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Demographic factors, denture status and oral health-related quality of life

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Abstract – *Objectives:* This study investigated the association between denture status, demographic factors, and oral health-related quality of life (OHRQoL). *Methods:* OHRQoL was measured using the German version of the Oral Health Impact Profile (OHIP-G, 53 items), which was administered in a personal interview to 2050 subjects (60% of eligible subjects responded) 16–79 years of age in a national survey. Median regression was used to analyze the influence of denture status (no, removable, complete dentures), age, gender, education (less than 10 years of schooling, 10–12 years, more than 12 years), and residential area (rural, urban) on the OHIP-G summary score. *Results:* In bivariable analyses, compared to the base category, the OHIP-G median increased 8.0 U for subjects with removable dentures, 20.0 U for subjects with complete dentures, 1.7 U for each 10-year age period, 2.0 U for men, 3.0 U for less than 10 years of schooling (compared to ≥10 years.), and 1.0 U for urban areas ($P < 0.05$ for all effects except for residential area). In the multivariable analysis, compared to subjects without dentures, subjects with removable dentures had a 7.5 (95% CI: 5.2–9.8) higher OHIP-G median and subjects with complete dentures had a 18.5 (95% CI: 14.7–22.4) higher median when demographic variables were controlled. No demographic variables were statistically significant except for residential area ($P = 0.04$). *Conclusions:* Denture status was a stronger predictor for impaired OHRQoL than demographic variables and rendered age and education almost negligible in their influence on OHRQoL.

Key words: demographic factors; denture status; oral health; oral health-related quality of life; risk factors

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Morbidity and mortality are heavily influenced by age, gender, and socioeconomic status. Oral health problems are no exception. Prevalence of caries and periodontitis (1) as well as temporomandibular disorders (2) differs by age and gender. Age and gender-related differences are observed for oral mucosa lesions (3) and oral cancer (4). Socioeconomic influences are widely present in oral health (5).

For oral health-related quality of life (OHRQoL), which characterizes peoples' perceptions about oral health, relationships with age (6–8), gender (6), and socioeconomic status indicators (6, 7) have been found. However, not all studies have found statistically significant OHRQoL differences for age (9) or gender (10, 11).

Tooth loss, the most tangible outcome of caries and periodontitis (12), is another well-documented factor that influences impaired OHRQoL. Many OHRQoL instruments have used tooth loss or denture status as validity criterion (6, 8, 13, 14). The tooth loss–OHRQoL association has substantial public health impact because, assuming this relationship is causal, impaired OHRQoL could be prevented via the prevention of tooth loss.

It is expected that the age–OHRQoL and the socioeconomic status–OHRQoL relationships are influenced by tooth loss because tooth loss is associated with increased age and poorer socioeconomic status (1). Using the Oral Health Impact Profile (OHIP) (15) to measure OHRQoL in adults of age 50 years and older, the number of missing teeth was correlated with the OHIP summary score ($r = 0.43$) (10). Although gender, age, and education were not statistically significant in bivariable analyses in this study, multivariable statistical analyses revealed statistically significant effects for age and household income while the number of missing teeth was the strongest predictor of impaired OHRQoL. Another study used the Oral Impacts on Daily Performances (OIDP) instrument (16) to measure OHRQoL in subjects of age 65 years and older. Compared with subjects with 1–10 teeth, the odds ratios of any dental impact were 0.50 for subjects with 11–20 teeth and 0.35 for subjects with 21 and more teeth when age, gender, social class, and region of origin were controlled (9). These relationships among demographic status and dental status have practical importance for public health programs and provide information on variables that should be included in analyses of analytical studies involving OHRQoL in order to control confounding appropriately.

It was aim of this cross-sectional study to investigate the relationship between sociodemographic factors, dental/denture status, and impaired OHRQoL measured with the German version of OHIP (OHIP-G) (17) in a national probability sample covering a wide age range of adults.

Materials and methods

Setting

Subjects were the 2050 participants in a national survey conducted in February 2001–April 2001 at 255 locations in Germany. Potential study participants were identified using a multistage sampling technique. Sixty per cent of the eligible subjects responded to the survey. The sample was designed to be representative of the German-speaking population aged 16–79 years. Details about design and sampling are described elsewhere (18).

Data collection

Data for the OHIP-G (17) were collected in a computer-assisted personal interview. Subjects were asked how frequently they had experienced each impact in the last month. Responses were made on a Likert-type scale (0, never; 1, hardly ever; 2, occasionally; 3, fairly often; and 4, very often).

Data analysis

The associations of four demographic variables (age, gender, education, and residential area) and denture status with the OHIP-G summary score (OHIP-G49 = sum of all 49 item responses contained in the English-language OHIP (OHIP-E)) were examined. Education, which was considered a proxy for socioeconomic status, had three categories (less than 10 years of schooling, 10–12 years, more than 12 years). Residential area was defined as rural when less than 20 000 inhabitants lived in the community and otherwise as urban. Self-reported denture status had three categories and was assessed with the following question: 'Do you have removable or complete dentures which you actually wear? (Hint: fixed prosthodontics such as crowns and bridges don't count as removable and complete dentures)

- No.
- Yes, I have own teeth and a removable or complete denture.
- Yes, I'm edentulous and have complete upper and lower dentures.'

As the OHIP-G49 distribution was not normal, the OHIP-G49 median instead of the OHIP-G49 mean was used to characterize the level of impaired OHRQoL for groups of subjects. Median regression was used to analyze the influence of all predictor variables on the median OHIP-G49. The object of median regression is to estimate the median of the dependent variable OHIP-G49, conditional on the values of the independent variables. This is very similar to ordinary regression, where the object is to estimate the mean. Therefore, median regression finds the linear combination of the predictors that minimizes the sum of the absolute residuals rather the sum of the squares of the residuals as in ordinary regression. The median is a more appropriate measure of OHIP-G49's central tendency than the mean because OHIP-G49 is not normally distributed; therefore, median regression is the natural statistical procedure to use for multivariable regression. The multivariable median regression included gender, age, residential area, and indicator variables for both education and denture status. After preliminary analyses using plots and formal statistical tests (fractional polynomial regression), the age association with OHIP-G49 was found to be approximately linear.

Two types of sensitivity analyses were performed. First, we investigated whether the results would change when the outcome variable was modified (OHIP-G46: three items referring to dentures only were removed from the summary score calculation; OHIP-G53: the four items unique to the German version were added to the 49 items also found in the English-language version). Second, we explored the influence of the survey design on the results. The sample design can affect the analysis because survey data generally have three important characteristics – weights, clustering, and stratification. Sampling weights reflect that different observations have different selection probabilities and point estimates can be affected by these weights. Clustering and stratification influence the dependence of the observations, which may affect the SEs of the point estimates. A 'design-based' analysis takes these characteristics of the sampling design into account in contrast to a 'model-based' approach, which assumes the observations are a simple random sample of the population. Bivariable and multivariable median regression did not incorporate the survey design because this option was not available in STATA's (Release 7.0 StataCorp. 1999, Stata Statistical Software, College Station, TX, USA) survey module (=model-based analyses). We fitted a model similar to median regression – ordinary linear regression (OLS) – and included weights and sampling design in the analyses with and without logarithmic transformation of the outcome (=design-based analyses) and compared the analytic strategies. A probability of a type I error of $\leq$0.05 was considered statistically significant.

Missing data

Of 2050 participants, 5 did not answer any of the 53 questions of the OHIP-G. Further 19 subjects were deleted because missing data compromised the calculation of an OHIP-G summary score. Missing answers ($n = 261$) in 174 subjects were imputed using regression. Details about dropping subjects from the analysis and the imputation procedure are provided elsewhere (18).

Results

Characteristics of the study population

Of the 2026 included subjects (mean age: 43.3 ± 16.2 years), 52% were women. The OHIP-G49 can range from 0 to 196 (4 × 49 items). When scores were divided into quartiles, the 25th percentile was 0, the 50th percentile was 7 points, the 75th percentile was 22 points, and the maximum was 165 points. The distribution of the OHIP-G49 was not normal with considerable floor effects (Fig. 1) and differed substantially by denture status category.

Table 1 shows the distributions of the demographic variables by OHIP-G49 quartiles. Subjects reporting more impaired OHRQoL (above the OHIP-G49 median vs. below the median) were more often male (51% vs. 46%), were older (mean age 46.5 years vs. 40.4 years), and more likely to have less than 10 years of schooling (49% vs. 42%). Differences between rural and urban areas were small (74% of subjects above the median lived in urban areas vs. 72% of subjects below the median). The largest differences were observed for denture status. Subjects with more impaired OHRQoL were more likely to have removable or complete dentures (35% vs. 14%).

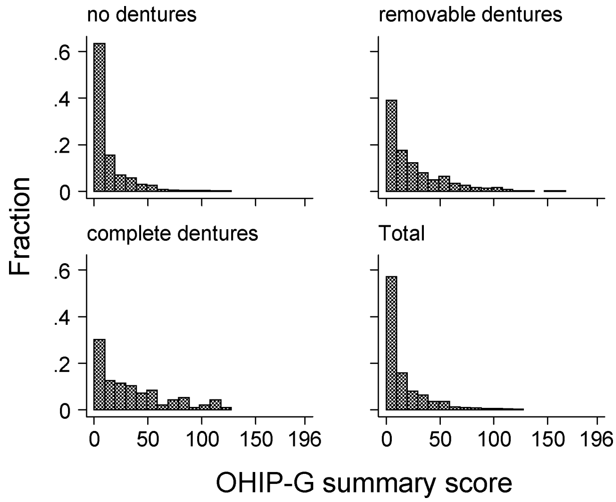

Fig. 1. Relative frequency of impaired OHRQoL shown as 10-units OHIP-G49 intervals for three status categories and the total sample.

When subdividing by denture status, the associations between demographic variables and the OHIP-G summary score were largely reduced or even removed (Table 2). This was most obvious in people without dentures – the largest group of subjects. The overall OHIP-G49 median in this group was 5. This value remained basically constant regardless of stratification variables. Except for residential area, none of the demographic variables presented consistent differences across denture status categories. Subjects in urban areas perceived their OHRQoL as more impaired than subjects in rural areas.

Regression analyses

Median regression analysis was used to test for statistically significant associations between the OHIP-G summary score and sociodemographic/denture status variables. First, the association of summary score with each variable was analyzed (Table 3, bivariable analyses). Except for residential area ($P = 0.38$), all variables were statistically significant (P-values: <0.001 to 0.048) confirming the results from descriptive analyses.

Table 1. Relationship between sociodemographic variables, denture status, and OHRQoL

	Boundaries for OHIP-G49 quartiles (% (number) or mean (SD))			
Variable	0	1–7	8–22	23–165
Women	53.3 (270)	55.2 (298)	48.6 (237)	49.3 (242)
Age (years)				
Mean (SD)	38.5 (15.3)	42.2 (16.1)	44.4 (16.0)	48.6 (16.0)
Education (years)				
<10	40.2 (204)	43.3 (234)	43.9 (214)	55.1 (270)
10–12	49.1 (249)	44.1 (238)	44.7 (218)	35.7 (175)
>12	10.7 (54)	12.6 (68)	11.5 (56)	9.2 (45)
Residential area (subjects)				
<20000	29.6 (150)	27.0 (146)	24.0 (117)	28.7 (141)
20000+	70.4 (357)	73.0 (394)	76.0 (371)	71.3 (350)
Denture status				
No dentures	91.9 (466)	80.7 (436)	72.5 (354)	58.0 (285)
Removable dentures	6.1 (31)	16.1 (87)	24.0 (117)	31.4 (154)
Complete dentures	2.0 (10)	3.2 (17)	3.5 (17)	10.6 (52)

Because the age range was 16–79 years, the age influence on OHRQoL was both clinically important and statistically significant. As an example, a 10-year-age increase was associated with a 1.7-U increase of the OHIP-G49 median. The gender effect was of similar magnitude as the 10-year age effect. Higher educational level was related to better OHRQoL. More than 10 years of education lowered the OHIP-G49 median by 3 U. When household income was chosen as an indicator for socioeconomic status (<3000 DM/month, 3000 to <6000 DM/month, 6000+ DM/month), results were similar (data not shown). The effect for residential area was the smallest among the analyzed demographic variables.

When all variables were considered simultaneously in one statistical model (Table 3, multivariable analysis), the previously observed bivariable results changed somewhat. Denture status remained the strongest predictor for the summary score median. As an example, the median OHIP-G49 score for a group of 65-year-old women without dentures (in the lowest education group and living in a rural area) was predicted to be 4.5. A group of women with the same demographic characteristics but with removable dentures had a predicted score of 12.0. A group of women wearing complete dentures with the same demographic characteristics had a predicted median OHIP-G49 of 23.0. A dose–response relationship between worse dental/denture status and impaired OHRQoL was obvious. Men had on average a 1.1 higher OHIP-G median than women had when denture status and other demographic variables were controlled, but the gender difference was not statistically significant. The previously observed age effect almost disappeared and became

Table 2. Relationship between sociodemographic variables and OHRQoL stratified by denture status

		OHIP-G49 median (*n*)		
Variable	Category	No dentures (*N* = 1541)	Removable dentures (*N* = 389)	Complete dentures (*N* = 96)
Gender	Women	4 (797)	16.5 (194)	22 (56)
	Men	5 (744)	12 (195)	28.5 (40)
Age (years)	16–29	4 (474)	57.5 (2)	23.5 (2)
	30–39	5 (429)	26 (11)	51 (1)
	40–49	6 (321)	27.5 (46)	14 (2)
	50–59	6 (213)	11 (111)	47 (12)
	60–79	5 (104)	12 (219)	23 (79)
Education (years)	<10	5 (588)	13 (254)	24 (80)
	10–12	5 (768)	18 (102)	53 (10)
	>12	5 (184)	9 (33)	3 (6)
Residential area	Rural	4 (400)	12 (117)	21 (37)
	Urban	5 (1141)	14 (272)	28 (59)
Overall OHIP-G49 median		5	13	24.5

Table 3. Relationship between sociodemographic variables, denture status, and OHRQoL analyzed by bi- and multivariable median regression analyses

Variable	Bivariable analyses relating each variable to OHIP-G49 median		Multivariable analysis (all variables are adjusted for each other in one final model)[a]		
	Coefficient	(95% CI)	Coefficient	(95% CI)	*P*
Removable dentures	8.0	(5.4, 10.6)	7.5	(5.2, 9.8)	<0.001
Complete dentures	20.0	(15.2, 24.8)	18.5	(14.7, 22.4)	<0.001
Age[b] (unit: 1 year)	0.17	(0.13, 0.22)	0.05	(−0.01, 0.11)	0.13
Male gender	2.0	(0.0, 4.0)	1.1	(−0.3, 2.6)	0.10
10–12 years education	−3.0	(−5.1, −0.9)	−0.1	(−1.7, 1.6)	0.91
>12 years education	−3.0	(−6.3, 0.3)	−0.3	(−2.8, 2.2)	0.83
Urban residential area	1.0	(−1.2, 3.2)	1.7	(0.1, 3.4)	0.04

[a]Intercept for multivariable model: 3.4; 95% CI: 1.6–5.3; $P < 0.001$.
[b]Age was centered at 43 years.

statistically nonsignificant. The coefficients for the education indicator variables were also close to 0 and were not statistically significant ($F_{(2,\ 2017)} = 0.02$; $P = 0.98$).

Because of the close relationships between age and denture status and between education and denture status in our data, knowledge of age and education (as a proxy for socioeconomic status) did not provide substantial additional information about OHRQoL when denture status was known for the individual. After controlling for other demographic variables and denture status, residential area became statistically significant. Subjects in urban areas had on average a 1.7 higher OHIP-G49 median compared with subjects in rural areas, which is consistent with Table 2.

Sensitivity analyses

Results of the sensitivity analyses using the OHIP-G46 or the OHIP-G53 as the outcome in the multivariable median regression supported the previous findings. Neither the magnitude of the coefficients nor the significance level for any variable changed notably. The design-based analytic approach, i.e. using weights and sampling design with an OLS regression model showed similar results with some differences. In OLS, as in median regression, the two denture status indicators were the dominant statistically significant predictors for the OHIP-G summary score. The level of statistical significance for residential area and gender changed. Residential area, previously statistically significant ($P = 0.04$), became statistically nonsignificant ($P = 0.87$). Gender, which was previously not statistically significant ($P = 0.13$), became significant ($P = 0.02$). Design-based OLS regression with logarithmic transformation of the outcome did not present different results.

Magnitude of coefficients and SEs were hardly changed when OLS models with (model-based) and without survey design (design-based) were compared. Thus, we interpret these results as an indication of differences between the two statistical techniques – median and OLS regression – but not as an indication that a design-based analysis gave different results compared to a model-based approach.

Discussion

This is the first large national population-based survey about OHRQoL covering a wide age range of adults in Germany. The study confirmed that denture status is by far the strongest predictor of impaired OHRQoL compared to sociodemographic factors. Age and socioeconomic status were not important predictors after adjusting for denture status.

Denture status is a strong predictor for impaired OHRQoL

Denture status category was found to be a strong predictor for impaired OHRQoL measured by the OHIP-G. This is in agreement with studies using the OHIP-E (to distinguish it from the German version) where this variable was used as a validity criterion in the development of the questionnaire (8, 15). The strong association between OHRQoL and denture status suggests that it should routinely be used as a stratifying factor in comparative studies. Denture status seems to be an intermediate variable potentially able to reduce (residual) confounding by variables related to age and socioeconomic status in exposure–OHRQoL assessment. Similar findings of an important intermediate variable are known for the age–periodontitis association. It was found that oral hygiene was the most important predictor for periodontitis. The effect of age on the progression of periodontitis could be considered negligible when good oral hygiene was maintained (19). Other studies investigated OHRQoL and used number of teeth – a measure related to denture status – as a control variable in their analyses (20).

Other studies exploring the influence of denture status on OHRQoL have found similar results. For example, denture status was strongly associated with OHRQoL measured by means of the OHQoL-UK(W)© (14). Another study found statistically significant associations between denture status and several subjective oral health status indicators such as 'limitation in chewing' and 'problem speaking' (13).

When other studies used slightly different variables than our categorized denture status but the same OHRQoL instrument in their analyses, they also found similar associations. A population-based cross-sectional Canadian study showed more impairment for edentulous subjects when compared to dentate subjects for all seven OHIP-E dimensions (21). With each additional missing tooth, the OHIP score increased by 0.3 when other important variables were controlled (22). Considering the potential number of missing teeth, this effect is considered a meaningful influence on OHRQoL. In a multivariable analysis, five variables (age, household income, dental insurance, general health, life stress) explained less variance of the OHIP summary score than the number of missing teeth, which explained 18% of the variance (10). Longitudinal studies using the OHIP-E have investigated trends and fluctuations in the impact of oral conditions among older adults over the period of 1 year (23). The number of missing teeth (categorized as <16 or $16+$ missing teeth) was a statistically significant predictor for trends and fluctuations in bivariable analyses – a stronger predictor than age or gender, which agrees with our findings. Another longitudinal study showed that 2-year incident tooth loss was a strong predictor for changes in the OHIP scores (24).

Studies with OHRQoL instruments other than the OHIP have also found the number of missing teeth to be influential. Number of missing teeth showed the strongest relationship ($r = 0.33$) with the Geriatric Oral Health Assessment Index (GOHAI) among six clinical measures investigated (6). In a multivariable analysis using the OIDP instrument where sociodemographic factors were controlled, a grouped linear variable number of teeth (1–10, 11–20, 21 and more teeth) showed a dose–response relationship of decreasing oral impacts with more teeth (9). Other multivariable analyses, including demographic factors and clinical variables, found number of missing teeth a statistically significant predictor for perceived oral health (25) and OHRQoL measured by means of the Dental Impact of Daily Living instrument (26).

Study weaknesses and strengths

It is a limitation of our study that we have no information about the bias that could arise from nonresponse. However, it does not seem likely that responders and nonresponders differ in how the measures are associated. Although we have favorable information about the psychometric properties of the outcome OHIP-G (17), we do not have information about reliability and validity of our denture status variable. We do not know whether subjects with dentures actually wear them. Misclassification is possible. For instance, we did not consider dental implants in our study because we assumed that this misclassification bias would be small. The most recent national oral health survey in Germany (1) found only one implant in $N = 655$ subjects aged 35–44 years and 10 implants in $N = 1367$ subjects aged 65–74 years.

Our statistical modeling strategy did not include interactions between the variables because we did not expect them *a priori*. Our exploratory analyses revealed possible gender differences in impaired OHRQoL between 60 and 79 years of age. Furthermore, younger subjects with dentures perceived their oral health as more impaired compared with older denture-wearing subjects, but there was little variation in OHRQoL with age among those without dentures. Similarly, less educated subjects with dentures had more impaired oral health than those with more education, but there was no variation with education among those without dentures. However, we were limited by the small number of subjects with dentures in younger age and more educated categories, and therefore had limited statistical power to detect any interactions. Therefore, our statistical model assumes the same effects for age and education in all denture status categories, and these effects may be heavily influenced by the group with no dentures as it is much larger than the other groups.

It is a strength of our study that design-based and model-based analytic strategies agreed in their main conclusions. Model-based analytic approaches should be compared with design-based analyses (27). Incorporating the survey design in the analyses increases the validity of findings (28). Furthermore, results were not sensitive to a change in the outcome definition.

Public health and clinical importance of the findings

Subjective indicators measuring OHRQoL can be of benefit in evaluating oral health for political, theoretical, or practical purposes (29). Although associations in cross-sectional studies do not automatically imply causation, this study's confirmation of the importance of denture status/tooth loss as the major predictor for OHRQoL provides hints to a successful way to prevent impaired OHRQoL. An easy and clinically meaningful categorization into subjects without dentures, with removable, and with complete dentures provides detailed information for patient groups with different prevention and intervention needs.

Our results about the denture status–OHRQoL association suggest that all lost teeth might not be equally important in their influence on OHRQoL. Clinical experience supports the notion that transition from the status of having one's 'own' teeth to having removable dentures is an important cut point for the oral functional and psychosocial well being of the patient. As long as lost teeth may be replaced by fixed prosthodontics or dental implants, OHRQoL may not notably deteriorate. A second important cut point is the transition from still having some of one's 'own' teeth to being edentulous. Support for this hypothesis comes from implant dentistry. By 'reversing' edentulous patients to patients 'with (a few) teeth', OHRQoL increased substantially (30). If our hypotheses about the relationship between tooth loss/denture status and OHRQoL are supported by future studies, public health and clinical efforts would be most effective for protecting subjects from impaired OHRQoL if strategies were focused on avoiding a transition to removable dentures and conserving a subject's last remaining teeth for denture retention.

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