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Depressive symptoms and untreated coronal dental caries among adults ages 21-64 years, NHANES 2013-2014

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Background: Depression has been linked to poor oral health among patients seeking dental care. However, systematic research on the relationship between depressive symptoms and oral health is limited. ***Objective:*** To examine the association of depressive symptoms with untreated dental caries among adults aged 21-64 years. ***Basic Research Design:*** Cross-sectional secondary analysis. ***Setting:*** The data were extracted national data collected in the United States (2013-2014 National Health Nutrition and Examination Survey). **Participants:** The sample consisted of 3,127 non-institutionalized civilians. ***Main outcome measure:*** Untreated coronal dental caries (yes, no) was the key outcome variable. Depressive symptom categories (none, moderate, and severe) were derived from the Patient Health Questionnaire-9 Depression Scale. ***Results:*** In the study sample, 33.4% of adults had untreated coronal dental caries. Most participants (77.9%) did not report depressive symptoms; 13.9% had mild and 8.2% had moderate or severe depressive symptoms. In unadjusted analyses, individuals with mild (Odds Ratio = 1.62 [95% CI: 1.26, 2.08] and moderate/severe depressive symptoms (Odds Ratio = 2.70 [95% CI: 1.81, 4.02]) were more likely to have untreated coronal caries as compared with individuals without depressive symptoms. When sex, race, age, education, family income-to-poverty ratio, dental visits, history of previous dental restorations, health insurance, and smoking were included into the model, the associations were no longer statistically significant (1.27 [95% CI: 0.96, 1.69] and 1.61 [95% CI: 0.95, 2.73], respectively). ***Conclusion:*** The relationship between depressive symptoms and untreated coronal dental caries failed to remain significant after the addition of tobacco usage in the analysis.

Key words: *Depressive symptoms, dental caries, NHANES, secondary analysis, United States*

Introduction

In the United States, in 2012-13, 8.4% of adults, aged 18 years or older, screened positive for depression (Olfson *et al.,* 2016). This prevalence is higher than reported results from 60 countries from all regions of the world, in which the 1-year prevalence for an ICD-10 depression episode was 3.2% (Moussavi, *et al*., 2007). Depression affects many aspects of life and is associated with increased disease-related morbidity (Simon and Von Korff, 2001). One aspect of disease-related morbidity with depression is poor oral health conditions such as periodontal disease (Araujo, *et al*., 2016.)

Several mechanisms have been proposed by which depression may affect oral health. Stress and other physiological responses associated with depression can reduce salivary flow via sympathetic nervous system stimulation (Delgado-Angulo *et al.,* 2015). Alternatively, or in addition to the reduced flow, the available saliva may have a lower buffering capacity. Other mechanisms which may contribute to a decline in oral health include altered immune responses, inflammation (Delgado-Angulo *et al*., 2015), and behavioral changes associated with depression (more carbohydrate and sugary food intake, less frequent brushing and flossing, fewer dental visits, etc.) (Anttila *et al.,* 2006). Additionally, if depression is unrecognized by health care providers who fail to clarify nonspecific symptoms, such as fatigue or poor concentration, as depression (Simon and Von Korff, 2001), the above mentioned mechanisms would then have time to influence oral health and ultimately increase dental caries. The United States National Institute of Dental and Craniofacial Research indicated that 26% of adults, aged 20-64 years, have untreated dental caries; that is, the average adult has 3.28 decayed or missing permanent teeth (no author, NIDCR 2014).

While behavioral changes associated with depression might affect oral health outcomes, an alternative pathway may flow from an allostatic load from the cumulative impacts of a physiological condition to all dimensions of poor health (physical, mental and oral health outcomes). For example, Sabbah and colleagues (2008) found that the allostatic load was associated with both ischemic heart disease and periodontal disease, based on data from the National Health and Nutrition Examination Survey from 1988-1994. They also reported that these associations were mediated by socioeconomic factors such as education and income.

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Both pathways, including physiological/immunological and behavioral/social pathways may affect oral health outcomes. Given the mediating influence of the behavioral/social pathway as suggested by Sabbah and colleagues, we focused on the behavioral/social pathways to investigate their effects on oral health outcomes.

There is limited research on depression/depressive symptoms and untreated dental caries (Delgado-Angulo *et al.,* 2015). A recent study explored the relationship between depression, self-efficacy, and oral health using data on 399 regularly scheduled dental patients (McFarland and Inglehart, 2010). The investigators concluded that depression is a risk factor for increased dental caries, and other oral health problems, since individuals who had higher (and more severe) scores on the Center of Epidemiological Studies Depression Scale (CES-D) had poorer oral health than those with lower depression scores (McFarland and Inglehart, 2010). It has also been reported that one in five patients who visit a dental office have clinically significant symptoms of depression (D'Mello, 2003). In a study of non-Hispanic white pregnant women (n=685) in Appalachia, decayed, missing, and filled teeth were associated with depression using the CES-D (McNeil *et al.,* 2016). While informative, these studies were restricted to specific populations and the findings may not be generalizable. The purpose of this study is to examine the association between depressive symptoms and untreated dental caries among a segment of the U.S. population, adults aged 21-65 years.

Methods

Study design and data source

This study received non-human subject acknowledgement from the West Virginia University Institutional Review Board (protocol number: 1601975288). The Strengthening Reporting of Observational Studies (STROBE) guidelines were followed. The study design was cross-sectional. The data were extracted from the 2013-2014 National Health Nutrition and Examination Survey (NHANES, 2013-2014). The National Center for Health Statistics at the Centers for Disease Control and Prevention conducts national surveys concerning the health and nutrition of U.S. residents who are not in institutions. The sampling method is nationally representative, complex, and multistage (CDC, 2015), allowing for generalizations to be made from the data to the nation as a whole. The surveys include interviews and physical examinations. The interviews occurred in participants' homes. Interviewers asked demographic, socioeconomic, dietary, and health-related questions. The medical, dental and physiological examinations occurred in mobile centers and were conducted by trained medical personnel. There are approximately 5,000 participants enrolled yearly in the survey (NHANES, 2016). Details of the survey are available at: http://www.cdc.gov/nchs/data/nhanes/nhanes_13_14/2013-14_overview_brochure.pdf.

Study sample

We included participants who were working age adults, ages 21-64 years, in our study. The selection was based upon available dental examination and Patient Health Questionnaire-9 Depression Scale (PHQ-9) data (our interest was in dental caries and depression in working-age adults). We excluded participants who had missing data on depressive symptoms, untreated coronal dental caries, or health insurance. The final sample size was 3,127.

Measures

Dependent variable: untreated coronal dental caries

The key outcome variable was the presence or absence of untreated coronal dental caries (yes, no), based upon the NHANES examiners' determination of any untreated coronal dental caries on all teeth excluding third molars. As part of the NHANES protocol, a reference dental examiner visited examining dentists to verify calibration, observe, and replicate 20-25 oral health examinations (NHANES, 2016). Calibrations occurred up to three times per year (NHANES, 2016). Examiners evaluated each quadrant of the mouth by first air drying the area, and then examining each tooth's surface with a reflecting mirror and dental explorer (No. 23) (NHANES 2011-2012). NHANES examiners provided a variable with the following characteristics: sound primary tooth; missing due to dental disease; permanent root tip present, but not restored; primary tooth with surface condition(s); missing due to other causes; missing due to dental disease, but replaced by a removable restoration; missing due to dental disease, but replaced by a fixed restoration; sound permanent tooth; permanent root tip is present but a restorative replacement is present; unerupted; tooth present; condition cannot be assessed; and, permanent tooth with surface condition. Teeth with surface conditions were further identified as to having restorations and their locations, or having caries on the lingual, occlusal, incisal, facial, mesial, or distal surface of the tooth. For this study, the presence of any such caries on any teeth was identified as untreated coronal dental caries as any morbidity is a public health concern.

Key independent variable: depressive symptoms

The key independent variable was the category of depressive symptoms (none, mild, and moderate/severe). The levels of severity were derived from interview responses to the PHQ-9. The PHQ-9 is a depression screening tool with nine questions. The participants were asked about their depression status over the previous two weeks in responses to each question about how bothered they were by the posed situation. The responses were scored as "not at all" (0), "several days" (1), "more than half of the time" (2), and "nearly every day" (3). Potential scores were 0 to 27. Scores 0-4 indicated no/minimal depressive symptoms (the reference group); scores 5-9 indicated mild depressive symptoms; scores 10 and above indicated moderate to severe depressive symptoms. The use of 10 as a cut-off score in PHQ-9 to identify major depression has been recommended in the literature (Manea *et al.,* 2012).

Other independent variables

Variables considered as predictors of dental caries, potential confounders, or for epidemiological completion were: sex (male, female); race/ethnicity (non-Hispanic White, other); poverty status (poor-low income, middle-high income, and missing); health insurance (yes, no); tobacco use (current smoker, former smoker, never smoked); education (less than college, college degree); history of previous dental

restorations placed (yes, no); visit to the dentist (within one year, more than one year and never); and age group (21-30 years, 31-40 years, 41-55 years, 56-64 years). Age was used in categories rather than as a continuous variable to simplify presentation in natural generational breaks (Baby Boomers, Gen Xers, Millennials, and Generation Z's). The health insurance question posed in the NHANES included health insurance from employment, purchased through government programs, Medicare, and Medicare.

Statistical Analysis

We used SAS® version 9.3 (SAS Institute, Inc., Cary, NC) to conduct the statistical analyses. First, the distributions of all variables were described, before conducting bivariate associations of the independent variables with depressive symptoms and with untreated coronal caries. Finally, logistic regression of depression as a predictor of untreated caries was carried out in unadjusted and two adjusted analyses. The analyses used the NHANES values to account for stratification, eligibility and sample weighting. Information was absent on poverty status for 6% (220) of participants and 0.06% (2) participants concerning visits to the dentist. Sensitivity analyses were conducted to justify using variables with missing cases.

Results

The sample included 3,127 adults aged 21-64 years. Of these, 49.6% were female. The weighted sample was reflective of the U.S. population with 63.3% non-Hispanic White. There were 24.5% aged 21-30 years; 23.2% aged 31-40 years; 343.1 aged 41-55 years; and, 17.4% aged 56-64 years. Most (67.2%) did not have a college education, had an income to poverty ratio above 200% (61.7%), and had health insurance (79.0%). The majority (58.8%) never smoked, while 21.2% were current smokers. Most (60.4%) had seen a dentist within the past year. One third (33.4%) had untreated coronal dental caries.

Table 1 shows sample characteristics stratified by depressive symptom categories. Of the 3,127 individuals, 77.9% did not have depressive symptoms, 13.9% had mild symptoms, and 8.2% had moderate/severe depressive symptoms. Women, low income, smokers, individuals with less than a college degree, those not visiting the dentist in the past year, and those with caries were significantly more likely to have depressive symptoms. The relationships with race, age, and history of previous dental restorations placed failed to reach significance.

Table 1. Description of 3127 participants by Depressive Symptom Categories

		None		*Mild*		*Moderate/Severe*		*P<0.005, Chi Sq.*
		N	*Wt %*	*N*	*Wt %*	*N*	*Wt %*	
ALL		2,374	77.9	462	13.9	291	8.2	
Sex								
	Women	1,119	72.6	269	16.4	192	11.0	*
	Men	1,255	83.1	193	11.5	99	5.4	
Race								
	White	971	78.5	192	13.6	133	8.0	
	Non-white	1,403	76.9	270	14.6	158	8.6	
Age group								
	21-30 years	610	80.4	104	12.7	51	6.9	
	31-40 years	576	78.6	111	13.9	57	7.4	
	41-55 years	780	77.1	161	14.7	106	8.2	
	56-64 years	408	74.8	86	14.3	77	11.0	
Education								
	College/above	727	86.0	97	11.3	33	2.8	*
	Less than College	1,647	74.0	365	15.2	258	10.8	
Poverty Status								
	Poor-Low Income	919	68.9	238	17.7	178	13.4	*
	Middle-High Income	1,290	82.9	195	11.7	87	5.4	
Health Insurance								
	Yes	1,785	79.8	321	12.8	204	7.4	*
	No	589	70.7	141	18.1	87	11.1	
Tobacco Use								
	Current Smoker	463	64.5	137	19.1	114	16.4	*
	Former Smoker	441	78.5	85	13.2	61	8.4	
	Never Smoked	1,470	82.5	240	12.3	116	5.1	
Dental Visit								
	Within the Past Year	1,341	80.5	231	12.9	128	6.6	*
	More than One Year	1,031	73.8	231	15.5	163	10.7	
Past Caries								
	Yes	1,951	78.0	395	14.2	229	7.8	
	No	423	77.1	67	12.3	62	10.5	

Missing data for poverty status are not presented
Wt = weighted

Table 2 shows sample characteristics by the presence of untreated coronal dental caries. Proportionately more adults with mild (40.9%) and moderate/severe depressive symptoms (53.5%) had untreated coronal caries than adults with no depressive symptoms (29.9%). There were significant associations of untreated coronal dental caries with depressive symptoms, race, education, family income-to-poverty ratio, insurance status, smoking, history of previous dental restoration(s) and no visit to the dentist within the previous year. For example, 50.7% of the individuals who had not visited a dentist in the previous year had untreated caries, which is more than twice that of the individuals who had visited dentist in the past year (22.0%).

Table 3 shows the odds ratios (OR) and adjusted odds ratios (AOR) and 95% confidence intervals (CI) from logistic regression analyses. In unadjusted analyses, individuals with mild depressive symptoms were more likely (OR = 1.62, 95% CI: 1.26, 2.08) to have untreated caries than individuals with no symptoms. The OR was 2.70 (95% CI: 1.81, 4.02) for individuals with moderate/severe depressive symptoms.

In the adjusted logistic regression model (2) with the addition of sex, race, age, education, poverty status, health insurance, dental visit within the previous years, and previous history of dental restoration, the odds ratio of mild depressive symptoms, and untreated coronal dental caries was 1.39 (95% CI: 1,05, 1.83) as compared with individuals who had no depression symptoms. The OR was 1.89 (95% CI: 1.14, 1.01) for individuals with moderate/severe depressive symptoms. However, when smoking was added to create logistic regression model (3), the associations remained positive, but were no longer significant. The adjusted OR for mild depressive symptoms was 1.27 (95% CI: 0.96, 1.69). The adjusted OR for moderate/severe depressive symptoms was 1.61 (95% CI: 0.95, 2.73).

Table 2. Description of 3127 participants by Untreated Coronal Caries status

		Caries		*No Caries*		*P<0.005, Chi Sq.*
		N	*Wt %*	*N*	*Wt %*	
ALL		1,193	33.4	1,934	66.6	
Depressive Symptoms						*
	None	826	29.9	1548	70.1	
	Mild	208	40.9	254	59.1	
	Moderate/Severe	159	53.5	132	46.5	
Sex						
	Women	572	31.3	1008	68.7	
	Men	621	35.5	926	64.5	
Race						*
	White	473	29.7	823	70.3	
	Non-white	720	40.0	1111	60.0	
Age group						
	21-30 years	309	37.1	456	62.9	
	31-40 years	277	32.4	467	67.6	
	41-55 years	418	34.5	629	65.5	
	56-64 years	189	27.2	382	72.8	
Education						*
	College/above	147	14.3	710	85.7	
	Less than College	1,046	42.7	1,224	57.3	
Poverty Status						*
	Poor-Low Income	719	51.9	616	48.1	
	Middle-High Income	398	23.6	1174	76.4	
Health Insurance						*
	Yes	754	28.0	1556	72.0	
	No	439	53.6	378	46.4	
Tobacco Use						*
	Current Smoker	423	57.2	291	42.8	
	Former Smoker	206	29.8	381	70.2	
	Never Smoked	564	26.0	1262	74.0	
Dental Visit						*
	Within the Past Year	434	22.0	1266	78.0	
	More than One year	757	50.7	668	49.3	
Past Caries						*
	Yes	902	30.9	1673	69.1	
	No	291	47.2	261	52.8	

Missing data for poverty status are not presented
Wt = weighted

Table 3. Logistic regression analysis for predictors of untreated caries

		Model 1		*Model 2*		*Model 3*	
		OR	*95% CI*	*AOR*	*95% CI*	*AOR*	*95% CI*
Depressive Symptoms							
	None (Ref)						
	Mild	1.62	[1.26, 2.08]	1.39	[1.05, 1.83]	1.27	[0.96, 1.69]
	Moderate/Severe	2.70	[1.81, 4.02]	1.89	[1.15, 3.11]	1.61	[0.95, 2.73]
Sex							
	Women			0.77	[0.59, 1.01]	0.80	[0.62, 1.05]
	Men (Ref)						
Race							
	White (Ref)						
	Non-white			1.00	[0.77, 1.30]	1.12	[0.84, 1.49]
Age group							
	21-30 years (Ref)						
	31-40 years			1.00	[0.74, 1.34]	1.00	[0.74, 1.37]
	41-55 years			1.27	[0.95, 1.68]	1.25	[0.94, 1.66]
	56-64 years			1.01	[0.75, 1.34]	1.07	[0.80, 1.42]
Education							
	College/above (Ref)						
	Less than College			2.71	[2.25, 3.27]	2.38	[1.96, 2.89]
Poverty Status							
	Poor-Low Income			1.91	[1.53, 2.37]	1.79	[1.45, 2.23]
	Middle-High Income (Ref)						
Health Insurance							
	Yes (Ref)						
	No			1.39	[1.10, 1.74]	1.36	[1.09, 1.69]
Dentist Visit							
	One year/less (ref)						
	More than One Year			2.40	[1.92, 3.01]	2.29	[1.81, 2.89]
Past Caries							
	Yes			0.77	[0.53, 1.11]	0.76	[0.53, 1.10]
	No (ref)						
Tobacco Use							
	Current Smoker					2.43	[1.77, 3.32]
	Former Smoker					1.11	[0.92, 1.35]
	Never Smoked (Ref)						

Discussion

Depression and its symptoms remain a serious problem worldwide, particularly among working-age adults. In this study, nearly one-fourth of participants reported some depressive symptoms within the previous two weeks, while 8.7% reported moderate to severe depressive symptoms. The depression prevalence we identified is slightly higher than the 6.7% determined in 2014 using the U.S. National Survey on Drug Use and Health (NSDUH) (National Institute of Mental Health, 2015). One explanation for the higher prevalence of depression is the age range of our participants, limited to U.S. working-age adults aged 21-64 years, whereas the NSDUH results included adults 18 years and above. At 21.7%, the percentage of individuals with untreated coronal dental caries is also high for this working-age group, but is somewhat lower than the results on the U.S. National Institute of Craniofacial Research (NIDCR) website in which 26% of adults aged 20-64 years had untreated caries. Different study design may also have influenced these values as NIDCR used combined data from 1999-2004 (NIDCR 2014) while the data for this study were from 2011-2012.

We did not observe a relationship between depressive symptom categories and untreated coronal dental caries after tobacco use was included in the adjusted logistic regression model with other socio-economic variables.

Similar studies are lacking in the literature. Researchers of a study of non-Hispanic white pregnant women (n=685) in Appalachia, in contrast to this study, did find that decayed, as well as *missing and filled* teeth were associated with depression using the CES-D (McNeil *et al.,* 2016).

Globally, several small studies have assessed the association between depression and untreated caries. A study (n=351) of Japanese adults, aged 77 and above, had similar results. The researchers of that study also failed to reject their null hypothesis. Dissimilarities between the protocols of the two studies, in addition to the ages of the participants, use of the General Health Questionnaire-30 to determine depression, and universal healthcare in Japan should be noted.

In a small study of 390 South Brazilians, aged 60 years and above, the researchers determined that depressive symptoms may lead to decayed, missing and filled teeth (DMFT) (Hugo *et al.,* 2012). The difference between our results and the results of the Brazilian study may have arisen from the different ages of the participants, use of the Geriatric Depression Scale to determine depression, and universal healthcare in Brazil.

A study of 853 homeless people in Scotland found an association between depression (using CES-D) and decayed *and missing* teeth (Coles, *et al*., 2011). Lastly, in a large study conducted in Finland (n=8,020), decayed teeth were associated with depression, but only in adults aged 35-54 years (Delgado-Angula *et al.,* 2015). The dissimilarities between our results and the results determined in Finland may be explained by their use of the Beck Depression Inventory, universal healthcare in Finland, and the age of participants (Delgado-Angulo *et al.,* 2015).

We found that education and income were associated with oral health outcomes (namely caries). The association between socio-economic disadvantage and depression has been well documented (Gilmer *et al.,* 2015). Emerging evidence suggest that depression can be conceptualized as a "systemic inflammation" (Gurenlian, 2009). The inflammatory responses to depression may also aggravate oral health problems (Sotelo & Nemeroff, 2017). Taken together these findings suggest that oral health can be influenced through physiological/immunological and behavioral/social pathways and coronal dental caries might be attenuated through programs that can address poverty, access to healthcare, and smoking cessation.

As researchers use various definitions for caries, depression, and select populations of various ages, there is difficulty in making study comparisons. The unique contributions of the current study include using a nationally representative sample, availability of oral health information from the actual examination of teeth (rather than from self-reports), and our ability to conduct analyses which controlled for a comprehensive set of risk factors for dental caries. Our ability to control for tobacco usage is particularly relevant as we showed that adding it to the adjusted model resulted in attenuating the odds ratio of depression.

However, the study does have limitations. The cross-sectional design limits the ability to infer causality. Another limitation was the use of PHQ-9 rather than a clinical diagnosis of depression. Another shortcoming is the failure to adjust for dietary sugar. The World Health Organization recommends less than 10% of one's daily nutrition be sugar. This variable, a known risk factor for dental caries, would be important to include in future research.

Conclusions

The relationship between depressive symptoms and untreated coronal dental caries failed to remain significant after the addition of tobacco usage in the adjusted logistic regression model.

Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

All authors have made substantive contributions to this study and/or manuscript, and all have reviewed the final paper prior to its submission.

Conflict of Interest

The authors claim no conflict of interest.

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