Risk Indicators for Missing Teeth in Working-Age Pomeranians – An Evaluation of High-Risk Populations

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Abstract

Objective: *The goal of this study was to examine whether psychosocial conditions for general health described in the public health literature are also reflected in tooth loss.* ***Methods:*** *The relation of psychosocial factors to missing teeth was evaluated among 2,501 individuals aged 25 to 59 years from the population-based cross-sectional Study of Health in Pomerania using logistic regression analyses. The case group included 15 percent of participants of each 5-year age group with the highest number of missing teeth.* ***Results:*** *Unemployment, dose-dependent current and former smoking, a poor general health status, and a longer time since the last dental appointment were significant risk indicators for missing teeth. Alcohol consumption, use of interdental cleaning products, and checkup as the reason for the last dental visit were protective. Women with low education and low income were identified as a high-risk group for missing teeth by the three-way interaction between gender, school education, and household income. The effect of marital status was modified by gender: being single was a risk indicator for men but it was protective for women.* ***Conclusions:*** *The study supports the hypothesis that psychosocial conditions that affect health status as described in the general public health literature also have an effect on tooth loss. Strategies to prevent tooth loss may be expeditiously implemented in combination with approaches to prevent other health-related problems.*

Key Words: epidemiology, cross-sectional studies, tooth loss, missing teeth, population groups

Introduction

Tooth loss is the final outcome of a multifactorial process that involves not only disease-related conditions but also other factors (1-6). Among psychosocial risks for tooth loss, there are factors which have widely been confirmed (2-6), rare factors, such as systemic diseases (2,7) or depressive symptoms (8), and factors about which opinions diverge. Oral health behavior (9-14), low education (4,9,10-12,14-16), low income (9,10,12,15,17), and smoking (1,2,5,7,9,10,12,14,16,18) have been consistently demonstrated as risk factors for tooth loss. Furthermore, race – specifically Black compared with Caucasian (8,17) – geographical area (6,14,16), urban or rural place of residence (14), poor general health (5,14,16), and marital status (15,18) have repeatedly been observed to be associated with tooth loss. Several studies have found positive associations between alcohol consumption and tooth loss (5,8), which could not always be confirmed (2,6,19).

The role of gender is an ambiguous one: There are longitudinal studies of psychosocial models identifying either men (1,9) or women (3,17) as having a higher risk for tooth loss, whereas others found no gender differences (4,5,16). There may be some explanations for these findings. The gender effect differs across regions in general (6) and in terms of the effects related to age (age effect, period effect, cohort effect) (9). In addition, the gender difference is related to behavioral and cultural factors rather than to a greater propensity for periodontal diseases or caries (14). This would imply that the gender effect may be related to its characteristic as an effect modifier rather than to its characteristic as a main effect. From the psychosocial literature, it is known that women suffer prior to a divorce but men do so afterward (20), and that marriage is more advantageous for men than for women (21). Marital status is not the only effect modified by gender, e.g., women use health services more frequently than men (22). Gender as an effect modifier may also lead to gender-specific high-risk groups. In Germany, women with low education, low income, many children, and no job are at high risk regarding general health (23). Unemployment is a further psychosocial factor that

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affects health status (24) and may also be related to tooth loss. A general population that is characterized by high tooth loss is especially suitable for examining the variety of these psychosocial conditions in relation to tooth loss.

To examine whether the effect-modifying role of gender and the combined action of psychosocial variables also apply to dentistry requires some methodological strategies when dealing with cross-sectional data. An appropriate case group definition is straightforward and uniform in longitudinal studies (1,3,4,6-9,17,18), but inconsistent in cross-sectional studies. If Poisson (3) or, if applicable, linear regression analyses (12) are used then a case definition on the individual level are not intended. Case definitions based on extreme values using edentulous individuals (2,15,16) or individuals missing any teeth (5) are not suitable for adults of middle age. Defining individuals by the number of missing teeth over a certain threshold as cases (13) is problematic in studies with a wide age range, because the mean number of teeth decreases with age. An appropriate case definition, however, has to avoid an overrepresentation of cases with long duration of tooth loss and an underrepresentation of those with short duration of tooth loss. The goal of this study was to examine whether psychosocial conditions for health, individually or in combination, are also reflected in tooth loss.

Methods

Participants. The Study of Health in Pomerania (SHIP-0) (25) is a cross-sectional population-based survey in northeast Germany involving three cities and 29 surrounding villages. The population in this catchment area was 212,157 in 1995. First, the three cities of the region (17,076- to 65,977 inhabitants) and the 12 towns (1,516 to 3,044 inhabitants) were selected, and 17 out of 97 smaller towns (<1,500 inhabitants) were randomly drawn. Second, from each of these, German individuals whose main residence was in the area were drawn at random, proportional to each community population size and stratified by age and gender. A representative sample of 6,262 individuals aged 20 to 79 years was thus invited to participate, and from October 1997 to May 2001, they were studied. The final observed sample included 4,310 individuals, reflecting an overall participation rate of 68.8 percent. The study was approved by the Ethics Committee of the University of Greifswald, and all participants gave informed written consent.

Data Assessment. The dental examination was performed by calibrated dentists. Wisdom teeth were not included in the analysis. The following sociodemographic variables were taken from the interview: gender, age, education [<10 years of school, 10 to 11 years (reference), >11 years of school], marital status, and current place of residence (urban: two cities of 50,000 or more population; rural: surrounding villages and a city having 17,000 inhabitants). Income (in German Marks) was a continuous variable of the questionnaire and was divided by the number of persons living in the household of the individual. The following behavioral variables were taken from the interview: smoking was categorized as always non-smoker, former smoker, and current smoker. The maximum quantity of cigarettes smoked per day over a year was divided into <10 cigarettes/day, 10 to 19 cigarettes/day, and ≥20 cigarettes/day. Alcohol intake during the previous week was queried for type and frequency of alcohol consumption. The mean daily alcohol consumption was calculated by the beverage-specific quantity/frequency method: number of days with alcohol intake (subdivided into three beverage types: beer, wine, spirits). The values are expressed in grams of pure alcohol/day and categorized into quintiles. Leisure physical activity was defined as one or more hours of exercises per week. Body mass index (BMI) was calculated using the data of the clinical examination.

The self-reported general state of health was quantified on a five-point scale (1, excellent; 2, very good; 3, fair; 4, less good; 5, poor) in response to the following question: How would you describe your general state of health? Oral health behavior was addressed using the following variables: frequency of toothbrushing (more than once a day, once a day, less frequently), use of interdental cleaning products, last dental appointment (during the last 6 months/during the last 7 to 12 months/more than a year ago), and reason for the last dental appointment (regular checkup/other).

Statistical Analyses. Cases were defined by assessing edentulous persons and persons with especially few teeth in relation to their age. Thus, 15 percent of participants with the highest number of missing teeth in each 5-year age group were considered as cases. In addition, these participants must have lost at least five teeth, and the difference from the median in each 5-year age group must have been at least four teeth. Sensitivity analyses with cases defined by the top 10 percent or top 20 percent instead of the top 15 percent were performed to reduce uncertainties regarding the results.

To describe the case group and the reference group (the remaining 85 percent of individuals), data on quantitative characteristics are expressed as median and interquartile range. Data on qualitative characteristics are expressed as absolute numbers and as percentages. Comparisons between the case group and the reference group were made using the Mann–Whitney's *U*-test (continuous data) and the Chi-square test (nominal data).

A psychosocial model of putative sociodemographic and behavioral risk factors similar to other studies was used (1,3,5,9,16,26). Logistic regression models [with various stopping rules setting the *P*-value from 0.15 to 0.25 for entering variables into the model and setting the *P*-value from 0.10 to 0.15 for deleting variables as recommended by Sun et al. (27)] were used. The odds ratios (OR) with 95 percent confidence intervals (CI) were determined.

In order to test the effect modifications known from the public health literature and to identify high-risk groups for missing teeth, the final model included prespecified interactions: between gender and marital status (20,21), between gender and time since or reason for the last dental appointment (22), and between gender, school education, and household income (23). All analyses were performed by SPSS for Windows version 12.0 (SPSS, Inc., Chicago, IL, USA). A P-value < 0.05 was considered as statistically significant, with the exception of interactions that were significant if $P < 0.10$.

Table 1
Characteristics regarding the Number of Missing Teeth and the Number of Individuals in the Case Group in Proportion to All Individuals of Each Age Group

Age (years)	Median number of missing teeth of all individuals	Number of missing teeth within the case group	Individuals of the case group in proportion to all individuals (%)
25-29	1	≥5	41/318 (12.9)
30-34	2	≥7	44/357 (12.3)
35-39	4	≥10	53/371 (14.3)
40-44	5	≥13	51/353 (14.4)
45-49	5	≥16	56/360 (15.6)
50-54	7	≥18	54/347 (15.6)
55-59	9	≥22	56/395 (14.2)
25-59	4		355/2,501 (14.2)

Results

Among the 60- to 64-year-old participants, more than 15 percent (17.9 percent) were edentate. The age group 20 to 24 years did not meet the other requirements for especially few teeth in relation to their age (minimal number of five missing teeth among individuals of the case group, difference of at least four teeth of the cases to the median) as 17.9 percent had lost two teeth and 9.7 percent had lost three teeth. Consequently, only the data of 2,621 participants aged 25 to 59 years were used. Moreover, sensitivity analyses with the top 10 percent or top 20 percent concerning the dependent variable were only feasible in the 25- to 59-year-old individuals and have showed only small differences. Excluding 120 individuals with incomplete records (4.6 percent), 2,501 individuals remained for further analyses. According to the definition, 355 out of 2,501 individuals belonged to the case group (Table 1). There were only slight insignificant gender differences regarding the number of teeth in the 5-year age groups.

The baseline characteristics and bivariable comparisons are presented in Table 2. Among individuals who had a lower level of school education, were married but separated, were divorced or widowed, and who were unemployed, the percentage of the case group was significantly increased compared with the respective reference group. Mean household income was lower and BMI was higher among individuals within the case group. Current and former smokers were more likely to have fewer teeth than those who had never smoked, whereas individuals with an increased weekly alcohol intake, with a better general state of health, and physically active individuals tended to have more teeth. Individuals who brushed their teeth more frequently, used interdental cleaning products, visited the dentist more frequently and for a checkup were more likely to have more teeth.

In the final logistic regression model, unemployment, current and former smoking, poorer general state of health, poor interdental hygiene, last dental visit more than 6 months ago, a reason different from a checkup for the last dental appointment, and weekly alcohol intake were protective and were identified as main effects that are not part of the interaction terms for fewer teeth (Table 3). The following variables were not significant: urban/rural place of residence, BMI, and toothbrushing frequency.

The interaction between gender and marital status was significant ($P = 0.04$; Table 4). Being single was a risk indicator for men (OR = 1.4; Table 5), but it was protective for women (OR = 0.4, Table 5; $P < 0.01$ for this interaction term, Table 4). A high-risk group, namely women with low school education and low income, could be identified by the three-way interaction between gender, school education, and household income ($P = 0.06$, Table 4). Among participants with 10 to 11 years of school education, gender differences were marginal regarding the effect by income, whereas in participants with less than 10 years of school education, gender differences were conspicuous: tooth loss in women was highly affected by income compared with tooth loss in men (Figure 1). The prespecified interactions between gender and time since or reason for the last dental appointment were not significant.

Discussion

We found that gender modified the effect of marital status as well as the effect of school education and income. The most prominent high-risk group was that of women with low school education and low income. In this general population with a high prevalence of tooth loss, a diversity of psychosocial factors, including unemployment, was associated with tooth loss. The effect of the psychosocial conditions remained after adjusting for variables related to oral health behavior.

The modifying role of gender is plausible for three reasons. First, the general psychosocial literature has supported the income effects on the health of women, whereas marital status affects the health of men (28).

Table 2
Baseline Characteristics of Individuals (n = 2,501) regarding the High Number of Missing Teeth

	% of the reference group (n = 2,146)	% of the case group (n = 355)
Female gender	53.2	55.2
School education†		
<10 years	20.0	40.0
10-11 years	59.6	55.5
>11 years	20.4	4.5
Marital status†		
Married	68.4	59.7
Married but separated	2.0	3.1
Single	19.3	18.0
Divorced	8.0	15.8
Widowed	2.1	3.4
Current place of residence: rural	39.8	42.0
Income per person living in the household† (in German Marks, continuous)	1,150 (833)‡	812 (646)‡
Being unemployed†	17.2	33.8
Smoking (cigarettes/day)†		
Never smokers	35.6	19.7
Current smokers		
<10	9.9	11.3
10-19	14.0	22.3
≥20	10.3	21.7
Former smokers		
<10	14.1	9.6
10-19	6.4	5.6
≥20	9.7	9.9
Alcohol intake (grams pure alcohol/week)†		
First quintile	28.7	41.7
Second quintile	9.5	7.6
Third quintile	20.3	20.0
Fourth quintile	21.0	13.8
Fifth quintile	20.5	16.9
Leisure physical activity ≥1 hour/week†	32.3	19.4
Body mass index (kg/m^2; continuous)*	26.3 (6.4)‡	26.9 (6.3)‡
General health status†		
Excellent	2.5	0.8
Very good	20.3	12.4
Fair	63.8	65.1
Less good	12.0	20.3
Poor	1.4	1.4
Frequency of toothbrushing*		
>1/day	86.2	82.4
1/day	12.4	13.6
<1/day	1.4	4.0
Interdental hygiene†	42.7	18.3
Time since the last dental appointment†		
≤6 months	70.9	56.9
7-12 months	19.2	22.5
>12 months	10.0	20.6
Reason for the last dental appointment		
Checkup†	57.3	43.9

Case group: 15% of individuals with the highest number of missing teeth per 5-year age group. Reference group: remaining 85% of individuals.
* $P < 0.05$.
† $P < 0.001$.
‡ Median (interquartile range).

The first observation is reflected by the modification of the effect of school education and income by gender, the second observation is reflected by the modification of marital status by gender. Second, the modification of the effect of marital status by gender was reported in detail in the psychosocial literature: "marriage is more advantageous for men than for women" (21). The observation "that women suffer prior to a divorce, but men do so afterward" (20) could not be confirmed because the number of married but separated individuals was low. A tendency towards an increased OR for men, however, could be supposed (95 percent CI = 0.4, 8.7; Table 5). The psychosocial effect of divorce on general health and use of health services has been reported previously (20). Third, for Germany, the high-risk group of women with low school education and low income has been described in the public health literature (23). These modifying roles of gender may in part explain the heterogeneity of the literature concerning the association between gender and tooth loss. Only a few studies have modeled prespecified interactions (1,3,8).

As expected, unemployed individuals showed a poorer dental health status. The unemployment in the study region is high (about 20 percent) compared with other regions in Germany. The higher power resulting from the high unemployment compared with other studies may be the reason why no other study has reported an association between unemployment and tooth loss. Unemployment means not only an economic but also a psychosocial burden linked with the demands to develop strategies to compensate the loss of social status (24).

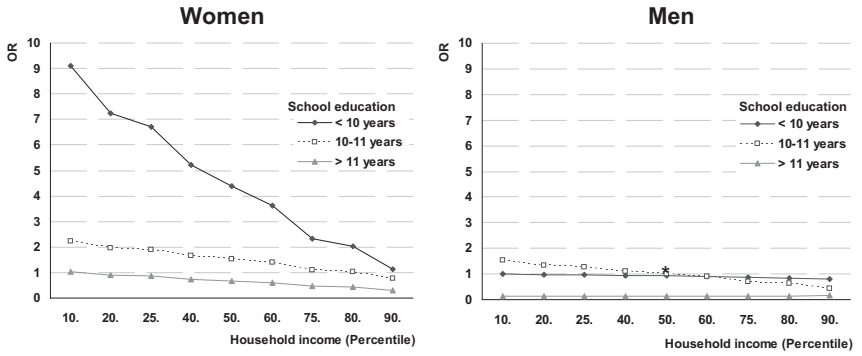
We did not find an association between urban/rural residence and tooth loss (14). There may be two explanations for this finding. First, the population is homogenous with respect to urbanization; the largest town in the study region has fewer than 70,000 inhabitants. Second, after

Table 3
Odds Ratios (OR), 95% Confidence Intervals (CI), and *P*-Values for All Main Effects That Are Not Part of the Interaction Terms of the Variables Remaining in the Final Model regarding the High Number of Missing Teeth

	OR	95% CI
Being unemployed (Ref.: no)*	1.4	(1.1, 1.9)
Smoking (cigarettes/day)‡		
Never smokers (Ref.)	1	
Current smokers		
<10†	2.1	(1.3, 3.3)
10-19‡	2.3	(1.6, 3.4)
≥20‡	3.5	(2.3, 5.4)
Former smokers		
<10	1.3	(0.8, 2.0)
10-19	1.7	(1.0, 3.1)
≥20‡	2.4	(1.4, 3.9)
Alcohol intake (g/week)†		
First quintile (Ref.)	1	
Second quintile	0.8	(0.5, 1.2)
Third quintile	1.0	(0.7, 1.5)
Fourth quintile†	0.6	(0.4, 0.9)
Fifth quintile†	0.6	(0.4, 0.8)
General health status*	1.2	(1.0, 1.5)
Interdental hygiene (Ref.: poor)‡	0.4	(0.3, 0.5)
Time since the last dental appointment‡		
≤6 months (Ref.)	1	
7-12 months†	1.5	(1.1, 2.0)
>12 months†	1.7	(1.2, 2.4)
Reason for the last dental appointment		
Checkup (Ref.: other)†	0.7	(0.5, 0.9)

* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.001$.
Ref., reference.

Figure 1
Odds ratios (OR) for the three-way interaction between gender, school education, and household income calculated from the final model regarding the high number of missing teeth. Reference category: men; income of 1,083.3 German Marks (50th percentile); 10 to 11 years of school education



the reunification in 1989, the mobility of the population in general became higher and the status of urban/rural was dissolved.

Contrary to other authors (5,6,8), an inverse association was observed between alcohol consumption and number of missing teeth. In a former study, Xie and Ainamo (2) supposed that the lack of the association between alcohol intake and edentulism in elderly people might be caused by the higher alcohol consumption of participants with a high socioeconomic status compared with those having a low socioeconomic status. In the present study, only 20 percent of individuals who had a 12-year school education were found within the lowest quintile of alcohol intake (versus 30.4 percent with 10 to 11 years and 39.5 percent with less than 10-year school education, $P < 0.01$). Furthermore, low alcohol consumption was significantly related to low household income ($P < 0.01$). Both confirm a previous study which established that women with high socioeconomic status drank more alcohol and had better dental status compared with women of low socioeconomic status (19). Additional research is needed regarding these findings.

Confirming other studies (9-11,13), regular dental attendees and individuals who visited the dentist for preventive care had a greater number of natural teeth. Regular dental visits may provide opportunities for the prevention and early treatment of oral diseases (10,13). A modifying role of gender regarding the use of dental health services (22) was not found in this study. Only the use of interdental cleaning products, but not the frequency of toothbrushing, was significantly associated with the number of teeth. This practice supports the hypothesis of Kressin et al. (11) that the lack of statistical significance of hygiene practices may also reflect the limits of a single versus longitudinal assessment of hygiene habits.

The use of psychosocial circumstances instead of clinical measures for the detection of high-risk populations has the benefit that the target group for prevention or interventions can be discovered more easily (26). In this way, the prevention policy might be focused more efficiently and "needs to apply both targeted and population strategies" (29). A

Table 4
Coefficients, Odds Ratios (OR), 95% Confidence Intervals (CI), and *P*-Values for All Main Effects and Interactions That Are Part of the Interaction Terms of the Variables Remaining in the Final Model regarding the High Number of Missing Teeth

	Coefficient	OR	95% CI	*P*-value
Terms of the interaction between gender and marital status*				
Gender (Ref.: male)	0.42	1.5	(0.7, 3.2)	
Marital status				
Married (Ref.)		1		
Married but separated living	0.62	1.9	(0.4, 8.7)	
Single	0.32	1.4	(0.9, 2.1)	
Divorced	0.51	1.7	(0.9, 3.0)	
Widowed	0.47	1.6	(0.3, 8.4)	
Gender (Ref.: male) × marital status				0.037
Married (Ref.)				
Married but separated living	–0.71	0.5	(0.1, 2.9)	0.435
Single	–1.14	0.3	(0.2, 0.7)	0.002
Divorced	0.01	1.0	(0.5, 2.2)	0.979
Widowed	–0.43	0.7	(0.1, 4.2)	0.652
Terms of the interaction between gender, school education, and household income†				
Gender (Ref.: male)	0.42	1.5	(0.7, 3.2)	
School education				
<10 years	–0.82	0.9	(0.4, 2.0)	
10-11 years (Ref.)		1		
>11 years	–1.98	0.1	(0.0, 0.7)	
Household income	–0.68	0.5	(0.3, 0.8)	
Gender (Ref.: male) × household income	0.10	1.1	(0.6, 2.0)	
Gender (Ref.: male) × school education				
<10 years	1.14	3.1	(1.1, 9.3)	
10-11 years (Ref.)		1		
>11 years	1.15	3.1	(0.3, 29.0)	
Household income × school education				
<10 years	0.55	1.7	(0.9, 3.3)	
10-11 years (Ref.)		1		
>11 years	0.82	2.3	(1.0, 5.2)	
Gender (Ref.: male) × household				0.063
Income × school education				
<10 years	–1.13	0.3	(0.1, 0.9)	0.026
10-11 years (Ref.)		1		
>11 years	–0.92	0.4	(0.1, 1.6)	0.194

* OR for men who are not married compared with married men can be directly seen from the table (i.e., OR = 1.4 for single men compared with married men), whereas the OR for the women who are not married compared with married women is to be calculated [i.e., OR = exp (0.32 – 1.14) = 0.4 for single women compared with married women or OR = exp (0.42 + 0.32 – 1.14) = 0.7 for single women compared with married men]. For the results of the calculation see Table 5.
† For the calculation see Figure 1. Ref., reference.

"targeted" strategy may include information concerning better oral health behavior or antismoking campaigns. The "whole population" strategy should aim for an enhanced school education or more employment in order to support an entire populational shift in terms of improved health behavior (29).

In conclusion, our study supports the hypothesis that psychosocial conditions that affect health status as described in the general public health literature also have an effect on tooth loss. Strategies to prevent tooth loss may be expeditiously implemented in combination with approaches to prevent other health-related problems.

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Table 5
Odds Ratios (OR) and 95% Confidence Intervals (CI) for the Two-Way Interaction between Gender and Marital Status Calculated from the Final Model

	Men		Women	
	OR	95% CI	OR	95% CI
Married (Ref.)	1		1	
Married but separated living	1.9	(0.4, 8.7)	0.9	(0.4, 2.2)
Single	1.4	(0.9, 2.1)	0.4	(0.2, 0.8)
Divorced	1.7	(0.9, 3.0)	1.7	(1.0, 2.7)
Widowed	1.6	(0.3, 8.4)	1.0	(0.5, 2.3)

Ref., reference.

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