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Oral health-related quality of life and oral status in a German working population

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The study aim was to identify predictors of impaired oral health-related quality of life (OHRQoL). Employees of five companies were offered a clinical full-mouth examination. Oral health-related quality of life was measured with the German version of the Oral Health Impact Profile (OHIP) and summarized as additive scores (OHIP-ADD) and as prevalence of negative impacts (OHIP-SC). Two logistic regression models were developed for the odds of increased scores of the target variables OHIP-ADD and OHIP-SC. The target variables were dichotomized, and for the OHIP-ADD, the cut-off point for having impaired OHRQoL was heuristically defined as OHIP-ADD > 34. For the OHIP-SC, the corresponding threshold was OHIP-SC > 0. In the model for the OHIP-ADD, female gender, impaired aesthetics, few posterior occluding pairs, and painful masticatory muscles proved to be significant independent variables. For the OHIP-SC, female gender, impaired aesthetics, painful masticatory muscles, joint sounds, missing mandibular teeth, and carious teeth were significant. This cross-sectional study showed that within the models for both OHIP-ADD and OHIP-SC the high-risk person for impaired OHRQoL is a woman with impaired aesthetics and painful masticatory muscles.

Studies assessing the association between objective measures of dental diseases and patient-based ratings of oral health status have pointed out that objective measures do not accurately reflect patients' perceptions (1–5). Looking at the need for prosthetic treatment, remarkable differences between normative and perceived needs have been found (5), and measurement instruments have been generated to assess oral health-related quality of life (OHRQoL). The best documented and most popular instrument for measuring OHRQoL in population-based studies and clinical research is the Oral Health Impact Profile (OHIP) (6). Even so, little is known about individual factors that influence a person's OHRQoL. In previous studies, associations between subjective oral health and several clinical and sociodemographic variables have been found. In preparation of this study the literature was screened for variables that might have a potential influence on OHRQoL (Table 1) (1, 5, 7–30). The results are diverse regarding the influence on OHRQoL of demographic factors, such as gender, age, and education. While several studies have reported that women have a significantly higher risk than men of having a distinctly impaired OHRQoL (12, 28, 29), others have found no significant associations (8) or have found significant associations only at higher ages (19). With respect to clinical findings, wearing removable dentures and tooth mobility seem to be generally accepted strong influences for impaired quality of life (20, 21, 29). Additionally, oral mucosal diseases and orofacial pain related to temporomandibular disorders were found to have a significant impact on quality of life (22, 26). However, a weakness of many of the studies is that they have been conducted in groups of patients with special conditions (12, 21, 31, 32).

The aim of this study was to explore possible predictors for impaired OHRQoL in a more general population. Such predictors can be useful in establishing oral health strategies on a population level by influencing the allocation of resources in dental care and the development and focus of preventive strategies. If, for example, periodontitis does not lead to impaired OHRQoL, this would indicate that preventive strategies would need to focus on information about the signs, symptoms, and potential damage caused by this disease. In individual clinical decision-making the expected outcomes in terms of changes in OHRQoL might provide useful information for the critical appraisal of different treatment options.

Material and methods

This cross-sectional study was conducted between September 2005 and June 2008 in the city of Dresden, Germany. The study was approved by the Research Ethics Board of

Table 1

Clinical and sociodemographic variables with potential impact on oral health-related quality of life and possible inter-relations between these variables

Clinical variables	Related publications (reference numbers)	Potential impact	Potential inter-relations
Age	(14, 19)	Negative with higher age	Missing teeth, prosthetic status
Gender	(8, 12, 19, 28, 29)	Negative when female	CMD, missing teeth,
Aesthetics	(23, 30)	Negative when impaired	CPITN, carious teeth, mobile teeth, prosthetic status
Number of POPs	(11, 16, 18)	Negative when heavily reduced	CMD, missing teeth, prosthetic status
Orofacial pain related to temporomandibular disorders (CMD)	(22, 26, 27)	Negative	Prosthetic status, POPs, missing teeth, gender, prosthetic treatment need, vocational education, highest level of school education
Missing teeth	(1, 9, 10, 28, 29)	Negative, depending on number and alignment of residual teeth	Prosthetic status, CMD, POPs, gender, age, vocational education, highest level of school education
Carious teeth	(1)	Uncertain	Aesthetics
Mobile teeth	(7, 9, 15, 17, 25)	Negative with high mobility scores and large number of affected teeth	CPITN, aesthetics
Filled teeth	(1)	Uncertain	Last dental visit
Prosthetic status	(20, 21, 29)	Negative in case of RDP-wearing, none in case of FDP-wearing	Missing teeth, aesthetics, POPs, age, CMD, vocational education, highest level of school education
Prosthetic treatment need	(29)	Negative when existing	
Periodontal disease (CPITN)	(10, 13, 24)	Negative, depending on severity	Mobile teeth, aesthetics
Oral mucosal diseases	(22, 26, 27)	Negative depending on specific disease	
Highest level of school education	(1, 16)	Uncertain	Missing teeth, prosthetic status, CMD, vocational education
Vocational education	(1)	Uncertain	Missing teeth, prosthetic status, CMD, highest level of school education
Last dental visit	(29)	Uncertain	
Reason for seeing the dentist	(14)	Uncertain	Gender, carious teeth, periodontitis, POPs, mobile teeth
Personal situation	(5)	Uncertain	

CMD, craniomandibular disorder; CPITN, community periodontal index of treatment needs; FDP, fixed dental prosthesis; POPs, posterior occluding pairs; RDP, removable dental prosthesis.

the Technische Universität Dresden (EK175102005). Exclusively for organizational reasons, data collection was conducted in parallel with a medical study focusing on the prevention of diabetes mellitus.

Participants were recruited from five different commercial companies in the Dresden metropolitan area. In order to minimize selection bias, the study included companies from different sectors to ensure a mixed social structure and a wide age range of participants (Table 2). A total of 9308 persons were invited to participate in the study, and 1015 agreed to take part (Table 2). The participation rate was heterogeneous owing to differences in company structure, commercial sector, and company size.

Participation was voluntary, free of charge and based on informed consent, which could be withdrawn at any stage of the study. Participants signed the informed consent form at the first appointment in the associated medical project, and were subsequently asked to complete a medical history form.

All employees were invited and eligible to join the present study. Exclusion criteria were: pre-existing conditions entailing a risk of endocarditis, or other diseases/conditions prohibiting periodontal probing without antibiotic protection; and the presence of any high-risk infectious diseases such as human immunodeficiency virus (HIV), hepatitis B/C/D, or tuberculosis. No employee who attended the dental examination had to be excluded for the above medical reasons.

According to the aim of the study, the dependent variable was the OHIP. The selection of independent variables was based on the literature, own conceptual considerations, and the final recommendations of an expert group brought together for a preparatory workshop held in Dresden. In this workshop, invited authorities of different dental specialties, professionals in the field of health services research, and a specialist in biometrics and statistics discussed variables and evaluation strategies. The data-collection process was pretested in a pilot project. A comprehensive clinical manual was available to guide the examiners through every step of the clinical examination. Examiners were two fully licensed dentists who were trained and calibrated regularly. Subjects lay on an examination table and the examiner was seated at the front end. A portable examination light was used (blue–white spectrum). Examiners used a plane mouth mirror and a WHO-probe, an internationally accepted periodontal probe with a ball tip, for caries diagnosis and periodontal status assessment (33). Computer-assisted data entry was conducted by a study assistant.

Oral health-related quality of life was measured with the German version of the OHIP (OHIP-G) (34). Compared with the original OHIP, this instrument contains four additional items. These items refer to avoiding eating with others, the need for longer time to finish a meal, joint sounds, and dry mouth. Within the questionnaire, seven subscales are used to categorize the OHIP-G items according

Table 2

Companies included, number of participants, and number of data sets available for analysis

Company	Commercial sector	No. of invited employees	Per cent participating (%)	No. of participants	No. of data sets included
1	Medical supply	250	23.6	59	33
2	Waste disposal	350	29.4	103	91
3	Water supply	428	19.9	85	74
4	High-tech industry	6600*	9.0*	593*	499
5	Public transport	1680	10.4	175	164
	Total	9308	10.9	1015	861

*The number of participants was restricted to 600 by the company management.

to functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap (6). Responses are graded on a Likert-like scale, offering the person five different response options (never = 0, hardly ever = 1, occasionally = 2, fairly often = 3, or very often = 4). Subjects were asked to refer to the preceding month in order to rate their current OHRQoL status (19, 20, 27, 32).

The OHIP-G questionnaire was supplemented by a set of sociodemographic and attitudinal items (level of education, age, gender, time since last dental visit, reasons for seeing a dentist, and subjective need of prosthetic treatment).

At the dental appointment, a clinical full-mouth examination was carried out based on the recommendations of the World Health Organization (WHO) (33). The decayed (D), missing (M) or filled (F) teeth (T) (DMFT) index was used to assess the caries experience. Caries recordings were conducted according to the WHO protocol (33), and caries was therefore recorded as present when 'a lesion in a pit or fissure, or on a smooth tooth surface has an unmistakable cavity, undermined enamel, or a detectably softened floor or wall'. Carious filled teeth were counted with D-T. Crowned teeth were counted with F-T. White spots or initial caries lesions were not counted. Periodontal status was assessed using the Community Periodontal Index (CPI) (35). Probing was performed with all teeth at six sites each (mesiobuccal, buccal, distobuccal, mesiolingual, lingual, and distolingual), recording the highest score per tooth. Tooth mobility was registered dichotomously as present or absent. A tooth was considered to be mobile when the incisal edge or the cusp of a tooth crown could be moved horizontally more than 1 mm according to mobility degree 2 or 3 of Nyman & Lindhe (36). Documentation of prosthetic status included crowns, bridges, teeth replaced with a removable dental prosthesis (RDP), un replaced missing teeth, and space closure. The number of occluding units was counted based on existing contacts between maxilla and mandible in the posterior regions [posterior occluding pairs (POPs)]. Contacts were related to all natural maxillary premolar and molar teeth (excluding wisdom teeth). Each maxillary posterior tooth that made contact with man dibular teeth, regardless of the actual number of opposing teeth, was counted as one POP. Fixed dental prostheses (FDPs) were considered as equivalent to natural teeth. Examiners also evaluated the RDPs according to the assessment criteria of the California Dental Association (37, 38). If one criterion was rated as 'not acceptable', the denture as a whole was rated as 'not acceptable'.

The functional assessments comprised measurement of maximum mouth opening by assessing the vertical incisal edge distance, palpation of temporomandibular joints, and palpation of two masticatory muscles (*Musculus masseter* and *Musculus temporalis*). The clinical protocol was completed by recording oral mucosal lesions (33).

Aesthetics was judged by dental professionals. The examiner took three digital photographs: (i) frontal view of both arches in occlusion with lips retracted, (ii) frontal view with lips at rest, mouth slightly opened, and (iii) frontal view, smiling. For privacy reasons, photographs comprised only the lower half of the face. Three dentists (the two examiners plus one colleague from the Department of Prosthetic Dentistry) were calibrated and evaluated the photographs independently applying a five-point scale (1 = very good, 2 = good, 3 = satisfactory, 4 = still acceptable, 5 = poor) for a general overall assessment of oral aesthetics. These three ratings were used to calculate a mean score for the patient rounded to whole numbers.

All participants' data were checked for completeness and plausibility. Only participants with complete data sets were accepted, with the exception of the OHIP-G, where missing values were replaced with the mean value for that OHIP-G-item (39). Data sets were excluded when more than nine OHIP-G items were missing (39) and in the case of incomplete clinical protocols or photographs of poor quality. This resulted in exclusion of data sets as follows: for 62 (6.1%) persons the questionnaire was not completed, and the clinical examination was refused; for 12 (1.2%) persons the questionnaire was completed, but clinical examination was refused; for 33 (3.3%) persons the questionnaire was missing more than nine items; for 18 (1.8%) persons clinical data were missing because of data-saving problems; 11 (1.1%) persons refused to have photographs taken; and for 17 (1.7%) persons the photographs were of poor quality.

The results were described for the 53-item OHIP-G but in order to maintain international comparability the four additional OHIP-G items were omitted in all further analyses. Summary OHIP scores were calculated as: (i) OHIP-ADD [i.e. the additive score of all 49 item-responses (range, 0–196)] (40) and (ii) OHIP-SC, where the individual score is calculated as the total number of 'fairly often' and 'very often' responses indicating a negative impact (10, 40). Both OHIP-ADD and OHIP-SC were dichotomized to comprise subjects with essentially impaired OHRQoL. For the OHIP-SC, a well-established approach was used. All subjects with an OHIP-SC of > 0 were considered essentially impaired. For the OHIP-ADD the cut-off point was heuristically defined with the aim of best possible discrimination between the essentially impaired and the remainder. This cut-off point conformed to the 90% percentile (OHIP-ADD = 34). The 90% percentile (OHIP-ADD > 34) was preferred to the 75% percentile (OHIP-G-ADD > 18) used in a previous study (29) because we wanted to ensure that only subjects with really essential impairments were in the target

group. Furthermore, this percentile showed the best possible multivariate discrimination between the two resulting categories.

Logistic regression models were developed using a mixed forward and backward stepwise strategy and likelihood ratio tests to evaluate models. The final models were tested for internal validity using the Hosmer & Lemeshow Goodness-of-Fit tests (41), and by estimation of the area under the curve (AUC) of the receiver–operating characteristics (ROC) curve, based on simple reclassification and on bootstrap cross-validation. We aimed to keep the number of parameters in the model as small as possible, and some categories of single variables were therefore combined.

All possible second-order interactions between covariates in the presented regression models were tested, but none reached statistical significance.

Table 3

Number of participants with responses 'fairly often' and 'very often' in the oral health-related quality of life (OHIP) subscales

OHIP subscale	Items per subscale	Patients scoring at least one item 3 or 4 *n* (%)
Functional limitation	9	167 (19.4)
Physical pain	9	80 (9.3)
Psychological discomfort	5	42 (5.0)
Handicap	6	36 (4.2)
Psychological disability	6	34 (3.9)
Physical disability	9	28 (3.3)
Social disability	5	3 (0.3)

Results

Complete data from a total of 861 (84.8%) subjects were used in the analyses.

Most (65.6%) of the employees included in the study were men (mean age = 41.8 yr; youngest, 20; oldest, 64 yr). Untreated caries was found in 122 (14.2%) subjects. Eight (0.9%) subjects had no fillings. There were no missing teeth in 321 (37.3%) subjects, regardless of replacement and space closure, and only 47 (5.5%) participants had RDPs. The average number of teeth missing from participants was about 2.5. Furthermore, the majority (73.6%) of the participants reported regular dental visits every 6 months or more frequently.

The analysis of the incomplete OHIP questionnaires revealed that in most cases, participants failed to answer only one question (63.8%, $n = 90$). Twenty-three participants did not respond to two items and most of the non-responses concerned items related to an unhealthy-looking tooth, financial difficulties, sore spots in the oral cavity, or inflammation of the jaw or mouth. An OHIP-SC of > 0 was most frequently found in the subscale 'functional limitation' (Table 3). The median OHIP-ADD values were 10.0 for the OHIP-G-53 and 9.0 for the OHIP-G-49.

The results of the univariate analyses are shown in Table 4. For the OHIP-ADD, several sociodemographic and clinical items showed a statistically significant relationship with impaired OHRQoL. The probability of belonging to the target group was, for example, higher for women than for men ($P = 0.03$), and higher for subjects 45–54 yr of age than for subjects ≤ 35 yr of age ($P = 0.04$). At least one tooth with increased tooth mobility was associated with belonging to the target group ($P < 0.01$) as was a reduced number of POPs ($P < 0.01$). Moreover, caries in anterior ($P < 0.01$) and posterior ($P < 0.01$) teeth, as well as aesthetic shortcomings ($P < 0.05$), were detected as a significant indicator for impaired OHRQoL. Wearing RDPs was also associated with belonging to the target group ($P < 0.01$).

For the outcome of 'OHIP-ADD score > 34', a logit model with a good fit ($P = 0.76$) for the Hosmer-Lemeshow-Test was found (Table 5). The following variables remained as significant indicators in the most-parsimonious multivariate model: female gender ($P = 0.02$), poor aesthetics ($P = 0.03$), low number of POPs ($P < 0.01$), and painful palpation of masticatory muscles ($P = 0.04$).

For the outcome of 'OHIP-SC > 0', a logit model with a sufficient fit ($P = 0.25$) for the Hosmer-Lemeshow-Test was found (Table 5). The following variables remained as significant indicators in the most-parsimonious multivariate model: female gender ($P < 0.01$), poor aesthetics ($P < 0.01$), painful palpation of masticatory muscles ($P = 0.04$), joint sounds ($P = 0.03$), unreplaced teeth only in the mandible ($P = 0.01$), and caries in posterior teeth ($P < 0.01$).

Discussion

This cross-sectional study of a non-patient German working population indicates that the best predictors of essential OHRQoL impairment, whether defined as OHIP-ADD > 34 or as OHIP-SC > 0, include female gender, poor aesthetics, and painful masticatory muscles. For the OHIP-ADD > 34 model, a small number of POPs was also influential, whereas the model for OHIP-SC > 0 also included un replaced teeth in the mandible and caries in posterior teeth.

In comparison with other studies, the median OHIP-ADD value was relatively low (OHIP-G-49 = 9.0) (12, 31). A possible explanation could be that young and healthy subjects were over-represented compared with a representative German study (13). In our study, only 14.2% of the subjects had untreated caries lesions, whereas the representative data showed a prevalence of 24.2% for the 35–44 yr age-group. This explanation corroborates the findings of LARSSON *et al.* (42), who found that healthy subjects had a significantly lower total OHIP score than did patient groups. Additionally, several studies have shown that denture status has a significant impact on OHRQoL (20, 21). Losing teeth and getting RDPs is an important milestone for the oral functional and psychological wellbeing of a patient (20). Getting dentures may cause stress that is comparable with the stress experienced when having trouble with a spouse (43). This milestone normally occurs at older

Table 4

List of variables used for multivariate logit model building: results of the univariate analysis for OHIP-ADD (Oral Health Impact Profile - Additive Score) and OHIP-SC (Oral Health Impact Profile - Single Count)

			Univariate analyses concerning OHIP-ADD > 34			Univariate analyses concerning OHIP-SC > 0		
Variable	Category	*n*	N_{Resp}†	OR (95% CI)	*P*-value	N_{Resp}†	OR (95% CI)	*P*-value
Age	< 35 yr*	200	12			47		
	35–44 yr	338	34	1.8 (0.9–3.5)	0.11	102	1.4 (0.5–2.1)	0.10
	45–54 yr	255	30	2.1 (1.0–4.2)	0.04	79	1.5 (1.0–2.2)	0.08
	55–65 yr	68	11	3.0 (1.3–7.2)	< 0.01	21	1.5 (0.8–2.7)	0.23
Gender	Male*	565	48			142		< 0.01
	Female	296	39	1.6 (1.1–2.6)	0.03	107	1.7 (1.3–2.3)	
Aesthetics	Very good/good*	262	13			59		
	Satisfactory	346	34	2.1 (1.1–4.0)	0.03	97	1.3 (0.9–2.0)	< 0.01
	Still acceptable	215	30	3.1 (1.6–6.1)	< 0.01	78	1.9 (1.3–2.9)	< 0.01
	Poor	38	10	6.8 (2.8–17.0)	< 0.01	15	2.2 (1.1–4.6)	< 0.01
Number of posterior occluding pairs	6–8*	656	48			185		
	4 + 5	131	25	3.1 (1.8–5.3)	< 0.01	37	1.0 (0.7–1.5)	1.00
	0–3	74	16	3.7 (2.0–6.9)	< 0.01	27	1.5 (0.9–2.4)	0.14
Painful palpation of masticatory muscles	No*	855	84			244		
	Yes	6	3	9.2 (1.8–46.3)	< 0.01	5	12.5 (1.5–107.9)	< 0.01
Joint sounds	No*	723	70			194		< 0.01
	Yes	138	17	1.3 (0.8–2.3)	0.34	55	1.8 (1.2–2.6)	
Unreplaced missing teeth	No*	528	41			141		
	Maxilla and mandible	105	16	2.1 (1.2–4.0)	0.01	28	1.0 (0.6–1.6)	1.00
	Only maxilla	82	8	1.3 (0.6–2.9)	0.53	22	1.0 (0.6–1.7)	0.97
	Only mandible	146	22	2.1 (1.2–3.7)	< 0.01	58	1.8 (1.2–2.7)	< 0.01
Carious teeth	None*	739	66					
	In anterior teeth	24	6	3.4 (1.3–8.9)	< 0.01	13	3.3 (1.4–7.4)	< 0.01
	In posterior teeth	98	15	1.9 (1.0–3.4)	0.04	39	1.8 (1.2–2.8)	< 0.01
Mobile teeth	0*	780	71			222		0.36
	> 0	81	16	2.5 (1.4–4.5)	< 0.01	27	1.3 (0.8–2.1)	
Filled teeth	Only posterior fillings*	212	12			53		
	> 1 filling in the front	529	63	2.3 (1.2–4.3)	0.01	170	1.4 (1.0–2.0)	0.06
	1 filling in the front	112	12	2.0 (0.9–4.6)	0.10	24	0.8 (0.5–1.4)	0.06
	No fillings	8	0	–	–	2	1.0 (0.2–5.1)	0.06
Prosthetic status‡	No restorations*	326	23			75		
	Crowns	253	25	1.5 (0.8–2.6)	0.22	81	1.6 (1.1–2.3)	< 0.01
	FDP	235	26	1.6 (0.9–3.0)	0.09	73	1.5 (1.0–2.2)	< 0.01
	RDP	47	13	5.1 (2.4–10.9)	< 0.01	20	2.5 (1.3–4.7)	< 0.01

*Reference category.
†Number of responders.
‡Most extensive restoration.
FDP, fixed dental prostheses; RDP, removable dental prostheses.

ages, which may explain why RDPs were not predictive in our study. Hence, the mean age of our study group was 41.8 yr, with the youngest at the age of 20 yr and the oldest at the age of 64 yr. Only 47 (5.5%) participants had removable partial dentures.

Impacts were most frequently recorded in the subscales 'functional limitation' and 'physical pain', which is in accordance with the results of other studies (19). The clinical parameters that showed significant correlations in the multivariate model also seem to be related to functional aspects. A reduced number of occluding pairs was associated with a higher probability of belonging to the target group. Witter *et al*. (44) suggested that elderly people may be able to function at a suboptimal level with 10 occluding pairs (equal to four POPs + six occluding pairs in the anterior region), or even a minimal level with eight occluding pairs (equal to two POPs). Within this so-called shortened dental arch concept, the optimal level is defined as 12 occluding pairs or six POPs (44). Taking this optimal level as a reference, we detected associations between reduced numbers of POPs and belonging to the target group. It is known from other studies that subjects with one or no POPs are more likely to report pain than are subjects with more POPs (45). Additionally, impaired OHRQoL was found in subjects who noticed pain during muscle palpation, which is in line with current studies showing that people suffering from craniomandibular disorders (CMDs) and orofacial pain have significantly higher OHIP scores (26, 27). The identification of poor aesthetic appearance as a predictor for impaired OHRQoL was expected. However, comparable actual data is missing. This might be related to the fact that there are no reproducible methods available for standardized assessment of aesthetics. Studies on the impact of oral aesthetics on patients' health perception deal with single aspects like the shape of the front teeth (46) or

Table 5

Logistic predictors for OHIP-ADD (Oral Health Impact Profile - Additive Score) > 34 and OHIP-SC (Oral Health Impact Profile - Single Count) > 0

Variable	Category	OHIP-ADD		OHIP-SC	
		OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Gender	Male*				< 0.01
	Female	1.7 (1.1–2.8)	0.02	1.6 (1.2–2.2)	
Aesthetics	All other categories*				< 0.01
	Still acceptable or poor			1.6 (1.2–2.3)	
	Poor	2.6 (1.1–5.9)	0.03		
Number of posterior occluding pairs	6–8*				
	4–5	2.9 (1.5–5.8)	< 0.01		
	0–3	3.2 (1.9–5.4)	< 0.01		
Painful palpation of masticatory muscles	No*				0.04
	Yes	6.1 (1.1–34.6)	0.04	9.9 (1.1–87.1)	
Joint sounds	No*				0.03
	Yes			1.6 (1.1–2.3)	
Unreplaced missing teeth	In the maxilla or in both jaws*				0.01
	In the mandible			1.6 (1.1–2.4)	
Caries	No*				
	In anterior teeth			2.5 (1.1–5.8)	0.03
	In posterior teeth			1.8 (1.2–2.8)	< 0.01

The regression model OHIP-ADD shows a good fit to the data ($P = 0.76$; Hosmer and Lemeshow Goodness-of-Fit Test) and has an area under the curve (AUC) = 0.69 (bootstrap cross-validated AUC = 0.58). The regression model OHIP-SC shows a sufficient fit to the data ($P = 0.25$; Hosmer and Lemeshow Goodness-of-Fit Test) and has an AUC = 0.65 (bootstrap cross-validated AUC = 0.56).
*Reference category.

orthodontic findings (47). The reason for using an objective rather than a subjective evaluation for aesthetics was that aesthetics, as seen from the patient's perspective, is included directly and indirectly in a number of items of the OHIP instrument.

Except for gender, the other sociodemographic variables seemed to play only a minor role in OHRQoL. Gender and impaired OHRQoL were associated, both in the univariate analysis and in the multivariate model, with a significantly higher risk of impaired OHRQoL for women. These findings of gender differences are in contrast with those of a representative survey in a Finnish population where the OHIP showed no gender differences (8). A study by Steele *et al*. (48) compared OHIP scores in an Australian and a UK population. Significant gender differences were found in the UK, but not in Australia. Another study detected gender differences only beyond the age of 70 yr (28). Other studies found that women had a higher risk of being unsatisfied with their OHRQoL than men (12, 19, 49). Hence, current data on gender differences in OHIP scores are inconclusive. They seem to be marginally significant or nonsignificant, and sensitive to sampling strategies or other sources of bias. The sampling strategy did not focus on a representative inclusion of social groups and might therefore have adversely affected the detection of these influences.

However, our primary goal was to detect associations rather than to collect epidemiological data. Nevertheless, we attempted to achieve an appropriate mix of social groups by choosing companies in different sectors. This approach was limited by practical and financial aspects. Another limitation might be the recruitment of the subjects, as participation was not controlled. It is known that people who voluntarily take part in studies tend to have a greater interest in their own health concerns than the average person and therefore might have fewer problems with their teeth, leading to lower OHIP-scores within the present study. This might have biased the results (50). Differing participation rates of employees were found for the companies included in this study. In the biggest company, the management restricted the number of participants to 600, leading to a low participation rate from this company, although more employees had been interested in taking part in the study.

Except for the POPs, the significant variables of the OHIP-ADD model were also significant in the OHIP-SC model. Additionally, decay in the front teeth, joint sounds, and unreplaced teeth in the mandible were associated with a higher risk of impaired OHRQoL.

As a result of the substantially different approaches, comparison between the OHIP-ADD and the OHIP-SC models is complex and difficult. While the OHIP-ADD method appears to be more comprehensive, the OHIP-SC method could be considered more specific for frequent or continuous problems (10). Nevertheless, both models delivered plausible results with considerable overlaps. Despite the striking differences of OHIP-ADD and OHIP-SC, the differences between the resulting logistic models were amazingly small. Gender, aesthetic appearance, and painful muscle palpation were significant in both optimal models (OHIP-ADD and OHIP-SC). Missing POPs were only significant in the OHIP-ADD model, while joint sounds, carious teeth, and unreplaced teeth were significant in the OHIP-SC model. We assume that using an additive score might be more

sensitive than the OHIP-SC approach. The most striking difference might be that within the OHIP-ADD method, items scored as 'hardly ever' and 'occasionally' might add up to a high total score and therefore lead to the assignment of the respective subjects to the target group. These lower scores would remain uncounted within the OHIP-SC method. Both models are equitable and supplement each other.

This cross-sectional study showed that within the models for both OHIP-ADD and OHIP-SC, a person with impaired OHRQoL is more likely to be a woman with impaired aesthetics and painful masticatory muscles.

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