.47)] reported "fair/poor" oral health. Among participants with depression, 50.84% have had dental ache, 33.83% have had periodontal disease, and only 19.75% have had bone loss. On the other hand, dental ache was 19.81%, and periodontal disease was 18.60% among the non-

depression group. Participants with depression who felt bad or embarrassed because of oral health were 42.72%, of the sample, and around 14% have had difficulty because of the mouth. For dental care access, 47.80% of depression group and only 17.39% of the non-depression group could not get the needed dental care. For oral care behavior, lack of using dental floss was 36.07% in participants with depression and 27.35% among participants without depression.

Table 3 contains a multivariate analysis for depression and chronic disease indicators (CDI) across preventative measures and clinical presentation of oral health outcomes. Individuals with depression were more likely to report having difficulty getting the needed dental care than others without depression [aOR=2.78 (2.00-3.86)] at significant level p-value 0.05. On the other hand, current smokers were less likely to visit the dentist [aOR=1.57 (1.15-2.13)] and get the needed dental care [aOR=1.61 (1.21-2.15)] than non-smokers, after adjusting for sociodemographics and CDI. Also, current smokers are more likely to report bone loss [aOR=2.20 (1.59-3.04)] than nonsmokers. On the other hand, individuals with three or more CDI-count were more likely to not get the needed dental care [aOR=4.42 (2.82-6.95)] than others. Moreover, not getting the needed dental care, and dentist visits were significant at p-value 0.05 across all CDI-count groups.

Table 4 shows a multivariate analysis for depression and chronic disease indicators (CDI) by self-reported participant's subjective prospective about oral health. After adjusting for age, gender, race, country of birth, marital state, education, income, smoking, diabetes, and BMI, participants with depression are more likely to report fair/poor oral condition [aOR=2.18 (1.33-3.57)] and ache [aOR=2.87 (1.86-4.44)] than others with no depression. Depression and oral health condition and oral ache were significant at p-value 0.05. Moreover, after adjusting for sociodemographic and CDI participants with depression were more likely to feel bad or

embarrassed because of their oral health [aOR=2.26 (1.51-3.38)] and to have difficulty at their school or job [aOR=2.96 (1.64-5.33)] than others with no depression. On the other hand, current smokers were more likely to report poor/fair oral health condition [aOR=2.02 (1.75-2.33)], mouth ache [aOR=1.44 (1.09-1.89)], and periodontal disease [aOR= 1.70 (1.41-2.06)] than non-smokers and all were significant at p-value 0.05. Also, current smokers reported feeling bad and embarrassed about their oral health more than non-smokers [aOR=1.97 (1.59-2.43)], after adjusting for sociodemographics and CDI. Individuals with three or more CDI-count were more likely to have “poor/fair” oral health [aOR=2.84 (1.45-5.53)], mouth ache [aOR=3.08 (1.93-4.90)], and periodontal disease [aOR=3.03 (1.66-5.53)] than others with no CDI-count, all were significant at p-value 0.05. On the other hand, Individuals with three or more CDI-count were more likely to report feeling bad and embarrassed because of the mouth [aOR=4.17 (2.26-7.69)] than others.

3.5 Discussion

The study aims to examine the relationship between oral health outcomes and depression. We assessed depression across participants’ sociodemographics data and CDI. Then, we measured depression within oral health outcomes. Our study found an association between depression and oral health condition and dental ache controlling for sociodemographic and CDI. Furthermore, depression increases the likelihood of having emotional difficulties concerning oral health condition. On the other hand, depression was not statistically significant in relation to periodontal disease and bone loss, which we consider is due to the fact that many participants have self-reported having a gum disease, which can be only gingivitis but not advance periodontitis and bone loss. Also, the question about bone loss at the time of the survey was “have you ever been

told by a doctor that you have bone loss around teeth?” which participants could have bone loss but were not diagnosed at the time of the survey. However, we propose that the association between depression and periodontal disease and bone loss is practically significant.

Previous studies published on depression, and oral health area were conducted in the United States (Silveira, et al., 2016; Rosania, et al , 2009), Brazil (Hugo, et al., 2012), Korea (Yang, et al., 2016; Kim, et al., 2017; Ma, & Cho, 2016; Park, et al., 2014), Japan (Takiguchi, et al., 2016), Australia (Quine,& Morrell, 2009) and Romania (Dumitrescu, et al., 2009). Some of the studies only included populations of 60 years and older (Hugo, et al., 2012); and others discussed depression in relation to only one oral health outcome such as periodontal disease (Rosania, et al., 2009) (Marques-Vidal, & Milagre, 2006) , dental caries (Yang, et al., 2016) and dental behaviors (Park, et al., 2014). A study by Silveira et al. for anxiety, depression, and oral health among only US pregnant women in 2010 found no significant association between depression and oral health outcomes: (dental visits, and tooth loss) after adjusting for health behaviors and body mass index (Silveira, et al., 2016). Another study in Korea, measured depression as an outcome and oral health as the exposor found an association between the two, which raises a question about the true direction of the relationship (Kim, et al., 2017). On the other hand, a study suggests that depression is connected to oral disease because depression and depression medication lower the salivary flow which increases the chance of having caries and periodontal disease (Gholami, et al., 2017). Others proposed that depression effect persons’ oral hygiene behaviors which leads to poor oral health. (Anttila, et al., 2006). However, a study by O’Neil et al., considered depression as an outcome, found that there is an association between depression and oral health (O’Neil, et al., 2014). Further studies are needed to explore the nature of this relationship.

3.6 Limitations

In this study, we used a depression screener to assess depression status and to evaluate participants' oral health condition, we used oral health outcomes questions. We have done a weighted percentage for participants' sociodemographic data and oral health outcomes among individuals with and without depression. We included variables representing subjective perspective about oral health, dental care access and oral hygiene behaviors. One of the greatest strengths of our study is that it is a population-based study with a large sample size. Using NHANES data adds credibility to the study due to its superior sampling technique and data assembly. NHANES survey and examination were done by trained personnel to ensure data quality. Another strength is applying the depression symptoms screener PHQ_9 as a scale for depression symptoms with the reference point of ≥ 10 for having depression and <10 for not having depression, to procure the depression status among study participants. The PHQ_9 is superior instruments to measure depression severity that are supported by the literature (Kroenke, et al., 2001). Also, having an age range from 18 years old and older in the study allowed us to view depression effects across age difference unlike other study who included only one age group.

The study also has some limitations. First, is the barrier of using secondary data where all desirable variables - for example: tooth loss as an outcome data - were not available. In addition, a detailed data of population dental hygiene care like brushing and flossing were not sufficient. The only available data contained general questions such as the following: "how many days do you floss and brush your teeth?" To understand the impact of dental care practice, we need more details about the technique used and if the participants used mouthwash or fluoridated toothpaste. Another limitation is the use of cross-sectional study which cannot capture the causality

relationship between depression and oral health. Moreover, the limitation of using a self-reported data may cause upward bias in estimating poor oral health outcomes across depression and non-depression groups. Also, the study is subjected to recall bias which can result in underestimating the results. Another limitation is NHANES cluster sampling technique which is prone to sampling bias and error.

3.7 Implications for Public health Professionals and Dentists

The association between depression and oral health has unlocked a new prospect for oral and mental disease prevention advocacy. For example, in future oral disease interventions, public health experts should incorporate and highlight the aspect of mental disorder as a risk factor in increasing the chance of getting poor oral health outcome. Furthermore, public health professionals should consider implementation oral health intervention programs among individuals with depression. They should also cogitate an easy, presentable way for people with depression or mental disorders to understand and access oral health information. Health professionals should also provide information about the high risk of poor oral health outcomes across individuals with depression for the public through different channels and media.

On the other hand, we found that access to needed dental care was lower among individuals with depression than others, which we believe is due to financial, physical, and emotional barriers facing individuals with depression. These barriers can be solved by first, increasing healthcare access, and providing the necessary dental treatment for individuals with depression. Second, mental health promotion and awareness programs to improve public knowledge. Third, designing

targeted interventions for mental disorder patients. Fourth, physicians, dentists and dental auxiliaries should participate in mental health awareness programs.

Finally, for dentists, it is essential to take into consideration the role of depression in decreasing oral health and improve overall oral health. It is crucial to include mental health status in patients' paperwork and to take it into account through treatment and future care. Furthermore, dental care professionals should improve patients' awareness regarding oral health in relation to depression through pamphlets and posters in clinics.

3.8 Conclusion

We concluded that there is an association between depression and poor oral health and oral ache taking into account sociodemographics and CDI. Moreover, regarding oral health related quality of life; individuals with depression were more likely to report feeling bad or embarrassed, and having difficulty at job/school because of the mouth. Further studies suggested, and due to the limitations of cross-sectional studies, a cohort is recommended in order to capture the nature of the relationship between depression and oral health outcomes independently from current smoking, diabetes, and BMI.

Table 1. Sociodemographic Characteristics of persons with and without depression and chronic disease indicators NHANES 2015-2016.

Participant Characteristics (dependents variables)	Independent variable					P-value ^A
	Total N=5,992	Depressed N=334 (5.48%)		Not depressed N=5,658 (94.51%)		
<u>Sociodemographic Characteristics</u>						
Age, years						
Mean (95%CI)	47.22 (45.97-48.46)	48.82	(45.99-51.65)	47.13	(45.88-48.37)	<.0001
Gender						
	Total N (95%CI)	n	% ^B (CI 95%) ^D	n	% ^B (CI 95%) ^D	
Male	2,759	130	34.46 (26.89-42.03)	2,629	48.99 (47.90-50.07)	<.0001
Female	2,976	204	65.54 (57.97-73.11)	2,772	51.01 (49.93-52.10)	
Race /Ethnicity						
Non-Hispanic White	1,839	122	63.61 (53.25-73.98)	1,717	63.33 (54.74-71.93)	0.9811
Non-Hispanic Black	1,227	67	11.85 (6.83-16.87)	1,160	11.48 (6.76-16.19)	
Other Race	2,669	145	24.54 (15.14-33.94)	2,524	25.19 (19.73-30.66)	
Marital Status						
Married / Living with partner	3,307	140	45.08 (35.60-54.56)	3,167	65.10 (61.85-68.35)	<.0001
Divorced / separated /Widowed /Never married	2,165	181	54.92 (45.44-64.40)	1,984	34.90 (31.65-38.15)	
Country of Birth						
USA	3,825	251	87.11 (81.91-92.31)	3,574	81.20 (77.11-85.28)	0.0113
Other	1,909	83	12.89 (7.69-18.09)	1,826	18.80 (14.72-22.89)	
Education						
Less than 9th grade	636	49	10.53 (4.44-16.63)	587	6.11 (4.08-8.15)	<.0001
9-11th grade *	659	53	12.65 (8.93-16.38)	606	8.71 (6.48-10.95)	
High school grad/GED **	1,159	79	24.58 (19.12-30.04)	1,080	19.40 (16.20-22.59)	
Some college or AA degree	1,644	107	36.69 (27.74-45.63)	1,537	31.54 (28.22-34.85)	
College graduate or above	1,403	32	15.55 (6.78-24.32)	1,371	34.24 (27.39-41.08)	
Family income						
less than \$25,000	1,676	169	42.81(33.74-51.87)	1,507	20.53 (17.66-23.41)	<.0001
\$25,000 to less than \$55,000	1,729	93	33.41 (22.52-44.32)	1,636	29.39 (26.44-32.33)	
More than \$55,000	1,946	54	23.78(17.29-30.26)	1,892	50.08 (45.30-54.87)	
<u>Chronic disease indicators and outcomes</u>						
Current Smoking						
Yes	1,055	134	45.43 (33.55-57.32)	921	16.66 (14.95-18.37)	<.0001
No	4,680	200	54.57 (42.68-66.45)	4,480	83.34 (81.63-85.05)	

Diabetes						
Yes	809	78	19.98 (13.97-25.99)	731	10.28 (8.75-11.82)	<.0001
No	4,922	255	80.02 (74.01-86.03)	4,667	89.72 (88.18-91.26)	
Body Mass Index (BMI)						
Underweight (BMI ≤ 18.49)	204	9	2.94 (0.41-5.46)	195	3.62 (3.00-4.24)	<.0001
Normal (BMI 18.5 – 24.99)	1,540	77	25.62 (16.27-34.98)	1,463	28.84 (25.80-31.89)	
Overweight (25 -29)	1,444	58	15.29 (10.52-20.06)	1,386	27.24 (25.64-28.85)	
Obese (BMI ≥ 30)	2,246	173	56.15 (46.50-65.80)	2,073	40.30 (36.72-43.86)	

A. P-value based upon Wilcoxon rank sum test for continuous variable(age), and χ^2 test for categorical variables.
B. Weighted column percentages were used.
C. Missing value were excluded.
D. 95% confidence limits of the point estimate between persons who have depression and who don't have depression.
Abbreviations: IQR, interquartile range
CI, Confidence limit of column percent
* Including 12th grade with no diploma
** Or equivalent.

Table 2. Association between oral health outcomes of persons with and without depression.

Oral Health Outcomes (dependent variables)	Independent variable					p- value ^A
	Total	Depressed		Not depressed		
	N=5,992	N=334 (5.48%)		N=5,658 (94.51%)		
	N	n (%) ^B	% ^B (CI 95%) ^D	n (%) ^B	% ^B (CI 95%) ^D	
Condition of teeth and gum						
Good/Very Good / Excellent	3,739	134	44.51 (35.53-53.50)	3,605	73.23 (69.87-76.59)	<.0001
Fair/Poor	1,991	200	55.49 (46.50-64.47)	1,791	26.77 (23.42-30.13)	
Had aching in the mouth						
Yes	1,128	136	50.84 (39.52-62.17)	992	19.81 (17.94-21.68)	<.0001
No	3,408	144	49.16 (37.83-60.48)	3,264	80.19 (78.32-82.06)	
Periodontal disease						
Yes	877	93	33.83 (22.76-44.89)	784	18.60 (16.63-20.58)	0.0002
No	3,581	179	66.17 (55.11-77.24)	3,402	81.40 (79.42-83.37)	
Bone loss						
Yes	742	58	19.75 (13.05-26.44)	684	16.39 (13.87-18.91)	0.3359
No	3,758	218	80.25 (73.56-86.95)	3,540	83.61 (81.09-86.13)	
Felt bad/ embarrassed						
Yes	913	129	42.72 (30.70-54.73)	784	16.09 (14.09-18.08)	<.0001
No	3,626	151	57.28 (45.27-69.30)	3,475	83.91 (81.92-85.91)	
Had difficulty with job/school						
Yes	255	45	14.53 (8.65-20.41)	210	3.59 (2.69-4.49)	<.0001
No	4,284	235	85.47 (79.60-91.35)	4,049	96.41 (95.51-97.31)	
<u>Dental care access and oral behaviors</u>						
Past year couldn't get needed dental care						
Yes	1,284	152	47.80 (36.92-58.69)	1,132	17.39 (15.17-19.60)	<.0001
No	4,311	174	52.20 (41.31-63.08)	4,137	82.61 (80.40-84.83)	
Visit dentist						
Last 6 months to 1 year ago	3,085	144	49.63 (39.96-59.30)	2,941	59.65 (55.93-63.38)	0.0053
More than 1 year	639	187	50.37 (40.70-60.04)	2,449	40.34 (36.62-44.07)	
Dental floss use						
Yes	3,026	157	63.93 (56.80-71.05)	2,896	72.65 (69.90-75.40)	0.0007
No	1,509	122	36.07 (28.95-43.20)	1,387	27.35 (24.60-30.10)	

A. P-value based upon χ^2 test for categorical variables

B. Weighted column percentages were used.

C. Missing value were excluded.

D. 95% confidence limits of the point estimate between persons who have depression and who don't have depression.

Abbreviations: CI, Confidence limit of column percent

Table 3. Multivariate analysis for depression and Chronic disease indicators by preventive measures and clinical presentation of oral health outcome.

		Dental care		Visit dentist		Dental floss use		Bone loss	
		No %	aOR	> 1 year %	aOR	No %	aOR	Yes %	aOR
Depression	No	17.39	1.00	40.34	1.00	27.35	1.00	16.39	1.00
	Yes	47.80	2.78 (2.00-3.86)*	50.37	0.93 (0.63-1.38)	36.07	0.92 (0.65-1.31)	19.75	1.54 (0.90-2.63)
Smoking	No	15.03	1.00	37.42	1.00	25.24	1.00	15.52	1.00
	Yes	32.54	1.61 (1.21-2.15)*	56.48	1.57 (1.15-2.13)*	39.61	1.54 (1.21-1.98)*	21.36	2.20 (1.59-3.04)*
Diabetes	No	18.67	1.00	40.34	1.00	26.91	1.00	15.72	1.00
	Yes	22.03	1.08 (0.84-1.38)	45.21	1.01 (0.80-1.54)	34.05	1.15 (0.84-1.57)	22.05	1.17 (0.93-1.47)
BMI	Under-weight	18.56	1.00	38.03	1.00	29.30	1.00	18.72	1.00
	Normal	16.48	0.89 (0.62-1.27)	37.97	1.23 (0.70-2.16)	25.03	1.10 (0.67-1.80)	16.49	0.84 (0.41-1.73)
	Over-weight	18.24	1.13 (0.83-1.54)	37.06	1.07 (0.59-1.95)	28.17	1.13 (0.64-1.99)	17.38	0.90 (0.37-2.17)
	Obese	21.40	1.24 (0.85-1.82)	46.45	1.59 (0.85-2.98)	29.40	1.24 (0.72-2.16)	15.76	0.84 (0.38-1.86)
CDI count	0	13.13	1.00	32.21	1.00	22.00	1.00	15.76	1.00
	1	20.80	1.56 (1.34-1.81)*	45.92	1.50 (1.29-1.76)*	30.42	0.77 (0.57-1.05)	15.02	0.95 (0.70-1.29)
	2	25.81	1.90 (1.37-2.64)*	49.68	1.62 (1.25-2.10)*	34.29	1.07 (0.89-1.29)	22.17	1.66 (1.32-2.10)*
	≥3	51.58	4.42 (2.82-6.95)*	57.64	1.73 (1.00-2.10)*	38.79	1.17 (0.61-2.25)*	20.80	1.69 (0.86-3.32)

A. Weighted row percentage were used.

B. Because of the mouth.

Abbreviations: aOR. the odd ratio adjusting for age, gender, race, country of birth, marital states, education, income, current smoking, diabetes, and BMI.

*Significant at 0.05.

Table 4. Multivariate analysis for depression and Chronic disease indicators by self-reported participant's subjective prospective about oral health.

		Condition of teeth and gum		Aching in the mouth		Periodontal disease		Felt bad/embarrassed ^B		Difficulty job/school ^B	
		Poor/ Fair % ^A	aOR	Yes %	aOR	Yes %	aOR	Yes %	aOR	Yes %	aOR
Depressio	No	26.77	1.00	19.81	1.00	18.60	1.00	16.08	1.00	3.59	1.00
	Yes	55.49	2.18 (1.33-3.57)*	50.84	2.87 (1.86-4.44)*	33.83	1.48 (0.93-2.36)	42.72	2.26 (1.51-3.38)*	14.53	2.96 (1.64-5.33)*
Smoking	No	24.32	1.00	18.97	1.00	17.12	1.00	14.36	1.00	3.26	1.00
	Yes	46.41	2.02 (1.75-2.33)*	33.32	1.44 (1.09-1.89)*	30.11	1.70 (1.41-2.06)*	32.22	1.97 (1.59-2.43)*	8.55	1.50 (0.99-2.28)*
Diabetes	No	27.27	1.00	21.27	1.00	18.53	1.00	16.72	1.00	4.19	1.00
	Yes	37.06	1.19 (0.92-1.53)	23.62	1.06 (0.73-1.52)	25.42	1.31 (0.94-1.80)	23.45	1.26 (0.93-1.71)	4.43	0.90 (0.58-1.40)
BMI	Under weight	28.73	1.00	20.88	1.00	17.01	1.00	18.80	1.00	4.60	1.00
	Normal	25.37	0.98 (0.62-1.52)	20.58	1.13 (0.55-2.33)	15.58	0.99 (0.60-1.63)	16.35	1.06 (0.60-1.89)	5.21	1.49 (0.70-3.19)
	Over-weight	26.69	0.94 (0.57-1.56)	20.59	1.21 (0.61-2.42)	18.46	1.15 (0.67-1.98)	15.06	0.96 (0.55-1.66)	3.92	1.25 (0.42-3.72)
	Obese	31.44	1.09 (0.70-1.71)	22.51	1.12 (0.55-2.26)	22.13	1.43 (0.87-2.26)	19.84	1.25 (0.75-2.08)	3.87	0.94 (0.39-2.29)
CDI count	0	19.51	1.00	17.17	1.00	14.70	1.00	12.14	1.00	3.15	1.00
	1	31.57	1.59 (1.22-2.07)*	21.91	1.22 (0.91-1.63)	19.21	1.25 (0.92-1.72)	16.98	1.25 (0.92-1.71)	3.88	1.00 (0.57-1.73)
	2	41.02	2.17 (1.68-2.80)*	26.49	1.34 (0.95-1.89)	29.29	2.11 (1.52-2.93)*	27.07	2.13 (1.49-3.02)*	6.38	1.46 (0.96-2.23)
	≥3	54.20	2.84 (1.45-5.53)*	51.33	3.08 (1.93-4.90)*	38.39	3.03 (1.66-5.53)*	51.45	4.17 (2.26-7.69)*	12.24	1.68 (0.78-3.60)

A. Weighted row percentage were used.

B. Because of the mouth.

Abbreviations: aOR. the odd ratio adjusting for age, gender, race, country of birth, marital states, education, income, current smoking, diabetes, and BMI.

*Significant at 0.05.

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