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Investigating oral health among individuals with depression: NHANES 2015–2016

Bayan Almohaimeed [a],*, Shanta R. Dube [b], Ruiyan Luo [c]

[a] *Department of Preventive Dentistry, College of Dentistry in Ar Rass, Qassim University, Ar Rass, Saudi Arabia*
[b] *Department of Public Health, Levine College of Health Sciences, Wingate University, Wingate, NC, United States*
[c] *Department of Population Health Sciences, School of Public Health, Georgia State University, Atlanta, GA, United States*

Abstract *Objectives:* Depression is highly prevalent across populations, yet studies on its contribution to oral health are lacking. Therefore, our goal is to examine the association of depression and oral health problems (preventative care, access to dental care, and oral condition in relation to quality of life) controlling for sociodemographic and chronic disease indicators (CDI).

Methods: 5,992 respondents' data 18 + years old were analyzed from the 2015–2016 National Health and Nutrition Examination Survey (NHANES). The independent variable of interest was depression symptoms status. Oral health outcomes were the dependent variables. We used the Patient Health Questionnaire-9 (PHQ-9) for depression and the Oral Health Questionnaire (OHQ) to measure oral health outcomes. Covariates included sociodemographics (age, education, sex, race/ethnicity, and income) and CDI included current smoking, diabetes, and body mass index. All data were weighted using 2 years sample weight.

Results: The mean age of respondents was 47.22 years (45.97–48.46) and 46% were males. Participants with depression present 6.93%, and females 63.85% were higher than males 36.15%.

Participants with depression have significantly low income 43.10% than others p value < 0.0001. After adjusting for sociodemographics and CDI, participants who have depression were more prone to report fair/poor oral condition [aOR = 1.91 (1.29–2.84)], oral pain [aOR = 2.66 (1.91–3.71)], and difficulty accessing needed dental care [aOR = 2.52 (1.96–3.24)] than others. Having depression was associated with poor oral health perceptions [aOR = 2.10 (1.41–3.13)], and having difficulty at job/school because of their oral health [aOR = 2.85 (1.90–4.26)].

* Corresponding author.
E-mail addresses: Ba.almohaimeed@qu.edu.sa (B. Almohaimeed), s.dube@wingate.edu (S.R. Dube), rluo@gsu.edu (R. Luo).
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Conclusion: Based on the empirical evidence provided by our study, there is an association between depression and oral health outcomes and oral health-related quality of life.

1. Introduction

Depression is a widespread mental-health illness that has become the focus of health professionals in the United States ("Prevalence of depression among adults aged 20 and over: United states, 2013–2016," 2018). The American Psychiatric Association defines depression as "a medical illness that negatively affects how you feel, the way you think, and how you act" (American Psychiatric Association, 2020). Since 2005, depression has been a prevalent disorder in the United State (Weinberger et al., 2018). According to the Centers for Disease Control and Prevention (CDC), during the years from 2013 to 2016, approximately 8% of American adults, age 20 and higher, suffered from depression. 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 ("Prevalence of depression among adults aged 20 and over: United states, 2013–2016," 2018). Also, it can affect individuals' quality of life (Barbosa et al., 2018). Like many psychological disorders, depression affects individuals' physical health and well-being and has been associated to many chronic diseases such as cancer, cardiovascular disease (CVD), diabetes and respiratory disease (Clarke and Currie, 2009; Lawrence et al., 2013, 2010). Depression also can cause physical pain and discomforts like head, back, and stomach pain. Moreover, an individual's sleep pattern, energy level, and daily activity can be disturbed by depression (Garcia-Cebrian et al., 2006; Lépine and Briley, 2004; Trivedi, 2004). For depression and physical activity, Da Sliva et al. concluded that the relationship was bidirectional (Da Silva et al., 2012). Depression as a psychological health disorder may also be a predictor of oral health problems (Gholami et al., 2017). There are other common oral health outcomes that is indicated to be associated with several psychological disorders such as anxiety, schizophrenia, and bipolar disorder (Table 1).

In 2011–2012, untreated dental caries in the United States 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). Recent studies have shown a relationship between depression and oral diseases like periodontal disease, dental caries but little data were available (Kisely et al., 2016). A study led by Elter et al. in the United States in 2002, discussed the relationship between depression and periodontal disease. After adjusting for sex, smoking status, antidepressant drugs 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 missing teeth and depression and anxiety disorder (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 demonstrate a relationship between depression and oral disease. However, vital oral health problems like dental prevention, dental access, and oral and dental health-related quality of life, have not been investigated by most of these studies. Preventative dental care and dental care access are critical to promoting oral health. Dental care, regular cleaning and checkups have been shown to prevent dental caries and periodontal disease and improve oral health (Kandelman et al., 2012). Therefore, understanding the contribution of depression to other critical oral health outcomes can inform the field about the factors that may impede proper oral health. Thus, the present study aims to assess the relationship between depression symptoms and oral health outcomes from 2015 to 2016 using the National Health and Nutrition Examination Survey (NHANES).

2. Methods

The study design is cross-sectional utilizing secondary data 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 physical examination part, collecting data about individual's lifestyle, genetic, and environmental risk factor that can cause certain disease or conditions. NHANES is a large, well-characterized program of the National Center for Health Statistics (NCHS) at the Center for Disease Control and Prevention (CDC). 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 and included in the study.

2.1. Independent variable

The Patient Health Questionnaire-9 (PHQ-9) was used to measure depression. The PHQ-9 is a nine-item depression screening tool developed in 2002 by Kroenke and Spitzer and measures the occurrence of depression symptoms for the past two weeks (Kroencke et al., 2001; Kroenke and Spitzer, 2002). 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

Table 1 Common oral health outcomes associated with selected psychological disorders.

Oral health outcome	Depression	Anxiety	Schizophrenia	Bipolar disorder
Poor oral hygiene	(Anttila et al., 2006) (Park et al., 2014) (Torales et al., 2017)	(Anttila et al., 2006) (Lkan et al., 2015) (Torales et al., 2017)	(Azodo et al., 2012) (Torales et al., 2017)	(Oflezer et al., 2018) (Torales et al., 2017)
Dental caries	(Kisely et al., 2016) (Hugo et al., 2012) (Yang et al., 2016) (Torales et al., 2017	(Torales et al., 2017)	(Cormac and Jenkins, 1999) (Kisely et al., 2015) (Yang et al., 2018)	(Kisely et al., 2015) (Oflezer et al., 2018) (Torales et al., 2017)
Periodontal disease	(Kisely et al., 2016) (Elter et al., 2002) (Rosania et al., 2009)	(Lkan et al., 2015) (Torales et al., 2017)	(Ramon et al., 2003) (Rekha et al., 2002) (Baghaie et al., 2017)	(Baghaie et al., 2017) (Oflezer et al., 2018)
Tooth loss	(Okoro et al., 2012) (Saman et al., 2014) (Torales et al., 2017)	(Okoro et al., 2012) (Torales et al., 2017)	(Kisely et al., 2011) (Kisely et al., 2015) (Baghaie et al., 2017) (Yang et al., 2018)	(Kisely et al., 2011)(Kisely et al., 2015)(Baghaie et al., 2017)

depression diagnostic criteria (Spitzer et al., 1999). A participant's total mark from 0 to 27 is calculated by addition of the sum of the marks in each questionnaire question. A predefined cut-point references were used to assess the depression symptoms severity. 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 severe depression (Kroencke et al., 2001). The Patient Health Questionnaire-9 (PHQ-9) depression symptoms scale 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.

2.2. Dependent variables

For oral health outcomes, we used the Oral Health Questionnaire (OHQ). This questionnaire 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). Other variables on oral and dental health conditions included present dental ache, periodontal disease, and bone loss. Also, we reported participants' quality of life 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.

2.3. Sociodemographic variables and Chronic disease indicators

Sociodemographic variables included Age, sex. 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.

Chronic disease indicators (CDI) included current smoking, diabetes, and BMI. Current smoking was defined as participants who reported that they have smoked 100 cigarettes and currently smoke "everyday" or "someday". For diabetes, we included "yes" for having diabetes and "no" for not having diabetes. The BMI was separated into four categories: underweight (BMI ≤ 18.49), Normal (BMI 18.5–24.99), Overweight (25–29), and Obese (BMI ≥ 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.

2.4. Statistical analysis

Data analyses were conducted using Analytics Software Solutions (SAS) version (9.4) software. All data were weighted using 2 years sample weight. Bivariate analysis was conducted to compare participants' sociodemographics, CDI, and oral health outcomes for individuals with and without depression. 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; a test with p-value less than 0.05 was statistically significant. Logistic regression was performed to investigate oral health outcomes between persons with and without depression. Uncomplete questionnaires with missing data were excluded from the study.

Table 2 Sociodemographic characteristics of persons with and without depression and chronic disease indicators NHANES 2015–2016.

Participant Characteristics (Dependent variables)	Independent variable					p-value[A]
	Total		With depression		Without depression	
	N = 5,992		N = 415 (6.93%)		N = 5,577 (93.07%)	
Sociodemographic Characteristics						
Age, years						
Mean (95%Cl)	47.22 (45.97-48.46)		47.25 (45.43-50.07)		47.22 (45.98-48.45)	< .0001
	Independent variable					
	Total		**With depression**		**Without depression**	
	N (95%Cl)	n	%[B] (Cl 95%)[D]	N	%[B] (Cl 95%)[D]	
Gender						
Male	2,759	164	36.15 (29.20-43.10)	2,595	49.06 (47.95-50.17)	< .0001
Female	2,976	251	63.85 (56.90-70.80)	2,725	50.94 (49.83-52.05)	
Race/Ethnicity						
Non-Hispanic White	1,839	152	63.70 (54.03-73.37)	1,687	63.32 (54.73-71.91)	0.9543
Non-Hispanic Black	1,227	84	11.97 (6.68-17.25)	1,143	11.46 (6.79-16.13)	
Other Race	2,669	179	24.33 (15.78-32.88)	2,490	25.22 (19.74-30.69)	
Marital Status						
Married/Living with partner	3,307	172	45.40 (37.25-53.56)	3,135	65.35 (62.08-68.62)	< .0001
Divorced/separated/Widowed/Never married	2,165	226	54.60 (46.44-62.75)	1,939	34.65 (31.38-37.92)	
Country of Birth						
USA	3,825	309	86.47 (81.19-91.76)	3,516	81.16 (77.08-85.25)	0.0205
Other	1,909	106	13.53 (8.24-18.81)	1,803	18.84 (14.75-22.92)	
Education						
Less than 9th grade	636	59	9.92 (4.49-15.35)	577	6.10 (4.06-8.14)	0.0003
9-11th grade *	659	66	12.88 (9.23-16.52)	593	8.64 (6.35-10.93)	
High school grad/GED **	1,159	91	22.57 (18.17-26.97)	1,068	19.47 (16.17-22.78)	
Some college or AA degree	1,644	132	35.86 (26.49-45.23)	1,512	31.53 (28.26-34.80)	
College graduate or above	1,403	49	18.77 (9.34-28.21)	1,354	34.26 (27.40-41.12)	
Family income						
less than $25,000	1,676	210	43.10 (35.54-50.66)	1,466	20.20 (17.39-23.01)	< .0001
$25,000 to less than $55,000	1,729	113	31.67 (23.53-39.81)	1,616	29.46 (26.46-32.46)	
More than $55,000	1,946	71	25.23 (18.51-31.95)	1,875	50.34 (45.56-55.13)	
Chronic disease indicators and outcomes						
Current Smoking						
Yes	1,055	159	42.83 (33.38-52.27)	896	16.46 (14.63-18.29)	< .0001
No	4,680	256	57.17 (47.73-66.62)	4,424	83.54 (81.71-85.37)	
Diabetes						
Yes	809	86	17.60 (12.40-22.79)	723	10.32 (8.79-11.85)	0.0001
No	4,922	328	82.40 (77.21-87.60)	4,594	89.68 (88.15-91.21)	
Body Mass Index (BMI)						
Underweight (BMI ≤ 18.49)	204	18	4.25 (1.80-6.70)	186	3.53 (2.93-4.14)	< .0001
Normal (BMI 18.5–24.99)	1,540	98	26.88 (18.97-34.79)	1,442	28.80 (25.78-31.81)	
Overweight (25–29)	1,444	73	15.68 (10.54-20.82)	1,371	27.37 (25.73-29.01)	
Obese (BMI ≥ 30)	2,246	205	53.19 (44.55-61.82)	2,041	40.30 (36.77-43.82)	

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, Cl, Confidence limit of column percent.
* Including 12th grade with no diploma.
** Or equivalent.

3. Results

The mean age of participants was 47.22 years [95% CI: (45.97–48.46)], with a median of 46.48 [95% CI: (44.73–48.23)]. The prevalence of depression symptoms was 6.93%. Among women, 63.85% [95% CI: [56.90–70.10]] depression which is higher than for men 36.15% [95% CI: (29.20–43.10)]. Among the levels of education, depression was 9.92% [95% CI: (4.49–15.35)] for the lower than the 9th grade group, 12.88% [95% CI: (9.23–16.52)] for the 9th to 11th-grade group, 22.57% [95% CI: (18.17–26.97)] for high school grade/GED group, 35.86% [95% CI: (26.49–45.23)] for some college or AA group, and 18.77% [95% CI: (9.34–28.21)] for the college graduate or above group. Sex, marital status, and family income were significantly associated with depression (p-value < 0.0001). Across marital status, divorced/separated/wido

Table 3 Association between oral health outcomes of persons with and without depression.

| Oral Health Outcomes (Dependent variables) | Independent variable | | | | | p-value[A] |
| | Total N = 5,992 | With depression N = 415 (6.93%) | | Without depression N = 5,577 (93.07%) | | |
	N	n	%[B] (Cl 95%)[D]	n	%[B] (Cl 95%)[D]	
Condition of teeth and gum						
Good/Very Good/Excellent	3,739	179	49.41 (42.07-56.61)	3,560	73.27 (69.92-76.61)	< .0001
Fair/Poor	1,991	236	50.59 (43.24-57.93)	1,755	26.73 (23.39-30.08)	
Had aching in the mouth						
Yes	1,128	158	47.29 (37.22-57.36)	970	19.67 (17.73-21.61)	< .0001
No	3,408	183	52.71 (42.64-62.78)	3,225	80.33 (78.39-82.27)	
Periodontal disease						
Yes	877	106	31.16 (21.50-40.81)	771	18.60 (16.64-20.56)	0.0006
No	3,581	225	68.84 (59.19-78.50)	3,356	81.40 (79.44-83.36)	
Bone loss						
Yes	742	65	17.68 (11.83-23.54)	677	16.50 (13.95-19.05)	0.7123
No	3,758	272	82.32 (76.46-88.17)	3,486	83.50 (80.95-86.05)	
Felt bad/embarrassed						
Yes	913	149	39.41 (28.05-50.78)	764	15.99 (14.00-17.98)	< .0001
No	3,626	192	60.59 (49.22-71.95)	3,434	84.01 (82.02-86.00)	
Had difficulty with job/school						
Yes	255	54	13.67 (8.75-18.60)	210	3.52 (2.68-4.36)	< .0001
No	4,284	287	86.33 (81.40-91.25)	3,997	96.48 (95.64-97.32)	
Dental care access and oral behaviors						
Past year couldn't get needed dental care						
Yes	1,284	186	44.49 (35.14-53.84)	1,098	17.21 (15.02-19.39)	< .0001
No	4,311	220	55.51 (46.16-64.86)	4,091	82.79 (80.60-84.98)	
Visit dentist						
Last 6 months to 1 year ago	3,085	185	48.97 (40.09-57.85)	2,900	59.84 (56.08-63.60)	0.0015
More than 1 year	2,636	227	51.03 (42.15-59.91)	2,409	40.16 (36.40-43.92)	
Dental floss use						
Yes	3,026	197	65.84 (58.37-73.31)	2,829	72.62 (69.94-75.30)	0.0112
No	1,509	143	34.16 (26.69-41.63)	1,366	27.38 (24.70-30.06)	

A. P-value based upon χ2 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: Cl, Confidence limit of column percent.

wed/never married individuals who have depression were 54.60% [95% CI: (46.44–62.75)], and 34.65% [95% CI: (31.38–37.92)] of the non-depression group. Participants who were married/living with a partner who reported depression were 45.40% [95% CI: (37.25–53.56)], and 65.35% [95% CI: (62.08–68.62)] of the non-depression group. Across income levels, individuals who have depression symptoms with low-income were 43.10% [95% CI: (35.54–50.66)], middle income 31.67% [95% CI: (23.53–39.81)], and high income 25.23% [95% CI: (18.51–31.95)]. Income levels among the group with depression was statistically significantly different from the group with no depression (p-value < 0.0001) (Table 2).

The association between depression symptoms and oral health outcomes such as the condition of the mouth, dental care access, and oral behaviors is reported in Table 2. For dental ache, 47.29% [95% CI: (37.22–57.36)] of participants with depression reported dental ache, and 19.67% [95% CI: (17.73–21.61)] of the non-depression group. For periodontal disease, 31.16% [95% CI:(21.50–40.81)] of individuals with depression reported periodontal disease, and only 18.60% [95% CI: (16.64–20.56)] of individuals without depression. Bone loss among group with depression were 17.68% [95% CI:

(11.83–23.54)] and none-depression group was 16.50% [95% CI: (13.95–19.05)]. Participants with depression who felt bad or embarrassed because of their oral health were 39.41% [95% CI: (28.05–50.78)], and 15.99% [95% CI: (14.00–17.98)] of the non-depression group. Participants have had difficulty because of oral health status among the depression group were 13.67% [CI 95%: (8.75–18.60)] and 3.52% [95% CI: (2.68–4.36)] of the participants with no depression. For dental care access, 44.49% [95% CI: (35.14–53.84)] of the group with depression and 17.21% [95% CI: (15.02–19.39)] of the non-depression group could not get the needed dental care. For dentist visit, 51.03% [95% CI: (42.15–59.91)] of participants with depression and 40.16% [95% CI: (36.40–43.92)] of participants without depression, did not visit the dentist for more than one year. For oral care behavior, lack of using dental floss was 34.16% [95% CI: (26.69–41.63)] in participants with depression and 27.38% [95% CI: (24.70–30.06)] among participants without depression (Table 3).

In multivariable logistic regression analysis, we examined the association between depression and dental care access, dental visits, dental floss use, and bone loss. Individuals with depression were more likely to have difficulty getting the

needed dental care than those without depression [aOR = 2.52 (1.96–3.24)] p < 0.0001. Current smokers were less likely to visit the dentist [aOR = 1.56 (1.15–2.11)], and getting the needed dental care [aOR = 1.62 (1.21–2.16)] than non-smokers. Current smokers were more likely to report bone loss [aOR = 2.22 (1.61–3.05)] than nonsmokers. Individuals with three or more CDI-count were more likely to not get the needed dental care [aOR = 3.75 (2.44–5.74)] than those with two or less CDI (Table 4).

In adjusted models, participants with depression were more likely to report fair/poor oral condition [aOR = 1.96 (1.29–2.84)] and oral aches [aOR = 2.66 (1.91–3.71)] compared to those with no depression (p < 0.05). Moreover, participants with depression were more likely to feel bad or embarrassed because of their oral health [aOR = 2.10 (1.41–3.13)] and to have difficulty at their school or job [aOR = 2.85 (1.90–4.26)] compared to those with no depression. Current smokers were more likely to report poor/fair oral health condition [aOR = 2.04 (1.76–2.35)], mouth ache [aOR = 1.44 (1.11–1.89)], and periodontal disease [aOR = 1.71 (1.41–2.07)] than non-smokers (Table 5).

4. Discussion

We had the unique opportunity to utilize the National Health and Nutrition Examination Survey (NHANES), which

included both a well-established depression screener, the PHQ_9 (16) and comprehensive measures on oral health. Our study found an association between depression and oral health conditions and dental ache controlling for sociodemographic and CDI. Furthermore, our findings indicate that depression increases the likelihood of having emotional difficulties concerning oral health conditions. However, the findings in our study indicate that depression is not associated with periodontal disease and bone loss, which may be due to the fact that individuals may be unaware they have periodontal disease or bone loss. It may also be because these outcomes are difficult to diagnose by non-health professional personal. In addition, proper equipment like an x-ray and periodontal probe is needed to detect the slight change in bone loss and periodontal health. Nonetheless, the relationship between depression and periodontal disease and bone-loss appears to have practical significance. Because NHANES uses a probability sampling design our weighted estimates for the association between depression symptoms and oral health outcomes can be extrapolated to the U.S. adult population.

There are many international studies documenting the association between depression and oral health (Dumitrescu et al., 2009; Hugo et al., 2012; Kim et al., 2017; M and C, 2016; Quine and Morrell, 2009; Rosania et al., 2009; Silveira et al., 2016; Takiguchi et al., 2016; Yang et al., 2016). Limitations of these studies include the age inclusion criteria of the study

Table 4 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	17.21	1.00	40.16	1.00	27.37	1.00	16.50	1.00
	Yes	44.49	2.52 (1.96–3.24)*	51.03	0.97 (0.66–1.42)*	34.16	0.88 (0.60–1.29)*	17.68	1.41 (0.87–2.28)
Smoking	No	16.04	1.00	37.42	1.00	25.24	1.00	15.52	1.00
	Yes	32.54	1.62 (1.21–2.16)*	56.48	1.56 (1.15–2.11)*	39.61	1.55 (1.21–1.99)*	21.36	2.22 (1.61–3.05)*
Diabetes	No	18.67	1.00	40.34	1.00	26.91	1.00	15.72	1.00
	Yes	22.03	1.09 (0.85–1.39)	45.21	1.01 (0.80–1.54)	34.05	1.15 (0.84–1.57)	22.05	1.17 (0.93–1.48)
BMI	Under-weight	18.56	1.00	38.03	1.00	29.30	1.00	18.72	1.00
	Normal	16.48	0.92 (0.64–1.32)	37.97	1.23 (0.70–2.15)	25.03	1.10 (0.67–1.80)	16.49	0.84 (0.41–1.73)
	Over-weight	18.24	1.18 (0.86–1.60)	37.06	1.07 (0.59–1.95)	28.17	1.13 (0.64–1.99)	17.38	0.90 (0.37–2.18)
	Obese	21.40	1.29 (0.88–1.89)	46.45	1.58 (0.84–2.97)	29.40	1.25 (0.71–2.17)	15.76	0.84 (0.38–1.87)
CDI count	0	13.13	1.00	31.88	1.00	22.00	1.00	15.91	1.00
	1	20.80	1.53 (1.32–1.78)*	46.09	1.55 (1.34–1.80)*	30.42	0.79 (0.58–1.07)	14.95	0.94 (0.68–1.28)
	2	25.81	2.03 (1.49–2.76)*	49.52	1.62 (1.23–2.14)*	34.29	1.09 (0.92–1.30)	21.85	1.61 (1.28–2.01)*
	≥3	51.58	3.75 (2.44–5.74)*	57.21	1.72 (1.07–2.77)*	38.79	1.11 (0.61–2.03)	20.44	1.70 (0.86–3.33)

A. Weighted row percentage were used.

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 5 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
Depression	No	26.73	1.00	19.68	1.00	18.60	1.00	15.99	1.00	3.52	1.00
	Yes	50.59	1.91 (1.29–2.84)*	47.30	2.66 (1.91–3.71)*	31.16	1.42 (0.97–2.10)*	39.41	2.10 (1.41–3.13)*	13.67	2.85 (1.90–4.26)*
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	2.04 (1.76–2.35)*	33.32	1.44 (1.11–1.89)*	30.11	1.71 (1.41–2.07*	32.22	1.98 (1.60–2.44)*	8.55	1.52 (1.00–2.29)*
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 (0.93–1.53)	23.62	1.06 (0.73–1.53)	25.42	1.31 (0.95–1.80)	23.45	1.27 (0.93–1.71)	4.43	0.91 (0.59–1.40)
BMI	Underweight	28.73	1.00	20.88	1.00	17.01	1.00	18.80	1.00	4.60	1.00
	Normal	25.37	0.99 (0.62–1.57)	20.59	1.14 (0.55–2.36)	15.58	0.99 (0.60–1.63)	16.35	1.07 (0.60–1.90)	5.21	1.50 (0.71–3.16)
	Over–weight	26.69	0.96 (0.57–1.61)	20.59	1.23 (0.62–2.46)	18.46	1.16 (0.68–1.98)	15.06	0.97 (0.56–1.68)	3.92	1.27 (0.44–3.70)
	Obese	31.44	1.12 (0.70–1.78)	22.51	1.14 (0.56–2.31)	22.13	1.44 (0.88–2.37)	19.84	1.26 (0.75–2.12)	3.87	0.95 (0.40–2.29)
CDI count	0	19.50	1.00	17.16	1.00	14.71	1.00	12.19	1.00	3.15	1.00
	1	31.45	1.58 (1.22–2.06)*	21.77	1.20 (0.88–1.62)	19.22	1.25 (0.91–1.71)	16.74	1.21 (0.88–1.66)	3.72	0.95 (0.53–1.69)
	2	40.73	2.16 (1.65–2.82)*	26.20	1.33 (0.92–1.90)	28.66	2.04 (1.44–2.90)*	26.89	2.11 (1.50–3.01)*	6.65	1.53 (0.99–2.38)
	≥3	52.75	2.69 (1.43–5.08)*	51.16	3.06 (1.90–4.93)*	38.15	3.00 (1.72–5.24)*	55.47	3.91 (2.09–7.32)*	11.92	1.61 (0.78–3.31)

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.

population of 60 years and older (Hugo et al., 2012) as well as examination of only one oral health outcome such as periodontal disease (Rosania et al., 2009), dental caries (Yang et al., 2016) and dental behaviors (Park et al., 2014).

There have also been mixed findings on the association between depression and oral health. A study by Silveira et al. conducted a study among US pregnant women in 2010 and found no significant association between depression and oral health outcomes of dental visits and tooth loss after adjusting for health behaviors and BMI (Silveira et al., 2016). Another study in Korea measured depression as an outcome and oral health as the exposure found an association between the two, which raises a question about the relationship's true direction (Kim et al., 2017). However, a study by O'Neil et al., considered depression as an outcome, found an association between depression and oral health (O'Neil et al., 2014). Despite the mixed findings, there exists biological plausibility for the association between depression and oral health outcomes Depression is known to lead to physiological changes as well as impact self-care behaviors. For example, Gholami et al., 2017 suggests that the association between depression and oral disease may be due to the reduced salivary response to depressive symptoms and depression medications, both of which lower salivary flow thus raising the probability of having dental decay and periodontal disease (Gholami et al., 2017). Individuals with compromised oral health tend to have high carbohydrate and sugar intake (Laniado et al., 2020), which the researchers believe to be a common factor among individuals with depression (Rosania et al., 2009). Others propose that depression affects persons' oral hygiene behaviors such as brushing and flossing, which can cause bad oral health conditions (Anttila et al., 2006). Further studies are needed to explore the nature of this relationship.

The study also has some limitations. First, the use of secondary data limits the ability to use specific variables. For example, NHANES did not include a measure on tooth loss. In addition, dental hygiene care was not detailed. The only available data contained general questions like 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 establish causality between depression and oral health. Moreover, the limitation of using a self-reported data may have resulted in recall bias. Remembering aspects related to oral health may have resulted in "do not know" or "missing". This may have resulted in underestimating the results.

Our study provides initial findings on the associations between depression and oral health, which have implications for both dentistry science and public health. For example, the field of dentistry science may consider the importance of mental health disorders as a risk factor for poor oral health outcomes. 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 negative oral health outcomes across individuals with depression for the public through different channels and media.

Importantly, 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. While we are unclear of the direction of the relationship, the associations make clear that dental care access is compromised among these individuals.

5. Recommendations

Physicians, dentists, and dental auxiliaries should participate in mental health awareness programs. For dentists, it is essential to take into consideration the role of depression in dental health status and in general oral health. It is crucial to include mental health conditions in patients' paperwork and consider it through treatment and future care. Also, dentists are advised to plan the phases of care in certain psychological cases after consulting the patients' psychotherapist. The collaboration between dentists and psychotherapists will provide the optimum level of care and comfort to patients with psychological disorders. Furthermore, dental care professionals should improve patients' awareness regarding oral health in relation to depression by discussion during office visits and through pamphlets and posters in clinics.

6. Conclusion

We concluded that depression symptoms have an association with poor oral health and oral ache taking into account sociodemographics and CDI. Moreover, regarding quality of life in relation to oral health, individuals with depression were more likely to report feeling bad or embarrassed, and having difficulty at job/school because of the mouth. Future research should consider prospective cohort design to examine if depression decreases preventative dental care over time.

CRediT authorship contribution statement

Bayan Almohaimeed: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Shanta R. Dube:** Methodology, Software, Writing – review & editing, Visualization, Supervision. **Ruiyan Luo:** Software, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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