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Depression as a Risk Factor for Denture Dissatisfaction

ABSTRACT

Depression is associated with impaired health outcomes. This study investigated whether there is a significant association between depression and dissatisfaction with dentures in older adults. In a population-based study (1180 adults aged 65-74 yrs), depression was measured by an abbreviated Geriatric Depression Scale. Denture dissatisfaction was assessed with a five-point Likert-type question ("very dissatisfied" to "very satisfied"). The depression-denture dissatisfaction association was analyzed with simple (dissatisfied *vs.* not dissatisfied outcome) and ordinal logistic regression (based on outcome's full range). For each unit increase on the 15-point depression scale, the probability of denture dissatisfaction increased by 24% [95% confidence interval, 15-34%, P < 0.001 (simple logistic regression)] and the probability for higher levels on the five-point dissatisfaction scale increased by 16% [95% CI, 11-22%, P < 0.001 (ordinal logistic regression)], adjusted for potential confounding variables. The likely causal association in older adults has major implications for the evaluation of treatment effects and the demand for prosthodontic therapy.

KEY WORDS: depression, satisfaction, dentures, older adults, population-based study.

INTRODUCTION

Depression is identified by the World Health Organization as the fourth-ranked contributor to the global burden of disease. It is projected that by 2020, depression will rise as a worldwide cause of disability and premature death, second only to ischemic heart disease (World Health Organization, 2005).

Although there is increasing awareness that depression affects dental conditions and treatment outcomes, especially in older persons (Friedlander *et al.*, 2003), one of the most important interventions in dentistry—the provision of dentures—has not been thoroughly investigated in relation to depression. This is perhaps surprising, because prosthodontic interventions specifically aim for improvements of perceived oral health, rather than changes in "harder" disease-related outcomes. The individual's functional and esthetic rehabilitation is at the heart of prosthodontics as a discipline (Jokstad *et al.*, 1998), and feeling "low" is likely to affect how a person perceives these, in turn affecting how that person perceives his/her oral health.

An association between depression and perceived benefits from prosthodontic treatment would have major implications for the evaluation of, and the demand for, treatment. For example, where depression is present, the potential for efficacious treatment with new dentures may not be fully appreciated by the individual, an impaired (prosthodontic) health status may be misjudged, or treatment may not be demanded when it may, in fact, help. While many outcomes related to prosthodontic therapy are difficult to measure, the measurement of satisfaction with dentures may characterize such benefits from prosthodontic interventions, and this outcome is probably one of the most widely used global indicators of the efficacy of prosthodontic therapy in daily dental practice and research (Strassburger *et al.*, 2004).

The research hypothesis tested in this population-based study was that there is a significant association between depression and dissatisfaction with dentures in older adults.

MATERIALS & METHODS

Participants, Study Design, and Setting

Data came from a national oral health survey conducted at 90 locations in Germany (Micheelis and Reich, 1999). Potential study participants of German nationality, including only those of German descent, were identified by multistage sampling of addresses taken from population registration offices. Only participants from the survey's oldest age group (65-74 yrs old, N = 1250) were included in this study (proportion of responding individuals: 56.4%). Of these, 94.4% (N = 1180) had a fixed, removable partial, or complete denture. These individuals constituted the pool used for the investigation of depression-denture dissatisfaction association. The study protocol was approved by an Institutional Review Board consisting of members of the Federal Chamber of

Dentists-Association of German Chambers of Dentists and the Federal Association of Health Insurance Fund Dentists. All study participants gave their signed informed consent.

Exposure, Outcome, and Confounding Variables

Depression, which, in epidemiological terms, could be referred to as an exposure, was assessed according to the German version (Geriatric Depression Scale, 2005) of the Geriatric Depression Scale, GDS (Brink *et al.*, 1982; Yesavage *et al.*, 1983). A raw score can be calculated from the 15 yes-no items and categorized into "no", "mild", and "severe" depression. The scale's internal consistency was calculated (Cronbach's alpha: 0.80).

The outcome, denture dissatisfaction, was assessed by means of a five-point Likert-type scale, from "very dissatisfied" through "dissatisfied", a neutral point ("not satisfied/not dissatisfied"), and from "satisfied" to "very satisfied".

Because of the expected influence of sociodemographic variables, these were included in the analyses as potential confounders. In addition, the person's physical oral health status may affect the associations. Consequently, the adjusted analyses included age (65-69 yrs *vs.* 70-74 yrs), gender, socio-economic status measured by yrs of schooling (under 10, 10 to under 12 yrs, 12 yrs or over), as well as physical oral health, characterized by the number of missing teeth (in the absence of an accepted content-based categorization, we used quartiles to categorize the variable according to the distribution of the data) and the type of denture (3 categories: only fixed partial dentures, removable partial dentures, which includes combinations of denture types, or complete dentures in both arches).

Statistical Analyses

We used logistic regression models to estimate the association between depression and denture dissatisfaction. We dichotomized the outcome variable by combining the categories "very dissatisfied" and "dissatisfied" *vs.* the remaining three satisfaction levels in ordinal logistic regression. The exposure depression was operationalized in different ways, so that we could investigate the functional relationship, including both linear and non-linear associations, between exposure and outcome.

Our analytic approach progressed from simple regression analyses to complex statistical models. We chose this approach to provide more insight into the exposure-outcome association when different, equally plausible, statistical models were applied. Initial analyses were based on categories of depression arranged or considered in different ways—a dichotomized depression measure (mild or severe *vs.* no depression, model 1), as well as the three categories of depression, either as indicator variables (model 2) or as a grouped linear variable (model 3)—and subjected to analysis.

To improve the precision of the results, we also used the full range of the 15-point raw score (model 4), but neither graphical (*e.g.*, locally weighted scatterplot smoothing) nor more formal statistical analyses (*e.g.*, fractional polynomial logistic regression analysis) revealed any non-linear relationship between exposure and outcome. Potential confounder variables were added stepwise (models 5 and 6). Tooth loss and years of schooling were modeled as indicator variables, to capture any possible non-linear influences on the depression-dissatisfaction association.

In a final step, we applied the logistic version of the ordinal regression with the proportional odds assumption (McCullagh, 1980), to analyze the exposure-outcome relationship with demographic and physical oral health status variables controlled

Table 1. Socio-demographic Characteristics, Number of Missing Teeth, Distribution of Denture Types, and Different Categories of Denture Satisfaction in Persons with and without Depression

Characteristic	Participants Not Depressed (N = 1064)		Depressed Persons (N = 116)	
	N	%	N	%
Women	585	55.0	81	69.8
Age (yrs)				
65-69	630	59.2	64	58.8
70-74	434	40.8	52	41.2
Education (yrs of schooling)				
< 10	795	74.7	96	82.8
10-< 12	152	14.3	9	7.8
12+	117	11.0	11	9.5
Quartiles of missing teeth				
1	776	72.9	91	78.5
3	100	9.4	10	8.6
4	188	17.7	15	12.9
Type of denture				
Fixed partial	196	18.7	13	11.3
Removable	573	54.8	69	60.0
Complete	277	26.5	33	28.7
Satisfaction				
Very satisfied	400	37.6	26	22.4
Satisfied	495	46.5	55	47.4
Not satisfied OR dissatisfied	112	10.5	23	19.8
Dissatisfied	37	3.5	8	6.9
Very dissatisfied	20	1.9	4	3.5

(model 7). Conceptually, this analysis is similar to simple logistic regression—in fact, simple logistic regression is a special case of the proportional odds model. However, using the complete range of the ordinal outcome can increase the statistical power of the analysis (Taylor and Becker, 1998) by avoiding arbitrary dichotomization of the outcome.

We exponentiated the statistical models' regression coefficients and standard errors to estimate odds ratios and 95% confidence intervals for the association between the dependent and relevant independent variables, adjusted for other factors included in the model. We used the odds ratios to approximate prevalence rate ratios (the prevalence of denture dissatisfaction in depressed persons divided by the prevalence of dissatisfaction in non-depressed persons). The overall model goodness-of-fit (Hosmer and Lemeshow, 2000) and the parallel odds assumption in the proportional odds model (Wolfe and Gould, 1998) were tested. The amount of missing data was small (< 2%). Years of schooling was missing for five participants, and denture status could not be determined for 19 participants.

RESULTS

Study Population Characteristics

Of the 1180 enrolled participants with dentures, 116 (9.9%) presented with mild or severe depression. These persons were more likely to be female [70 *vs.* 55%, P = 0.001, Pearson χ^2 (1) = 9.4] and to have less education [83 *vs.* 75% had < 10

Table 2. Logistic Regression Models Relating the Independent Variable, Depression, to Denture Dissatisfaction (dependent variable)

Regression Models Including the Independent Variable (Depression) in Different Ways	Odds Ratio (95% CI)	P-value
Depression, yes/no (model 1)	2.04 (1.06- 3.92)	0.033
Indicator variables (model 2)		
Mild *vs.* no depression	1.44 (0.64- 3.25)	0.383
Severe *vs.* no depression	4.91 (1.76-13.69)	0.002
Grouped linear variable (model 3)	1.94 (1.22- 3.08)	0.005
Raw score (range 0 to 15) (model 4)	1.21 (1.13- 1.30)	< 0.001
Raw score adjusted for demographic factors (model 5)	1.22 (1.13- 1.32)	< 0.001
Raw score adjusted for demographic factors and physical oral health# (model 6)	1.24 (1.15- 1.34)	< 0.001
Raw score in ordered logistic regression adjusted for demographics indicators and physical oral health# (model 7)	1.16 (1.11- 1.22)	< 0.001

\#   Indicator variables for type of prosthodontic device and quartiles of tooth loss.

yrs of schooling, P = 0.05, Pearson χ^2 (1) = 3.7, Table 1]. The number of missing teeth was comparable (5.0 missing teeth *vs.* 4.9 in non-depressed individuals); the distribution of quartiles of missing teeth favored depressed individuals slightly, but depressed persons also had slightly more removable and complete dentures. This indicated that physical oral health status was likely to be comparable between depressed and non-depressed individuals. Depressed persons were considerably less satisfied with their dentures (10.4% were very dissatisfied *vs.* 5.4% of non-depressed persons).

Association between Depression and Denture Dissatisfaction

Using the odds ratio (OR) from logistic regression to approximate the ratio of prevalences of dissatisfaction in depressed *vs.* non-depressed persons, we found that the probability of dissatisfaction doubled in exposed persons [Table 2, data used to compute the odds ratio from Table 1: OR, [(8+4)/26+55+23)]/[(37+20)/(400+495+112)] = 2.04]. When compared with non-depressed study participants, when the odds ratios in Table 2 were translated, the probability of dissatisfaction increased by an estimated 44% in persons with mild depression, and by 391% in persons with severe depression. A dose-response relationship between depression and denture dissatisfaction was apparent in regression analyses that modeled exposure as a grouped linear or as a 0-15 raw score variable. The probability of denture dissatisfaction increased by 21% for one unit of increase in the depression raw score. This result did not change substantially when the influence of sociodemographic variables or indicators of physical oral health was included.

When the proportional odds model, which used the complete range of 5 dissatisfaction levels as the outcome, was applied, the magnitude of the exposure estimate decreased to 16%. However, the estimate referred to comparison of not only two outcome categories, as in simple logistic regression, but also of each pair of adjacent

categories of the five-level outcome. Results of the proportional odds model can be interpreted as follows: For each unit increase in the 15-point depression raw score, the probability of higher dissatisfaction increased by 16% (95% confidence interval, 11-22%).

All results from the depression-dentures dissatisfaction association were consistent with each other and were statistically significant (except for the comparison of mild *vs.* no depression). Regression diagnostics, including the investigation of proportional odds assumption, did not reveal substantial problems of model fit.

DISCUSSION

The present findings contribute to the existing wealth of data about depression's influence on a variety of psychosocial and physical outcomes in medical/dental treatments. Depression and denture satisfaction were associated in the general population of older adults. However, the association was far from deterministic, and it is worth noting that 70% of the depressed persons were still (very) satisfied with their dentures, while 5% of non-depressed persons were dissatisfied, compared with 10% of the depressed persons.

Nine criteria proposed by Bradford Hill (Hill, 1965) have found widespread acceptance and provide a framework for a structured approach to the evaluation of observed associations.

A strong association (criterion 1) and a dose-response relationship (criterion 5) were both observed in this study. Measurement error probably did not influence the results substantially. Although other instruments exist to determine an individual's mood state, the depression measure used is a good screening instrument for major depression as defined by both the ICD-10 and DSM-IV (Almeida and Almeida, 1999). Reliability in our study was sufficient according to guidelines (Streiner and Norman, 2003). A non-response analysis (see Reichart, 2000, for details) indicated that bias due to differences in the prevalence of sociodemographic and oral health indicators between the actual sample and the intended population was less than 5% (Micheelis and Reich, 1999). There is also strong evidence for biological plausibility (criterion 6) of an association between depression and denture satisfaction. Depression influences perceived health (Alexopoulos, 2005) and, in particular, perceived oral health characterized by oral-health-related quality-of-life measures (Kressin *et al.*, 2002). Because of the relationship between denture satisfaction and oral-health-related quality of life (Veyrune *et al.*, 2005), it seems plausible that depression influences denture satisfaction, too.

Other criteria outlined by Hill lend support to the possibility of causality, albeit more limited. Although satisfaction with dentures is a widely used outcome in prosthodontics (*e.g.*, Allen, 2005; Wong and McMillan, 2005), and depression is considered a major determinant of health status (World Health Organization, 2005), we found only limited existing literature to support a relationship

(consistency-criterion 2) (Smith, 1976; Hayden-Smith, 1984). Depressed individuals may view efficacious treatments in general as less beneficial for them, which may be interpreted as evidence for coherence (criterion 7). There is also some evidence of analogy (criterion 9). Psychological factors, especially personality factors such as neuroticism, affect denture satisfaction (al Quran *et al.*, 2001) and related outcomes, such as oral-health-related quality of life (Kressin *et al.*, 2001). Depression is known to influence other major outcomes in dentistry, *e.g.*, satisfaction with temporo-mandibular disorder treatment success (Fricton and Olsen, 1996; Riley *et al.*, 2001), periodontal treatment outcome (Elter *et al.*, 2002), or dental-fear treatment (Abrahamsson *et al.*, 2003).

The major limitation of our cross-sectional study is that we could not demonstrate that the cause preceded the effect (criterion 4). Experimental evidence (criterion 8) is not possible, because, for ethical reasons, depression status is not subject to manipulation (although depression could be treated in clinical trials). Finally, the association's specificity (criterion 3) is of minor importance (Rothman and Greenland, 1998). It would be expected that a person with depression would be likely to be less satisfied with any treatment than one who does not have depression.

In summary, an influence of depression on denture dissatisfaction seems likely, because of the strong and precise association, the observed dose-response relationship, and the association's plausibility.

Clinical Relevance of the Findings

Depression is prevalent in dental practice, even if it is often overlooked. In our sample, 8% of the participants were mildly depressed, and 2% were severely depressed, similar to other reports, *e.g.*, in Germany (Simon *et al.*, 2002). A potentially causal association between depression and denture dissatisfaction, therefore, has several possible clinical consequences.

In dental practice, the presence of depression in a patient may not be obvious, because of a reluctance on the part of the patient, and possibly the dentist, to discuss the condition. Awareness of the relationship may be important, however: Depressed individuals may view efficacious treatment as worse than it is, or new treatment may be sought when none is required on the basis of physical oral health status. Conversely, impaired (prosthodontic) health status may be misjudged, and treatment may not be demanded when it would be helpful. Because depression often co-occurs with other medical illnesses, such as cardiovascular disease, stroke, diabetes, and cancer (Evans and Charney, 2003), detection of depression may also influence treatment decisions. Screening for depression in primary health care settings has been suggested as an important step in improving outcomes, particularly where the system allows for appropriate treatment and follow-up (Pignone *et al.*, 2002). Furthermore, there is evidence that such screening to help clinicians identify and diagnose persons with major depression is possible (Williams *et al.*, 2002).

Although the reported association between depression and denture dissatisfaction is probabilistic and not deterministic, awareness of the relationship, and possibly even screening for depression prior to complex or comprehensive prosthodontic therapy in older adults, is recommended.

REFERENCES

Abrahamsson KH, Berggren U, Hakeberg M, Carlsson SG (2003). The importance of dental beliefs for the outcome of dental-fear treatment. *Eur J Oral Sci* 111:99-105.

al Quran F, Clifford T, Cooper C, Lamey PJ (2001). Influence of psychological factors on the acceptance of complete dentures. *Gerodontology* 18:35-40.

Alexopoulos GS (2005). Depression in the elderly. *Lancet* 365:1961-1970.

Allen PF (2005). Association between diet, social resources and oral health related quality of life in edentulous patients. *J Oral Rehabil* 32:623-628.

Almeida OP, Almeida SA (1999). Short versions of the geriatric depression scale: a study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV. *Int J Geriatr Psychiatry* 14:858-865.

Brink TL, Yesavage JA, Lum O, Heersema PH, Adey M, Rose TL (1982). Screening tests for geriatric depression. *Clin Gerontol* 1:37-43.

Elter JR, White BA, Gaynes BN, Bader JD (2002). Relationship of clinical depression to periodontal treatment outcome. *J Periodontol* 73:441-449.

Evans DL, Charney DS (2003). Mood disorders and medical illness: a major public health problem. *Biol Psychiatry* 54:177-180.

Fricton JR, Olsen T (1996). Predictors of outcome for treatment of temporomandibular disorders. *J Orofac Pain* 10:54-65.

Friedlander AH, Friedlander IK, Gallas M, Velasco E (2003). Late-life depression: its oral health significance. *Int Dent J* 53:41-50.

Geriatric Depression Scale (2005). http://www.stanford.edu/~yesavage/GDS.html.

Hayden-Smith P (1984). The relationship of mental disorder with dental treatment dissatisfaction. *Br Dent J* 157:164-165.

Hill AB (1965). The environment and disease: association or causation? *Proc R Soc Med* 58:295-300.

Hosmer DW, Lemeshow S (2000). Applied logistic regression. 2nd ed. New York: John Wiley & Sons, Inc.

Jokstad A, Ørstavik J, Ramstad T (1998). A definition of prosthetic dentistry. *Int J Prosthodont* 11:295-301.

Kressin NR, Reisine S, Spiro A 3rd, Jones JA (2001). Is negative affectivity associated with oral quality of life? *Community Dent Oral Epidemiol* 29:412-423.

Kressin NR, Spiro A 3rd, Atchison KA, Kazis L, Jones JA (2002). Is depressive symptomatology associated with worse oral functioning and well-being among older adults? *J Public Health Dent* 62:5-12.

McCullagh P (1980). Regression models for ordinal data (with discussion). *J R Statist Soc* 42:109-142.

Micheelis W, Reich E (1999). Dritte Deutsche Mundgesundheitsstudie (DMS III). Köln: Deutscher Ärzte-Verlag.

Pignone MP, Gaynes BN, Rushton JL, Burchell CM, Orleans CT, Mulrow CD, *et al.* (2002). Screening for depression in adults: a summary of the evidence for the U.S. Preventive Services Task Force. Ann Intern Med 136:765-776.

Reichart PA (2000). Oral mucosal lesions in a representative cross-sectional study of aging Germans. *Community Dent Oral Epidemiol* 28:390-398.

Riley JL 3rd, Myers CD, Robinson ME, Bulcourf B, Gremillion HA (2001). Factors predicting orofacial pain patient satisfaction with improvement. *J Orofac Pain* 15:29-35.

Rothman KJ, Greenland S (1998). Modern epidemiology. 2nd ed. Philadelphia: Lippincott-Raven Publishers.

Simon GE, Goldberg DP, Von Korff M, Ustun TB (2002). Understanding cross-national differences in depression prevalence. *Psychol Med* 32:585-594.

Smith M (1976). Measurement of personality traits and their relation to

patient satisfaction with complete dentures. *J Prosthet Dent* 35:492-503.

Strassburger C, Heydecke G, Kerschbaum T (2004). Influence of prosthetic and implant therapy on satisfaction and quality of life: a systematic literature review. Part 1—Characteristics of the studies. *Int J Prosthodont* 17:83-93.

Streiner DL, Norman GR (2003). Health measurement scales. 3rd ed. Oxford: Oxford University Press.

Taylor GW, Becker MP (1998). Increased efficiency of analyses: cumulative logistic regression vs ordinary logistic regression. *Community Dent Oral Epidemiol* 26:1-6.

Veyrune JL, Tubert-Jeannin S, Dutheil C, Riordan PJ (2005). Impact of new prostheses on the oral health related quality of life of edentulous patients. *Gerodontology* 22:3-9.

Williams JW Jr, Noel PH, Cordes JA, Ramirez G, Pignone M (2002). Is this patient clinically depressed? *J Am Med Assoc* 287:1160-1170.

Wolfe R, Gould W (1998). sg76: an approximate likelihood-ratio test for ordinal response models. *Stata Techn Bull* 42:24-27.

Wong MC, McMillan AS (2005). Tooth loss, denture wearing and oral health-related quality of life in elderly Chinese people. *Community Dent Health* 22:156-161.

World Health Organization (2005). Depression. http://www.who. int/mental_health/management/depression/definition/en/.

Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, *et al.* (1983). Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res* 17:37-49.