ORIGINAL ARTICLE

Depression is related to edentulism and lack of functional dentition: An analysis of NHANES data, 2005–2016

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Keywords
tooth loss; depression; National Health and Nutrition Examination Survey; cohort study.

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Received: 5/4/2020; accepted 11/19/2020.

doi: 10.1111/jphd.12433

J Public Health Dent (2020)

Abstract

Objective: Depression and tooth loss are significant health problems that affect individuals' functionality and quality of life. Comorbidity between depression and oral diseases has been reported. The aim of this study was to investigate the association between depression and tooth loss in a US representative adult sample.
Methods: This study included data from 22,532 adults ≥18 years by combining six 2-year cross-sectional cycles of the National Health and Nutrition Examination Survey (NHANES) administered between 2005 and 2016. Data were analyzed using descriptive statistics and multinomial logistic regression adjusted for gender, age, race/ethnicity, smoking, education, socioeconomic status, body mass index, diabetes, and alcohol intake.
Results: Of the total sample, 4.5 percent were edentulous, 10.3 percent were lacking functional dentition (1–19 remaining teeth) and 85.2 percent had functional dentition (≥20 remaining teeth); among whom, the prevalence of depression was 12.4, 11.7, and 5.9 percent, respectively. Compared to individuals without depression, those with depression were more likely to be edentulous or lacking functional dentition versus having functional dentition (adjusted odds ratios (95% CI): 1.48 (1.16–1.89) and 1.43 (1.18–1.75), respectively).
Conclusions: Depression was associated with edentulism and a lack of functional dentition. Further longitudinal and interventional studies are needed to elucidate the nature and direction of the relationship between depression and tooth loss.

Introduction

Oral diseases pose significant global health concerns and represent a substantial economic burden, affecting people throughout their lifetime.[1] Dental caries and periodontitis are the most common oral diseases and are the main cause of tooth loss worldwide.[1, 2] Tooth loss is a leading cause of disability due to oral diseases and the presence of at least 20 natural teeth is considered necessary to have functional dentition. [3, 4] In the most recent data from the United States, the prevalence of edentulism and lacking functional dentition among adults 50 years of age or older were 10.8%, and 31.8%, respectively.[3]

Extensive tooth loss may lead to poor nutrition due to diminished ability to chew and therefore might minimize food choices and reduce the pleasures of eating.[4, 5] In fact, the substitution of foods that are high in fibers, vitamin C and carotenes with easy to chew food rich in saturated fats and cholesterol, is common among individuals with severe or complete tooth loss.[4] Even when removable dentures are used, a 30% reduction of chewing efficiency is observed, compared to having natural dentition. [4] In addition to reduced masticatory function, the loss of anterior teeth has a significant impact on esthetics and speech, leading to social embarrassment and impaired work opportunities. [3, 4] Furthermore, tooth loss has been related to chronic systemic conditions such as cardiovascular diseases and diabetes and has also been associated with early onset of disability and mortality in elderly.[4, 6] Thus, the

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individual's physiologic and psychological health and quality of life might be adversely affected by tooth loss especially if the proper dental occlusion is not rehabilitated.

Depression is one of the most prevalent mental disorders in the United States, with an increasing prevalence during the last two decades.[7, 8] In 2012–2013, more than 10 percent of adults reported depressive symptoms in the previous year, and over 20% reported depressive symptoms in their lifetime.[7] Depression is associated with mortality, disability, and poor general health; and its effects can be recurrent or long-lasting. [7, 9] In addition to its relation to general health, depression has also been associated with poor oral health.[10-15] Individuals suffering from depression tend to disregard preventive home care measures and are less likely to visit their dentists leading to increased risk of oral diseases and consequently tooth loss.[11, 16-18]

A limited number of studies have investigated whether depression was a predictor for tooth loss and their results were inconsistent and inconclusive. These studies included diverse age groups and study populations and used different methods of recording and categorizing tooth loss. Two studies have investigated if depression is related to both partial tooth loss and edentulism among adults 18 years or older.[11, 13] Two other studies investigated if depression is related to edentulism among middle-aged and older adults. [12, 19] Another four studies investigated if depression is related to partial tooth loss among pregnant women, and adults ≥18 years, 35–74 years, and ≥ 60 years, but did not include edentulism in their analysis. [15, 20-22]

Recently, two meta-analyses showed an association between depression and tooth loss.[17, 18] In most of the included studies, assessment of tooth loss was carried out utilizing self-reported measures leading to possible recall and social desirability biases, whereas only one study used clinical examination. In addition, the majority of the investigations were restricted to specific populations, resulting in an inability to generalize the findings.[17, 18] Thus far there are no studies in the US population that investigated the association between depression and clinically recorded tooth loss.

The aim of this study, therefore, was to investigate the relationship between depression and tooth loss (both edentulism and lack of functional dentition) as assessed by clinical examination in a large representative sample of US adults aged 18 years or older.

Methods

Study population

Data from the National Health and Nutrition Examination Survey (NHANES) six 2-year cycles that was administered between 2005 and 2016 were combined and used in compliance with the Data Use Restrictions for data collected by the National Center for Health Statistics, Center for Disease Control and Prevention (CDC). NHANES is a cross-sectional stratified multistage probability sample of the non-institutionalized civilians in the US 50 states and the District of Columbia.[23] It included questionnaires, laboratory testing, and medical and dental examinations. Interviews were conducted at participants' homes while clinical examinations were performed afterward in mobile examination centers. The oral clinical exams were conducted by registered dental hygienists and general dentists. For all teeth sites, examiners registered whether a permanent tooth was present/missing, or if there was a primary tooth, dental implant, or root fragment. We selected the latest cycles (2005–2016) that have comparable data of items of interest. There was a total of 60,936 NHANES respondents in the six selected NHANES cycles of whom 36,287 participants were 18 years or older. Among the participants aged 18 and over, 30,123 had complete Oral Health Examination Status. We excluded 2,003 participants due to missing responses for depression and further 5,588 for missing responses of covariables, yielding a final analytical sample of 22,532 participants.

Exposure and the outcome

The exposure variable was major depression. Depression was assessed using the Patient Health Questionnaire (PHQ-9). The PHQ-9 questionnaire screens only for major depression via a 9-item survey that asks about the frequency of symptoms of depression over the past 2 weeks. The PHQ-9 has been validated and widely used in the literature.[24, 25] The answer for each question ranges from 0 to 3, based on the frequency of present symptoms. The sum score ranges between 0 and 27. Participants were categorized as having depression if they had scores ≥10. This cut-off point has been widely used in the literature to represent clinically significant depressive symptoms and has been shown to have a high sensitivity and specificity for detecting major depression.[24] The outcome variable was the number of permanent teeth present at the time of examination excluding third molars. Hence, the number of teeth ranged from zero (for edentulous individuals) to 28 for fully dentate individuals. Participants were categorized into three groups: edentulous subjects, subjects with 1–9 teeth (lacking functional dentition), and subjects with 20–28 teeth (having functional dentition). We used 20 teeth as the cut-off point as at it is considered the demarcation between functional and none functional dentition.[3, 4]

Covariates

To adjust for confounding, we selected major variables that are related to the exposure, are possible risk factors for tooth loss, and are not suspected to be in the causal pathways. The following covariables were selected: gender, age,

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race/ethnicity, smoking, education, socioeconomic status, body mass index (BMI), diabetes, and alcohol intake. Age was categorized as 18–34, 35–49, 50–64, and ≥ 65 years. Race/ethnicity was classified as non-Hispanic White, non-Hispanic Black, Mexican-American, other Hispanic, and other Race-including Multi-Racial. Smoking was categorized into current, former and never smoked. Level of education was categorized into less than high school, high school or equivalent or some college or higher. For socioeconomic status, the ratio of family income to poverty was used based on the Federal poverty level (FPL). Participants were categorized into four categories: <100, 100–199, 200–399, and ≥400%, similar to a previous NHANES study.[26] Body mass index (BMI) was categorized as underweight (<18.5 Kg/m^2), healthy weight (18.5–24.9 Kg/m^2), overweight (25–29.9 Kg/m^2), and obese (≥30 Kg/m^2). Participants were considered diabetic if they answered "yes" to the question "have you ever been told by a doctor that you have diabetes?" For alcohol, consistent with a previous study,[27] participants were classified according to their average alcohol intake into non-drinkers, light, moderate, and heavy drinkers. For men, those values were: 0, 0.01–0.49, 0.5–2.49, and ≥2.5 drink/day, respectively. For women: the values were: 0, 0.01–0.49, 0.5–1.49, and ≥1.5 drink/day, respectively.

Statistical analysis

We calculated the unweighted number and weighted percentages for the study participants by the number of teeth categories. Chi-square tests were used to examine the relationship between the dependent and independent variables used in the study. Using multinomial logistic regression models, the odds ratio (OR) and 95% confidence interval (CI) were estimated by the number of teeth categories, using the 20–28 teeth group as a reference. The final model was adjusted for all the selected covariates which included: gender, age, race/ethnicity, smoking, education, socioeconomic status, BMI, diabetes, and alcohol intake. All the variables were entered into the model as categorical variables, using the categories described in the previous sections. Age was modelled as a categorical variable as its relationship with the study outcomes was not linear (Table S1). We used the CDC analytical published guidelines for estimation and testing that included weights, strata and cluster variables in the survey analysis procedures.[23] NHANES uses cluster sampling; participants are sampled from strata defined by geographical locations and proportions of minority populations. Each participant is assigned a sample weight, which is interpreted as the number of people that they represent in the population. Weights account for oversampling, and for nonresponse. The weight variable was created by using the original weight divided by the number of cycles (i.e., 6). All Analyses were done using SAS statistical software (version 9.4; SAS Institute, Cary, NC). The significance level was set at alpha = 0.05.

Results

The overall prevalence of depression among the studied sample was 6.8 percent. The prevalence of depression among edentulous individuals, those who did not have functional dentition and those with functional dentition, was 12.4, 11.7, and 5.9 percent, respectively. Of the studied sample, 4.5 percent were edentulous, whereas 85 percent had functional dentition (≥20 teeth) as shown in *Table* 1. More than 5 percent of females were edentulous, whereas less than 4 percent of males were edentulous. In the older group, 59 percent had functional dentition compared to 98.6 percent in the younger group. Non-Hispanic Blacks had a higher percentage of individuals who were edentulous, or lack functional dentition compared to the other ethnic categories. Ninety percent of never smokers had functional dentition compared to 77 percent of current smokers. As the level of education increased, the percentage of edentulism decreased. Less than 3 percent of individuals with some college education or higher were edentulous compared to more than 11 percent of those who did not attain a high school diploma. Similarly, edentulism decreased as levels of socioeconomic status increased. Less than 2 percent of the highest income category were edentulous whereas more than 8 percent of the lowest income category were edentulous. About 79 percent of the underweight category had functional dentition while the prevalence in obese, overweight, and normal-weight individuals was 83, 86, and 87 percent, respectively. Only 65 percent of diabetics had functional dentition compared to 87 percent of non-diabetics. Edentulism percentage was lowest among individuals with moderate alcohol intake. Individuals with depression had a higher percentage of edentulism and lacking functional dentition than those without depression. Edentulism was almost twice as prevalent in individuals with depression compared to those without depression, 8 percent versus 4 percent, respectively. Among individuals with depression, almost 18 percent had lacking functional dentition compared to 10 percent of those without depression (*Table* 1).

The results from the logistic multinomial regression are presented in *Table* 2. Compared to individuals without depression, those with depression were twice more likely to be edentulous versus having functional dentition (OR = 2.24, 95% CI = 1.82–2.75); this association became stronger after adjusting for age, gender and ethnicity (OR = 3.21, 95% CI = 2.53–4.06). In the fully adjusted model, the association was attenuated but remained

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Table 1 Characteristics of the Study Population by Tooth Loss Categories

		Edentulous (no teeth)			Lack of functional dentition (1–19 teeth)			Functional dentition (≥20 teeth)			
		n	%	SE	*n*	%	SE	*n*	%	SE	*P*-value
Total sample		1,406	4.54	(0.24)	3,347	10.27	(0.34)	17,779	85.19	(0.51)	
Gender	Male	611	3.78	(0.27)	1,610	9.86	(0.42)	8,652	86.36	(0.59)	<0.001
	Female	795	5.24	(0.30)	1737	10.65	(0.45)	9,127	84.10	(0.62)	<0.001
Age (years)	18 to 34	22	0.32	(0.09)	84	1.05	(0.12)	5,951	98.62	(0.15)	<0.001
	35 to 49	100	1.44	(0.20)	482	5.71	(0.35)	5,562	92.85	(0.42)	<0.001
	50 to 64	377	5.30	(0.43)	1,319	16.60	(0.76)	3,941	78.10	(0.93)	<0.001
	≥ 65	907	16.26	(0.87)	1,462	24.52	(0.83)	2,325	59.21	(1.22)	<0.001
Race/Ethnicity	Mexican American	91	1.49	(0.18)	420	7.45	(0.60)	3,059	91.06	(0.64)	<0.001
	Other Hispanic	135	3.59	(0.41)	406	12.50	(0.73)	1,647	83.91	(0.91)	<0.001
	Non-Hispanic White	759	4.92	(0.33)	1,270	9.30	(0.44)	7,800	85.78	(0.68)	<0.001
	Non-Hispanic Black	329	5.10	(0.34)	1,024	17.79	(0.65)	3,347	77.12	(0.74)	<0.001
	Other – including multi-ethnic	92	4.18	(0.65)	227	9.87	(0.95)	1926	85.95	(1.13)	<0.001
Smoking	Current smoker	417	7.83	(0.62)	913	15.54	(0.73)	3,292	76.63	(1.08)	<0.001
	Former smoker	475	6.40	(0.39)	958	13.09	(0.77)	3,621	80.51	(0.94)	<0.001
	Never smoker	514	2.60	(0.19)	1,476	7.22	(0.32)	10,866	90.18	(0.44)	<0.001
Level of education	Less than high school	624	11.27	(0.65)	1,208	19.74	(0.84)	3,400	68.99	(1.01)	<0.001
	High school or equivalent	397	6.45	(0.48)	927	14.85	(0.53)	3,745	78.71	(0.79)	<0.001
	Some college or higher	385	2.28	(0.17)	1,212	6.43	(0.31)	10,634	91.29	(0.39)	<0.001
Socioeconomic level (% FPL)	< 100	493	6.68	(0.48)	1,075	15.02	(0.70)	4,271	78.30	(0.88)	<0.001
	100–199	483	8.22	(0.44)	996	15.36	(0.61)	3,733	76.42	(0.83)	<0.001
	200–399	300	4.33	(0.32)	835	10.90	(0.51)	4,589	84.77	(0.59)	<0.001
	≥ 400	130	1.79	(0.23)	441	4.89	(0.37)	5,186	93.32	(0.48)	<0.001
Body Mass Index (kg/m2)	< 18.5	34	8.97	(1.91)	59	11.89	(2.05)	248	79.13	(2.49)	<0.001
	18.5–24.9	352	3.70	(0.32)	820	8.91	(0.51)	5,160	87.39	(0.66)	<0.001
	25–29.9	490	4.74	(0.32)	1,098	9.56	(0.48)	6,010	85.70	(0.70)	<0.001
	≥ 30	530	4.86	(0.31)	1,370	12.02	(0.43)	6,361	83.12	(0.51)	<0.001
Diabetes	No	1,029	3.81	(0.22)	2,614	9.15	(0.32)	16,320	87.04	(0.47)	<0.001
	Yes	377	12.41	(0.88)	733	22.41	(0.98)	1,459	65.18	(1.32)	<0.001
Alcohol consumption	Light	490	3.82	(0.29)	1,168	8.24	(0.31)	7,953	87.94	(0.47)	<0.001
	Moderate	156	2.26	(0.27)	522	7.95	(0.49)	3,755	89.78	(0.62)	<0.001
	Heavy	64	3.56	(0.68)	233	13.26	(1.24)	977	83.18	(1.46)	<0.001
	None	696	8.16	(0.48)	1,424	15.26	(0.66)	5,094	76.58	(0.93)	<0.001
Depression	No	1,229	4.27	(0.23)	2,983	9.73	(0.34)	16,532	86.00	(0.49)	<0.001
	Yes	177	8.22	(0.79)	364	17.68	(1.01)	1,247	74.10	(1.27)	<0.001

Data are presented as unweighted number, weighted percentage and standard error (SE).

significant (OR = 1.48, 95% CI = 1.16–1.89). Compared to individuals without depression, individuals with depression were 48 percent more likely to be edentulous versus having functional dentition. The association was similar in subjects with lacking functional dentition versus those having functional dentition. In the unadjusted model, compared to individuals without depression, individuals with depression were also twice more likely to have lacking functional dentition (OR = 2.11, 95% CI = 1.81–2.46), and when adjusting for age, gender and ethnicity, the strength of the association slightly increased (OR = 2.55, 95% CI = 2.15–3.02). In the fully adjusted model, compared to individuals without depression, individuals with depression were 43 percent more likely to have lacking functional dentition versus having functional dentition (OR = 1.43, 95% CI = 1.18–1.75).

In a further analysis, we re-categorized the outcome (tooth loss) into five categories: edentate, severe tooth loss (1–8 teeth), lacking functional dentition (9–19 teeth), functional dentition (20–27 teeth) and fully dentate, based on a recent CDC publication. [3] The association between depression and tooth loss was re-assessed with multinomial

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Table 2 Odd Ratios and 95% Confidence Intervals From Multinomial Logistic Regression Relating Depression to Edentulism and Lack of Functional Dentition

		Edentulism (no teeth) versus functional dentition (≥20 teeth)	Lack of functional dentition (1–19 teeth) versus functional dentition (≥20 teeth)
		Odds ratio (95% CI)	Odds ratio (95% CI)
Model 1	Depression: No	1 (reference)	1 (reference)
	Yes	2.24 (1.82–2.75)	2.11 (1.81–2.46)
P-Value		<0.001	<0.001
Model 2	Depression: No	1 (reference)	1 (reference)
	Yes	3.21 (2.53–4.06)	2.55 (2.15–3.02)
P-Value		<0.001	<0.001
Model 3	Depression: No	1 (reference)	1 (reference)
	Yes	1.48 (1.16–1.89)	1.43 (1.18–1.75)
P-Value		0.002	<0.001

Model 1 = Unadjusted; Model 2 = Adjusted for age, gender and ethnicity; Model 3 = Adjusted for age, gender, race/ethnicity, smoking, diabetes, body mass index, socioeconomic status, education, and alcohol consumption.

Table 3 Odd ratios (OR) and 95% Confidence Intervals (CI) From Multinomial Logistic Regression Relating Depression to Extent of Tooth Loss

		Edentulous versus fully dentate	Severe tooth loss (1–8 teeth) versus fully dentate	Lacking functional dentition (9–19 teeth) versus fully dentate	Functional dentition (20–27 teeth) versus fully dentate
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Model 1	Depression:				
	No	1 (reference)	1 (reference)	1 (reference)	1 (reference)
	Yes	2.82 (2.23–3.58)	2.82 (2.10–3.79)	2.61 (2.13–3.20)	1.52 (1.30–1.79)
P-Value		<0.001	<0.001	<0.001	<0.001
Model 2	Depression:				
	No	1 (reference)	1 (reference)	1 (reference)	1 (reference)
	Yes	4.60 (3.50–6.04)	4.34 (3.24–5.81)	3.42 (2.70–4.32)	1.68 (1.42–1.98)
P-Value		<0.001	<0.001	<0.001	<0.001
Model 3	Depression:				
	No	1 (reference)	1 (reference)	1 (reference)	1 (reference)
	Yes	1.76 (1.33–2.32)	1.72 (1.25–2.38)	1.69 (1.31–2.18)	1.25 (1.06–1.49)
P-Value		<0.001	<0.01	<0.001	0.01

Model 1 = Unadjusted; Model 2 = Adjusted for age, gender and ethnicity; Model 3 = Adjusted for age, gender, race/ethnicity, smoking, diabetes, body mass index, socioeconomic status, education, and alcohol consumption.

regression using the "fully dentate" as reference. As shown in *Table* 3, no meaningful changes were observed except for an increase in the strength of the association by about 19 percent for the edentate and those with non-functional dentition. For those with functional dentition compared to fully dentate, the association was the weakest (odds ratio = 1.25, 95% CI = 1.06–1.49).

Discussion

The findings of the present study show that there is a significant association between depression and tooth loss. Compared to those without depression, individuals with depression were 43 percent more likely to have lacking functional dentition and 48 percent more likely to be edentulous, versus having functional dentition. To the best of our knowledge, this study is the first to investigate the associations between depression and clinically recorded tooth loss in a large representative sample of the US adult population.

Prior research that assessed the relationship between depression and tooth loss yielded inconsistent results. [11-13, 15, 19-22] The majority of the studies relied on self-reporting rather than clinical examination to record missing teeth. Furthermore, most studies dichotomized tooth loss into two categories comparing those who have ≤31 teeth to those who have full dentition, or those who are edentulous to those who have one or more remaining teeth. In our study, we applied a more structured approach to categorize

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the outcome (functional dentition, lacking functional dentition, and edentulism).

The results of our study are in line with previous studies that investigated the association between depression and partial tooth loss, [11, 13, 22] and depression and edentulism. [11-13] However, our results are in partial agreement with Urzua et al. [15] who showed an association between depression and partial tooth loss only among the 35–44 age group but not among the 65–74 age group. The lack of association among the 65–74 age group in the above-mentioned study might be due to the small sample size.

Conversely, Silveira et al. [20] compared ≥18 years old pregnant women with any number of remaining teeth (1–31 teeth) to those with full dentition (32 teeth) and found no association between current depression and self-reported tooth loss. Our results also differ from Singh et al. [21] in which no association was found among older adults (≥60 years) with any tooth loss compared to individuals with full dentition. In regard to total tooth loss, our results differ from Hybels et al.,[19] who found no association between depression and edentulism when edentates were compared to those who have one or more teeth remaining. Therefore, the inconsistency between our results and the above-mentioned studies may be related to the method of recording and categorizing tooth loss and to the difference in the age groups and target population.

Collectively and despite the major methodological differences between previous research and our study, the findings do support the association between depression and tooth loss. Several hypotheses could explain this association. One is that depression predisposes individuals to caries and periodontitis which in turn may lead to tooth loss. This is supported by the reported reduced use of oral health services and poor dental habits such as infrequent tooth brushing among those with depression when compared to those without depression.[16] This might suggest that depressed people, because of avoidance of social contacts, are less likely to visit dental clinics, increasing the risk of tooth pathology and consequent tooth loss.[11, 16] Periodontitis could also mediate the association between depression and tooth loss, as individuals with depression might have a higher risk of periodontitis and subsequently tooth loss. Dumitrescu [28] in an articulate review discussed and illustrated the possible relationship between depression and periodontitis. Depression is associated with dysregulation of the hypothalamic–pituitary–adrenal axis, which, in turn, might cause cortisone and adrenal disturbances, immune system dysfunction, and excessive secretion of proinflammatory cytokines. These alterations, in addition to concurrent changes in health-related behaviors, such as oral hygiene, smoking, diet, and alcohol consumption, can elicit periodontal tissue breakdown which in turn might lead to tooth loss.[28] Another risk for the exacerbation of periodontal pathology and subsequent tooth loss is related to xerostomia, a frequent adverse effect of antidepressant medications.[28]

An opposite hypothesis to explain the association between depression and tooth loss is that depression is the outcome rather than the exposure.[17, 18] Coles et al.[29] reported that decayed and missing teeth predicted depression through indirect pathways via anxiety and oral health-related quality of life, where subjects felt embarrassed about their mouth and teeth appearance and felt that their life was less satisfying due to problems with their teeth and mouth, and discomfort during eating.[29] Similarly, periodontitis is associated with poor oral hygiene and causes halitosis and tooth loss.[30] These factors can have severe psychosocial effects such as shame, isolation, embarrassment, loneliness, and diminished well-being, body-image, self-esteem, and social status leading to depression.[28] In addition, periodontitis is associated with the production of bacterial endotoxins, which can cause excessive secretion of proinflammatory cytokines increasing the vulnerability to depression.[28] An alternative hypothesis to explains the association between depression and tooth loss is the presence of a bidirectional relationship between the two conditions.

A major limitation of our study is its cross-sectional design. Owing to the inherent limitation of cross-sectional studies, an association between two variables does not necessarily imply a cause-and-effect or establish the direction of the relationship. Thus, whether depression is the cause or the consequence of or has a bidirectional relationship with tooth loss requires interventional and/or longitudinal investigations. It is also possible that the association is spurious due to residual or unmeasured confounding by the shared risk factors between depression and tooth loss. Another limitation is that we combined multiple 2-year cross-sectional cycles of NHANES from 2005 to 2016 and the change of exposures and outcomes during this time period cannot be ruled out.

The results of our study further support a need for better integration and collaboration between medical and dental health care providers to improve populations' health care outcomes. Medical health care professionals can thus help in preserving natural dentition by recognizing common oral health problems and advising their patients to seek dental care and reinforce the importance of preventative oral care. [3, 4]

Further studies to assess the risk and benefit of depression treatment on oral health and tooth loss are needed. Also, studies to assess the effect of dental treatment on depression are certainly warranted. At least partial relief of depression symptoms could be anticipated after the treatment of oral diseases and satisfactory replacement of

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missing teeth through improving the individuals' quality of life.

Conclusions

The findings of our study showed that depression is associated with edentulism and lack of functional dentition, independent of gender, age, race/ethnicity, smoking, education, socioeconomic status, body mass index, diabetes, and alcohol intake. Given the possible bidirectional relationship between depression and tooth loss, further longitudinal studies to assess the nature of this association, are needed.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 Odds ratios and 95% Confidence Intervals from multinomial logistic regression associating depression to tooth loss.

How to cite this article: Al-Zahrani MS, Alhassani AA, Melis M, Zawawi KH. Depression is related to edentulism and lack of functional dentition: An analysis of NHANES data, 2005–2016. *J Public Health Dent*. 2020;1–8. https://doi.org/10.1111/jphd.12433

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