



The association between poor dental health and depression: findings from a large-scale, population-based study (the NHANES study)



Adrienne O'Neil, Ph.D. ^{a,b,*}, Michael Berk, Ph.D. ^{a,c,d,e}, Kamalesh Venugopal, Ph.D. ^a, Sung-Wan Kim, Ph.D. ^f, Lana J. Williams, Ph.D. ^{a,c}, Felice N. Jacka, Ph.D. ^{a,c}

^a IMPACT Strategic Research Centre, Deakin University, Geelong, Australia

^b School of Public Health and Preventive Medicine, Monash University, Australia

^c The University of Melbourne, Department of Psychiatry, Parkville, Australia

^d Orygen Youth Health Research Centre, Parkville, Australia

^e Mental Health Research Institute, Parkville, Australia

^f Department of Psychiatry, Chonnam National University Medical School, Gwangju, Republic of Korea

ARTICLE INFO

Article history:

Received 16 July 2013

Revised 19 January 2014

Accepted 22 January 2014

Keywords:

Depression

Inflammation

Dental disease

Dental health

C-Reactive Protein (CRP)

ABSTRACT

Objective: To examine the relationship of poor dental health and depression, controlling for markers of inflammation (C-reactive protein; CRP) and adiposity (body mass index; BMI).

Method: Data from two National Health and Nutrition Examination Surveys (2005–2008) were utilized ($n=10214$). Dental health was assessed using the Oral Health Questionnaire (OHQ). Depression was measured using the Patient Health Questionnaire-9 (PHQ-9), where cases were identified using a cut off score of 10 or above. Logistic regression was applied to measure magnitude of associations, controlling for a range of covariates including CRP and BMI.

Results: After adjustment for covariates, a significant dose–response relationship between number of oral health conditions and likelihood of PHQ-9 defined depression was observed. Compared with individuals without an oral health condition, adjusted odds ratio (95% confidence interval) for depression in those with two, four and six conditions were 1.60 (1.08–2.38), 2.13 (1.46–3.11) and 3.94 (2.72–5.72), respectively. Level of CRP and being underweight or obese were associated with being depressed.

Conclusions: A positive association exists between poor dental health and depression that is independent of CRP and BMI.

© 2014 Elsevier Inc. All rights reserved.

1. Introduction

Poor dental health is well recognized as a source of systemic inflammation, with emerging literature identifying it as a risk factor for the progression of inflammatory diseases such as cardiovascular disease (CVD). For example, poor oral hygiene is associated with a 70% increased risk of CVD [1], while periodontal disease is associated with a two-fold increase in the risk of CVD-related mortality [2].

There is now abundant evidence that depression is also an inflammatory disorder. This high prevalence condition is accompanied by chronic, low-grade inflammation, indicated by increased levels of acute phase proteins, such as C-reactive protein (CRP), as well as pro-inflammatory cytokines including interleukins and tumor

necrosis factor [3]. Data from large-scale, prospective studies have shown that elevated inflammatory markers, such as high-sensitivity CRP, increase the risk of developing major depressive disorder [4]. As such, the identification of potentially modifiable sources of such inflammation is imperative, particularly in view of the global burden of disease imposed by depression [5].

Currently, the relationship between poor dental health and depression is not well understood. Many studies have investigated the contribution of depression and the onset of periodontal disease or poor dental health, but few have explored the converse association at the population level. In regards to the former studies, depression was found to be associated with periodontal destruction [6], poorer perceived oral health [7] and oral health concerns [8]. When the underlying contribution of behavioral and physiologic factors to these relationships has been explored, physiological mechanisms including salivary cortisol have been demonstrated to be more important than behaviors such as health care utilization [6]. Marques-Vidal et al [7], who reported that depression was associated with poor dental health, concluded that the link was independent of limited dental health care. While these data provide some insight into the association between poor mental and dental health, this relationship has seldom been

Abbreviations: CVD, Cardiovascular disease; CRP, C-reactive protein; BMI, Body Mass Index; NHANES, National Health and Nutrition Examination Surveys; OHQ, Oral health questionnaire; PHQ-9, Patient Health Questionnaire-9; DPQ, Depression Screener Questionnaire; OR, Odds Ratio; CI, Confidence Intervals; hsCRP, High Sensitivity C-reactive protein.

* Corresponding author. IMPACT Strategic Research Centre, Deakin University PO Box 281 Geelong, VIC 3220, Australia. Tel.: +61-342153304; fax: +61-342153491.

E-mail address: AONEIL@barwonhealth.org.au (A. O'Neil).

explored at the population level or determined whether it exists independent of physiological indicators of systemic inflammation or inflammatory conditions.

Using a well characterized, nationally-representative, population-based study, we therefore sought to examine the association of poor dental health to depression, controlling for key inflammatory indicators; CRP and Body Mass Index (BMI).

2. Methods

2.1. Study design and sampling

Cross-sectional, population-based data from the National Health and Nutrition Examination Surveys (NHANES) (2005–2008) were utilized. This methodology has been described in detail elsewhere [9]. Briefly, NHANES is conducted by the National Center for Health Statistics. The study sample was drawn from a stratified, multistage probability sample of non-institutionalized, United States civilians aged 20–75 years. Approximately 5000 individuals participated in detailed, home-based interviews annually. Physical examinations occurred at a mobile examination centre. NHANES data are collected annually and released in two-year cycles. For the purpose of this paper, we combined surveys 2005–2006 and 2007–2008; the reason for this was that the dental health questions and target sample changed from 2009 onwards (the target groups for 2005–2008 and 2009–2010 were 18+ years and 30+ years, respectively). The overall response rate for these surveys was 76.4%. Markers of dental health and depressive symptoms were available for 10,214 participants. NHANES received approval from the National Center for Health Statistics research ethics review board and informed consent was obtained for all participants.

2.2. Data collection instruments

2.2.1. Dental health

Participants completed an oral health questionnaire (OHQ) in which they were asked to rate the condition of their teeth (Poor, Fair, Good, Very Good, Excellent) and then respond yes/no to the following seven questions: In the past year, have you: had aching in the mouth, felt bad because of mouth, had difficulty with your job because of mouth, had your taste affected because of mouth, avoided some food because of mouth, been unable to eat because of mouth, been embarrassed because of mouth. For descriptive purposes, the condition of tooth was classified into a dichotomous variable as follows; good, very good, and excellent versus fair and poor. For the purpose of our analyses, dental health was treated as a continuous variable, classified according to the number of oral health conditions reported (0–7) and treated as the independent variable in our analyses.

2.2.2. Depression

Depression was assessed using the Patient Health Questionnaire-9 (PHQ-9) [10], which is a version of the Prime-MD diagnostic tool. This is a self-reported assessment that is based on the nine DSM-IV depression symptoms over the past 2 weeks. It is referred to as the Depression Screener Questionnaire (DPQ) in the NHANES. The nine symptom questions are scored from “0” (not at all) to “3” (nearly every day). A further follow-up question assesses the overall impairment of the depressive symptoms. The PHQ-9 is used most often in primary care settings and has been shown to be a reliable and valid tool for depression diagnosis both in clinical and the general population [11]. As we were specifically interested in observing the influence of dental health on the presence or absence of depression, we treated the data dichotomously. As such depression was defined as a PHQ-9 score of 10 or higher, a cut point that has been well validated and is commonly used in clinical studies that measure depression,

with a sensitivity of 88% and a specificity of 88% for major depression [12]. Participants recording a PHQ-9 score of 0–9 were defined as not having depression.

2.2.3. Covariates

Demographic variables were self-reported and included: gender, age, poverty level, education, and smoking status. Level of poverty was classified using definitions generated by the Social Security Administration [13], comprising family income and size, number of children and (for families with two or fewer adults) age of the adults in the family, and included a set of income thresholds that vary by family size and composition [14]. Participants with an income below their corresponding thresholds were classified as below the poverty level. The values were not computed if the income screener information (INQ 220: <\$20,000 or ≥\$20,000) was the only family income information reported. If family income was reported as a range value, the midpoint of the range was used to compute the variable. Values at or above 5.00 were coded as 5.00 or more because of disclosure concerns. The values were not computed if the family income data was missing. Current smoker was defined by the question, “Do you now smoke cigarettes?” Persons who responded “every day” or “some days” were included in the current smoker category. Persons who reported using only other forms of tobacco were not included in this definition. Former smokers or persons who had quit smoking were defined as answering “yes” to the question, “Have you smoked at least 100 cigarettes in your entire life?” and “no” to the question, “Do you now smoke cigarettes?”

As detailed in previous NHANES papers [15], CRP was quantified using latex-enhanced nephelometry; analyses were conducted in the Department of Laboratory Medicine, Immunology Division at the University of Washington Medical Center. Specimens with results between 0–1 mg/dL were defined as being in the normal range and high levels of CRP was defined as >1 mg/dL. BMI was calculated using standardized protocols comprising height and weight which were collected in the mobile examination centre. BMI (kg/m²) was categorized into four levels as following; underweight (BMI ≤18.49), normal (BMI 18.50–24.99), overweight (25–29) and obese (BMI ≥30).

2.3. Statistical analysis

Data were publicly available and provided by the National Center for Health Statistics [9]. The demographics, DPQ, OHQ, smoking, body measurements and CRP data were merged into a master file and additional variables were created for analysis. Weighting was applied to account for the stratified multistage survey design, oversampling and non-response and were constructed according to the CDC guidelines [16]. Stata 12 (survey procedures) was used for all statistical analyses. Comparisons were made between depressed and non-depressed participants as assessed by the PHQ-9 for socio-demographic and dental health characteristics using appropriate parametric tests where data were normally distributed and non-parametric statistical tests for categorical or non-normal data. The association between depression status, demographic characteristics and dental health characteristics was based on the Pearson chi-square test. Logistic regression analysis for survey data was performed in STATA using the SVY commands to account for the complex sampling design for determining variance estimates and the reference group within the selected categorical variables was specified. Two inflammatory markers (CRP and BMI) were then added to the main effects model of oral health and depression to determine whether the relationship was independent of these; both were treated as continuous variables in these analyses. The odds ratio (OR), 95% confidence intervals (CIs) and *P* values are presented. All tests were two-tailed and a *P* value of .05 was used for statistical significance.

3. Results

3.1. Samples characteristics

The key characteristics for all survey participants are displayed in Table 1. Of a total of 10,214 participants, 820 (8.0%) had depression defined by PHQ-9 scores ≥ 10 . Of those with depression, almost two thirds were female (63.2%), almost one-quarter aged between 45–54 years (23.2%), 42.3% white (non-Hispanic), over one-third were

Table 1
Demographic and clinical characteristics by depression status, aged 18 years and above (unweighted)

Demographic and clinical characteristics	Not depressed (Total score 0–9) (n=9394)		Depressed (Total score ≥ 10) (n=820)		<i>P</i> ^a
	n	%	n	%	
Gender					<.001
Male	4697	(50.0)	302	(36.8) ^d	
Female	4697	(50.0)	518	(63.2) ^d	
Age ^b					<.001
18–24 years	1528	(16.3)	111	(13.5) ^d	
25–34 years	1516	(16.1)	115	(14.0)	
35–44 years	1451	(15.4)	156	(19.0) ^d	
45–54 years	1406	(15.0)	190	(23.2) ^d	
55–64 years	1324	(14.1)	141	(17.2) ^d	
65+ years	2169	(23.1)	107	(13.0) ^d	
Race/ethnicity					<.001
Mexican-American	1821	(19.4)	150	(18.3)	
Other Hispanic	666	(7.1)	93	(11.3) ^d	
Non-Hispanic white	4496	(47.9)	347	(42.3) ^d	
Non-Hispanic black	2062	(22.0)	204	(24.9)	
Other race, including multi-racial	349	(3.7)	26	(3.2)	
Marital status					<.001
Married	4817	(52.6)	301	(37.7) ^d	
Widowed	746	(8.2)	53	(6.6)	
Divorced	868	(9.5)	139	(17.4) ^d	
Separated	260	(2.8)	53	(6.6) ^d	
Never married	1794	(19.6)	161	(20.2)	
Living with partner	668	(7.3)	92	(11.5) ^d	
Country of birth					.915
USA	7325	(78.0)	637	(77.7)	
Mexico	1069	(11.4)	92	(11.2)	
Elsewhere	999	(10.6)	91	(11.1)	
Education					<.001
Student (age 6–19 years)	723	(7.7)	50	(6.1)	
Less than 9th grade	1023	(10.9)	130	(15.9) ^d	
9–11th grade	1359	(14.5)	188	(22.9) ^d	
(including 12th grade with no diploma)					
High school grad/GED or equivalent	2100	(22.4)	204	(24.9)	
Some college or AA degree	2385	(25.4)	191	(23.3)	
College Graduate or above	1799	(19.2)	57	(7.0) ^d	
Poverty level ^c					<0.001
Below 100%	1648	(18.8)	284	(38.0) ^d	
100% to less than 200%	2241	(25.5)	238	(31.9) ^d	
200% or higher	4898	(55.7)	225	(30.1) ^d	
Smoking					<0.001
Current	1790	(20.7)	312	(40.5) ^d	
Former	2262	(26.1)	159	(20.6) ^d	
Never	4614	(53.2)	299	(38.8) ^d	
Body mass index (BMI)					<0.001
Underweight (BMI ≤ 18.49)	171	(1.8)	15	(1.9)	
Normal (BMI 18.50–24.99)	2748	(29.6)	218	(27.0)	
Overweight (25–29)	3183	(34.3)	226	(28.0) ^d	
Obese (BMI ≥ 30)	3188	(34.3)	347	(43.1) ^d	
CRP					<0.001
Normal (0–1 mg/dL)	8051	(89.7)	644	(83.3) ^d	
High (>1 mg/dL)	920	(10.3)	129	(16.7) ^d	

^a The *P* value is based on the Pearson chi-square and tests for the association between depression status and the demographic characteristics.

^b Mental health respondents in the 5–17 years age group are not included.

^c The poverty level is based on the Poverty income ratio.

^d Denotes significant difference in the proportions.

married (37.7%), 15.9% had less than 9th grade education, almost two-thirds were current or former smokers, and 71.1% were overweight or obese. The majority of these individuals (83.3%) had CRP levels within the normal range (0–1 mg/dL). In contrast to participants with no depression, depression cases were relatively evenly distributed across poverty levels.

Table 2 displays the results of chi-square tests, demonstrating significant differences in condition of tooth and all seven items regarding dental health between those with and without depression. Almost two thirds of participants reporting depression (61.0%) also reported having an aching mouth in the past year. More than half (57.4%) considered the condition of their teeth to be fair or poor.

3.2. Association between dental health and depression

Table 3 displays the results of the logistic regression analyses. After adjustment for gender, age, poverty level, education and smoking, a significant dose–response relationship between dental health and PHQ9-defined depression was observed; the number of dental conditions was associated with corresponding increases in the likelihood of having depression. Compared with individuals without a dental condition, those with two conditions were 1.60 times as likely to have depression (95% CIs: 1.08–2.38). Those with four dental conditions were twice as likely to have depression (adj. OR: 2.13; 95% CIs: 1.46–3.11). Those with six dental conditions were almost four times as likely to have depression (adj. OR: 3.94; 95% CIs: 2.72–5.72) when compared with the reference group. There was only one exception to this dose–response effect; while those with seven dental conditions were shown to have elevated odds of depression (adj. OR: 3.79; 95% CIs: 2.49, 5.78), these odds were slightly less than for those with six conditions. When we re-ran the analyses including, separately, CRP and BMI in the original model, these inclusions were shown to have little effect on results, although both underweight and obesity and CRP were independently associated with an increased odds for depression (Table 3).

Table 2
Depression (past 2 weeks) and dental health status in the last year, NHANES, 2005–2008 (unweighted)

Dental Health	Not depressed		Depressed		<i>P</i> ^a
	n	%	n	%	
Condition of tooth					<.001
Good/very good/excellent	6104	(65.2)	348	(42.6)	
Fair/Poor	3254	(34.8)	468	(57.4)	
Had aching in the mouth					<.001
No	5202	(55.4)	320	(39.0)	
Yes	4190	(44.6)	500	(61.0)	
Felt bad because of mouth					<.001
No	7324	(78.0)	448	(54.7)	
Yes	2061	(22.0)	371	(45.3)	
Had difficulty with job because of mouth					<.001
No	8470	(90.3)	636	(77.8)	
Yes	911	(9.7)	181	(22.2)	
Taste affected because of mouth					<.001
No	8312	(88.6)	590	(72.3)	
Yes	1067	(11.4)	226	(27.7)	
Avoided some food because of mouth					<.001
No	6918	(73.7)	412	(50.3)	
Yes	2475	(26.3)	407	(49.7)	
Couldn't eat because of mouth					<.001
No	6743	(71.8)	388	(47.4)	
Yes	2646	(28.2)	431	(52.6)	
Embarrassed because of mouth					<.001
No	7282	(77.5)	478	(58.4)	
Yes	2110	(22.5)	341	(41.6)	

^a The *P* value is based on the Pearson chi-square and tests for the association between depression status and the dental health characteristics.

Table 3

Survey data logistic regression model for odds of being depressed

Independent variables	OR	95% CI	P ^a		OR	95% CI	P ^a	
Gender	MODEL 1 +				MODEL 2 ±			
Female	1.83	1.53	2.20	.000	1.87	1.54	2.27	<.001
Age								
18–24 years	1.10	0.64	1.88	.728	1.05	0.59	1.87	.874
25–34 years	1.20	0.87	1.68	.258	1.21	0.85	1.73	.271
35–44 years	1.65	1.20	2.27	.003	1.63	1.17	2.27	.005
45–54 years	2.30	1.62	3.25	.000	2.23	1.57	3.16	<.001
55–64 years	1.68	1.17	2.42	.006	1.61	1.11	2.34	.013
Poverty level								
Below 100%	2.88	2.33	3.55	.000	2.79	2.25	3.45	<.001
100% to less than 200%	1.79	1.46	2.20	.000	1.75	1.42	2.17	<.001
Education								
Less than 9th Grade	2.33	1.41	3.83	.002	2.18	1.30	3.67	.005
9–11th grade	2.25	1.35	3.75	.003	2.06	1.23	3.45	.007
High school grad/GED or equivalent	2.32	1.44	3.73	.001	2.09	1.30	3.38	.004
Some college or AA degree	1.84	1.12	3.01	.017	1.68	1.01	2.79	.046
Smoking								
Current smoker	1.93	1.45	2.59	.000	2.16	1.59	2.92	<.001
Former smoker	1.22	0.85	1.76	.272	1.25	0.86	1.81	.238
Body mass index								
Underweight (≤18.49)	-	-	-	-	0.38	0.21	0.67	.002
Overweight (25–29.99)	-	-	-	-	1.16	0.90	1.51	.247
Obese (30+)	-	-	-	-	1.47	1.09	1.97	.012
CRP	-	-	-	-	1.18	1.06	1.31	.004
Number of dental conditions								
1	1.13	0.69	1.83	.616	1.15	0.72	1.86	.544
2	1.60	1.08	2.38	.021	1.67	1.13	2.48	.012
3	1.87	1.17	2.98	.011	1.89	1.18	3.02	.010
4	2.13	1.46	3.11	.000	2.14	1.48	3.10	<.001
5	2.50	1.74	3.60	.000	2.63	1.82	3.81	<.001
6	3.94	2.72	5.72	.000	3.81	2.61	5.54	<.001
7	3.79	2.49	5.78	.000	3.73	2.38	5.85	<.001

Reference categories: gender, male; age group, 65 + years; poverty level, 200% or higher; education, college graduate or above; smoking, never smoked; number of dental conditions, 0 (i.e. no dental condition). + Model 1: includes gender, age, poverty level, education, smoking and number of dental conditions. ± Model 2: includes all of the variables in model 1 plus BMI and CRP.

^a Statistically significant value is denoted using bold font.

4. Discussion

This study aimed to examine the association between markers of dental health and depression at the population level. We observed a dose–response relationship between the number of dental problems and the likelihood of depression, before and after controlling for inflammatory markers of CRP and BMI.

The majority of the previous studies in this area that have been conducted in the US [6], Europe [7] and Australia [8], have discussed this relationship as the putative contribution of depression to poor dental health. While we were unable to elucidate the nature of the relationship due to the cross sectional data, we were particularly interested in exploring depression as an outcome, as opposed to an exposure. Our results demonstrate a clear association between the two conditions; a finding that has been observed for other inflammatory diseases such as CVD [1]. An association between dental health and dementia has also been shown both at neuropathological and epidemiological levels [17,18], in which inflammatory processes have been implicated.

While this study did not find inflammation to influence the relationship between poor oral health and depression, it is possible that the marker of inflammation utilized in this study, CRP, was not sufficiently sensitive to detect effects. Newer assays with improved sensitivity are now available, which allows the detection of subclinical levels of systemic inflammation (e.g., High Sensitivity CRP; hsCRP). While CRP is a valid marker of an inflammatory condition, we acknowledge that it largely reflects severe systemic inflammation. Indeed, dental disease such as periodontitis may constitute only local

inflammation. Moreover, increases in CRP can occur not only with infection, but also with trauma, tissue necrosis, malignancies, and autoimmune disorders. These facts may help explain our finding that CRP did not influence the relationship between dental health and depression. Rather, an association between poor dental health and depression could be explained by other factors. For example, poor dental health may be related to lifestyle including nutritional deficits, from diet, alcohol and other factors which may subsequently increase the risk of depression [19,20]. For example, dental problems have been shown to influence food selection and nutritional status [21,22]. Depressed individuals have been shown to under-utilize dental services [23], be more likely to smoke [24], drink [25] and crave carbohydrates and sweet foods, neglect oral hygiene [6] and have reduced saliva output [26]. Further, it is possible that particular types of anti-depressant medications contribute to deteriorating dental health. Well documented side effects of these medications include hyposalivation, xerostomia (dry mouth syndrome), periodontitis, gum infection and bruxism (teeth grinding) [27]. While these are plausible inferences, it may be the case that a bi-directional relationship exists between dental and mental health. Although we were unable to detect any influence of inflammation or an inflammatory condition in the observed relationship, it may be that a relationship exists via other, unexplored, factors. For example, both poor dental health and depression could be the result of diets high in refined carbohydrates and other sweet foods [19]. Identification of potentially modifiable risk factors for depression is an important imperative [28]; as such, continued investigation of potentially causal mechanisms underlying the link between poor dental health and depression is warranted.

The key strength of the study was the use of data from a large, well-characterized, probability sample from the general population, thereby enhancing the robustness and representativeness of the findings. The use of the PHQ-9, which has been widely validated in the general population [11], is another positive feature of this study. A further strength was the availability of a marker of inflammation derived from blood samples, which allowed us to investigate the influence of inflammation in the association between dental health and depression. In addition to the cross-sectional nature of the data, a key limitation was that most data utilized in this study were derived from self-report instruments over different recall periods. These measures may have led to recall bias, under- or over-estimation of oral hygiene or incorrect identification of depression (e.g. the PHQ-9 does not allow for assessment of duration of depression). In addition to including objective measure of dental health, future studies investigating this relationship should consider the administration of a diagnostic interview to assess depression as well as to address long term versus acute depressive symptoms and their association with dental health.

Our findings, coupled with recent data generated from cohort studies which demonstrate the predictive effect of oral health on adverse health and quality of life outcomes, suggests that oral health could be a potential key determinant of population health [29]. Indeed, this is an area of research that we consider warrants further exploration. Once our understanding of this relationship is more advanced, it is possible that population-based, educational programs designed to improve oral health could be considered as a primary prevention strategy.

We conclude that a positive association exists between poor dental health and depression, independent of markers of inflammation, CRP and BMI (an inflammatory condition). We acknowledge that the cross sectional nature of the dataset precludes confirmation of causative associations therefore recommend that prospective cohort studies be enacted to determine the direction of the relationship between dental health and depression and exploring its underlying physiology. If in fact poor dental health is an independent risk factor for depression, this may have implications for depression management, as well as depression prevention from a public health perspective.

Acknowledgment

AO and FNJ are supported by Fellowships from the National Health and Medical Research Council (NHMRC)(#1052865 and #628912, respectively).

References

- [1] Cesar de O, Richard W, Mark H. Toothbrushing, inflammation, and risk of cardiovascular disease: results from Scottish Health Survey. *BMJ* 2010;340:C2451.
- [2] Ajwani S, Mattila K, Narhi T, Tilvis R, Ainamo A. Oral health status, C-reactive protein and mortality – a 10 year follow-up study. *Gerodontology* 2003;20(1):32–40.
- [3] Raison CL, Capuron L, Miller AH. Cytokines sing the blues: inflammation and the pathogenesis of depression. *Trends Immunol* 2006;27(1):24–31.
- [4] Pasco JA, Nicholson GC, Williams LJ, Jacka FN, Henry MJ, Kotowicz MA, et al. Association of high-sensitivity C-reactive protein with de novo major depression. *Br J Psychiatry* 2010;197(5):372–7.
- [5] Murray CJL, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2197–223.
- [6] Rosania AE, Low KG, McCormick CM, Rosania DA. Stress, depression, cortisol, and periodontal disease. *J Periodontol* 2009;80(2):260–6.
- [7] Marques-Vidal P, Milagre V. Are oral health status and care associated with anxiety and depression? A study of Portuguese health science students. *J Public Health Dent* 2006;66(1):64–6.
- [8] Quine S, Morrell S. Hopelessness, depression and oral health concerns reported by community dwelling older Australians. *Community Dent Health* 2009;26(3):177–82.
- [9] United States Department of Health and Human Services. Centers for Disease Control and Prevention. National Center for Health S: National Health and Nutrition Examination Survey (NHANES), 2005–2006. In: Inter-university Consortium for Political and Social Research (ICPSR) [distributor].
- [10] Spitzer RL. Validation and utility of a self-report version of PRIME-MD The PHQ Primary Care Study. *JAMA* 1999;282(18):1737.
- [11] Martin A, Rief W, Klaiberg A, Braehler E. Validity of the Brief Patient Health Questionnaire Mood Scale (PHQ-9) in the general population. *Gen Hosp Psychiatry* 2006;28(1):71–7.
- [12] Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med* 2001;16(9):606–13.
- [13] The 2011 HHS Poverty Guidelines [<http://aspe.hhs.gov/poverty/11poverty.shtml>].
- [14] Dye BA, Li X, Beltrán-Aguilar ED. Selected oral health indicators in the United States, 2005–2008. NCHS data brief, no 96. Hyattsville, MD: National Center for Health Statistics; 2012.
- [15] Vasunilashorn S. Retrospective reports of weight change and inflammation in the US National Health and Nutrition Examination Survey. *J Obes* 2013;2013:6.
- [16] Center for Disease Control. When and How to construct weights when combining survey cycles. <http://www.cdc.gov/nchs/tutorials/nhanes/SurveyDesign/Weighting/Task2.htm>. Accessed May 2, 2013.
- [17] Schmidt R, Schmidt H, Curb JD, Masaki K, White LR, Launer LJ. Early inflammation and dementia: a 25-year follow-up of the Honolulu-Asia Aging Study. *Ann Neurol* 2002;52:168–74.
- [18] Kim JM, Stewart R, Prince M, Kim SW, Yang SJ, Shin IS, et al. Dental health, nutritional status and recent-onset dementia in a Korean community population. *Int J Geriatr Psychiatry* 2007;22:850–5.
- [19] Jacka FN, Pasco JA, Mykletun A, Williams LJ, Hodge AM, O'Reilly SL, et al. Association of western and traditional diets with depression and anxiety in women. *Am J Psychiatry* 2010;167:305–11.
- [20] Kim JM, Stewart R, Kim SW, Yang SJ, Shin IS, Yoon JS. Predictive value of folate, vitamin B12 and homocysteine levels in late-life depression. *Br J Psychiatry* 2008;192:268–74.
- [21] Ship JA, Duffy V, Jones JA, Langmore S. Geriatric oral health and its impact on eating. *J Am Geriatr Soc* 1996;44:456–64.
- [22] Joshipura KJ, Willett WC, Douglass CW. The impact of edentulousness on food and nutrient intake. *J Am Dent Assoc* 1996;127:459–67.
- [23] Okoro Catherine A, Strine Tara W, Eke Paul I, Dhingra Satvinder S, Balluz Lina S. The association between depression and anxiety and use of oral health services and tooth loss. *Community Dent Oral Epidemiol* 2012;40:134–44.
- [24] Hughes JR, Hatsukami DK, Mitchell JE, Dahlgren LA. Prevalence of smoking among psychiatric outpatients. *Am J Psychiatry* 1986;143(8):993–7.
- [25] Sullivan LE, Fiellin DA, O'Connor PG. The prevalence and impact of alcohol problems in major depression: a systematic review. *Am J Med* 2005;118(4):330–41.
- [26] Bergdahl M, Bergdahl J. Low unstimulated salivary flow and subjective oral dryness: association with medication, anxiety, depression, and stress. *J Dent Res* 2000;79(9):1652–8.
- [27] Keene J, Galasko GT, Land MF. Antidepressant use in psychiatry and medicine: importance for dental practice. *J Am Dent Assoc* 2003;134(1):71–9.
- [28] Jacka FN, Mykletun A, Berk M. Moving towards a population health approach to the primary prevention of common mental disorders. *BMC Med* 2012;10:149.
- [29] Yiengprugsawan V, Somkotra T, Seubsman S-a, Sleight A. Longitudinal associations between oral health impacts and quality of life among a national cohort of Thai adults. *Health Qual Life Outcomes* 2013;11(1):172.