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Dental health and disease determinants among 35-year-olds in Oslo, Norway

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Abstract

Objective. The aim of the present study was to identify non-biological determinants associated with the number of sound teeth (ST) and presence of decayed surfaces (DS) among 35-year-old Oslo citizens. ***Material and methods.*** Randomly selected participants ($n = 149$, response rate 64%) completed a self-administered questionnaire and were examined clinically and radiographically. Dental caries was registered clinically following World Health Organization (WHO) diagnostic criteria for caries registration, and the findings were combined with radiographic caries recordings. The number of sound teeth and the presence of two or more dentine caries lesions ($D_3S \geq 2$) were selected as dependent variables. Associations between selected dependent variables and possible determinants were assessed by linear and logistic regression analyses, taking into account the hierarchical relationships between the independent variables. ***Results.*** On average, 35-year-olds had 17.1 (SD = 5.6) ST. Half of the participants had no DS and 26% had $D_3S \geq 2$. Non-Western region of birth, being single, and having a university education were significantly associated with higher numbers of ST. Low family income, presently a smoker, and irregular dental visits were significantly associated with the presence of dentine caries. ***Conclusions.*** The results of this study indicate that several non-biological determinants operating at different levels are important for health and disease in this adult population.

Key Words: *Adults, dental caries, determinants, sound teeth*

Introduction

Studies on trends in dental caries in industrialized countries indicate that during the past three decades there has been substantial improvement in the dental health of children and cohorts of younger adults [1], but there are disparities.

In Norway, the decline of caries in children and young adults is well documented [2–6]. However, only a few studies have examined the variation in dental health among Norwegians. In children, disparities in dental caries have been attributed to lower social status and immigrant background [7]. The available studies on adults indicate that higher caries experience scores are associated with low education [8]. Parameters such as poor oral hygiene scores, irregular dental visits and dissatisfaction with personal economy [5], alcohol problems, male gender [9], and high levels of dental fear [10] have been studied and related to a higher number of carious tooth surfaces. In two recent Norwegian studies, socioeconomic disparities have also been found in relation to self-reported dental health measures [11,12]. Low income was found to be associated with an increased likelihood of having fewer than 20 natural teeth [11] as well as of being edentulous [12]. Since reducing inequalities in health, including dental health, is an important health policy issue in Norway, there is a need for information on dental health determinants in different subgroups of the population. However, studies explaining variation in the dental status of adults using objective clinical indicators and a broader range of determinants are lacking.

Although caries development is primarily related to biological factors that operate directly in the mouth, the importance of social and behavioral determinants for differences in caries at the population level has now been widely recognized. It has been suggested that while biological variables are

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active at one level, there are broader macro-level social settings which mediate the disease process [13,14]. In a risk factor model for dental caries suggested by Petersen [15], distal socio-environmental factors influence more proximal behavioral factors that are associated with dental disease outcomes. However, epidemiological studies that take into account the different levels at which caries determinants operate are scarce [14].

The aim of the present work was to identify non-biological determinants associated with number of sound teeth and presence of decayed surfaces among randomly selected 35-year-old Oslo citizens, determinants accounting for the hierarchical relationship between the independent variables used in the analyses.

Material and methods

The present study was based on data from a cross-sectional epidemiologic study on dental health conditions among 35-year-olds in Oslo in 2003. The study aimed primarily at describing dental health trends in a 30-year perspective by comparing the present study data with available data from similar studies in 1973, 1984, and 1993. These results have been published previously [3]. As a secondary analysis, the data from the 2003 study were further used to identify dental health determinants in this population.

In 2003, a random sample of 250 thirty-five-year-olds was drawn from the National Bureau of Statistics Recordings. As 18 of the individuals were excluded because of a change of address or temporary residence abroad, the sample comprised 232 eligible individuals who were invited to participate. Approval for the study was obtained from the Regional Committee for Medical Research Ethics, Norway. Of the 232 individuals selected, 149 attended the study (response rate 64%). Fifty-six (68%) of the 83 non-attenders were contacted by telephone and asked to indicate their reason for not attending the study. The main reasons reported among men ($n=20$) were lack of time (60%) and lack of interest (30%). Women ($n=36$) reported pregnancy/maternity (31%), lack of time (31%), and dental fear (11%) as the main reasons for non-attendance. In addition, 44 (53%) of the contacted non-attenders agreed to be briefly interviewed about their education, dentist-visiting habits, toothbrushing, and smoking habits. Comparison between the interviewed non-attenders and the study participants demonstrated that there was a higher proportion of women and twice as many smokers in the non-attenders group. A slightly higher number of the study participants visited their dentist regularly; however, there were more non-attenders who visited their dentist during the past year. Compared with the general population of 35-year-old Oslo citizens, participants with higher education were slightly overrepresented in the study [3].

Data-collection included clinical and radiographic examination of the participants and self-administered questionnaires. Dental caries was registered clinically and radiographically at the surface level and recorded as decayed, missing, and filled surfaces/teeth (DMFS/T). Clinically visible caries was registered at the cavitation level following the World Health Organization (WHO) criteria for caries diagnosis [16], and one examiner conducted the examination. In order to control intra-examiner consistency in clinical caries registration, 738 surfaces in 6 individuals were examined twice. The kappa value for intra-examiner agreement was 0.97.

Four bitewing radiographs, one for the premolar and one for the molar area, were taken using Kwik-bite film holders (Hawe Neos Dental, Switzerland), Insight film (Eastman-Kodak, Rochester, N.Y., USA), and a Siemens X-ray unit (Siemens, Erlangen, Germany). Caries was registered from bitewing radiographs independently by three examiners using standardized conditions. All lesions seen radiographically on the proximal tooth surfaces were registered and recorded as enamel caries, enamel and dentine caries, or recurrent caries [17]. Caries was registered as present only if it was recorded by at least two examiners. Inter-examiner agreements for caries scoring from radiographs gave kappa values from 0.67 to 0.76.

Participants completed a structured questionnaire designed to assess socio-demographic and behavioral variables relevant to dental health. Region of birth was recorded and defined as born in Norway, Western, and non-Western countries. As defined by Statistics Norway [18], the participants from non-Western countries were from Asia (including Turkey), Africa, South and Central America, and Eastern Europe. Dental anxiety was assessed using the Dental Anxiety Scale (DAS) [19], which contains four multiple-choice items dealing with patients' reactions to dental treatment. The sum of DAS scores can range from 4 (no fear) to 20 (high fear). For statistical analyses, the dichotomous variable was constructed based on low (DAS <13) and high dental anxiety scores (DAS ≥ 13), as suggested by Corah et al. [20]. Smoking habits were assessed in three categories – non-smoker, former smoker, and present smoker. For regression analysis, the smoking variable was transformed into multiple dichotomous variables with non-smokers as the reference group. All the independent variables and their categories are presented in Table I.

Statistical analysis

Sound teeth (ST) and decayed surfaces (DS) were used as dependent variables. Initial data analysis included assessment of variable distribution and

Table I. Proportion of persons with decayed surfaces ($D_3S \geq 2$) and the mean number of sound teeth (ST) in relation to selected variables.

Variable	Categories	N (%)	% $D_3S \geq 2$	Sound teeth Mean (SD)
Gender	Male	89 (60%)	26	17.2 (5.9)
	Female	60 (40%)	25	17.1 (5.1)
Marital status	Married/partner	106 (71%)	26	16.3 (5.6)
	Single	43 (29%)	26	19.2 (5.1)**
Region of birth	Norway	111 (75%)	21	16.2 (5.2)
	Western countries	15 (10%)	20	17.1 (5.2)
	Non-Western countries	23 (15%)	52**	21.4 (5.7)**
Education	No university	57 (38%)	37	17.1 (6.3)
	University	92 (62%)	19**	17.1 (5.1)
Family income (NOK/year)	≤299.000 (low)	34 (23%)	50	19.6 (5.5)
	300–599.000 (medium)	56 (38%)	14	16.8 (5.0)
	≥600.000 (high)	59 (39%)	22**	16.0 (5.8)**
Dental anxiety score	Low	136 (91%)	24	17.4 (5.5)
	High	13 (9%)	46*	14.6 (6.1)*
Toothbrushing frequency	Once a day or less	28 (19%)	39	17.8 (6.5)
	More than once a day	121 (81%)	22*	17.0 (5.4)
Use of dental floss	Seldom	116 (78%)	27	17.0 (5.7)
	Daily or several times a week	32 (22%)	22	17.8 (5.3)
Dental visits	Regular	108 (73%)	15	16.9 (5.5)
	Irregular	41 (27%)	54**	17.7 (5.9)
Time since previous dental visit	≤1 year ago	84 (56%)	18	16.5 (5.5)
	>1 year ago	65 (44%)	35**	18.0 (5.6)*
Smoking	Non-smoker	86 (58%)	14	17.5 (5.6)
	Former smoker	31 (21%)	32	16.0 (5.1)
	Smoker	32 (21%)	50**	17.4 (6.0)

**$p < 0.05$; *$p < 0.20$

bivariate analysis in order to identify significant relationships between independent and outcome variables, i.e. using the *t*-test and ANOVA for continuous variables and the Chi-square test for categorical variables. The correlation matrix for these variables was calculated in order to check the independent variables for multicollinearity. Since all of the pairwise correlations were <0.7, the absence of multicollinearity appeared to be confirmed [21].

Linear regression analysis was used to assess the association between the ST variable and selected independent variables. The DS variable, chosen as a second outcome variable, was treated as dichotomous in further analyses because of its skewness. The presence of two or more dentine caries lesions ($D_3S \geq 2$) was considered to be an indication of recent disease. Variables that could be associated with the presence or absence of decayed surfaces were assessed by logistic regression analysis.

Regression analysis was performed taking the hierarchical relationships between the independent variables into account (Figure 1). Background variables were considered as block I variables. Block II variables comprised behavioral variables, which were assumed to be partly determined by level I variables. Consequently, all the independent variables were entered in the analysis in a predetermined order. First, all the background variables associated with the outcome in bivariate analyses at *p*-value <0.20 were entered and block I regression was analysed. An exception was made for education in ST regression, which was included in the analysis as a relevant but bivariately non-significant variable. Variables with the highest *p*-value were then removed from the analyses using one-by-one manual backward elimination until all the remaining variables were statistically significant ($p<0.05$). In the block II regression, all behavioral variables were entered in the analyses while controlling for the effect of the distant variables. Similarly, as stated above, non-significant variables were removed from the model.

The data were analyzed using the SPSS statistical program package (SPSS for Windows v. 16.0, Chicago, Ill., USA).

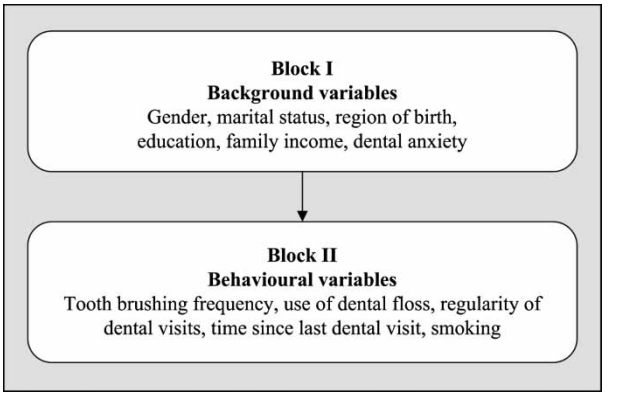

Figure 1. Hierarchical blocks of independent variables in the study.

Results

The descriptive results of the present study show that the dental health of 35-year-olds was generally good. On average, 35-year-olds had 17.1 (SD = 5.6) sound teeth (ST) without any caries or treatment (range 0–28 teeth). The mean DMFS of the participants was 24.6 and DS was low (mean DS = 1.5, SD = 3.8). The frequency distribution of DS scores revealed that 50% of the participants had no decayed surfaces, 44% had at least one dentine caries surface, and 26% had two or more dentine caries surfaces. Filled surfaces (FS) constituted a major part of the DMFS index.

A majority of the participants (81%) brushed their teeth more than once a day, but only 22% reported using dental floss daily or several times a week. Moreover, 73% reported regular dental visits and 56% having visited a dentist less than a year previously.

Bivariate analyses revealed that region of birth, marital status, together with family income, were all significantly associated with number of sound teeth. Single participants and those born in non-Western countries had a significantly higher mean number of sound teeth, as well as participants with a low family income. In addition, low dental anxiety scores and >1 year since the previous dental visit showed a trend of association with higher numbers of sound teeth (Table I).

The results of hierarchical linear regression analysis for factors associated with number of sound teeth are presented in Table II. First, all the bivariately significant background (block I) variables were entered in the analysis. After elimination of the variables with the highest *p*-value, non-Western region of birth, being single, and university education were the three background variables significantly associated with number of sound teeth. These explained 17% of the variation in the number of sound teeth.

When time since the last dental visit variable from the block of behavioural variables was entered in the analyses, together with the background variables in the block II analyses, it did not contribute significantly after controlling for the effect of significant background variables.

Thirty-eight participants (26%) had two or more dentine caries lesions ($D_3S \geq 2$). Bivariately, non-Western region of birth, lower income and education group, being a former or present smoker, visiting the dentist irregularly, and >1 year since the previous dental visit were significantly and positively associated with presence of $D_3S \geq 2$ (Table I). At the same time, high dental anxiety scores and infrequent toothbrushing showed a tendency of association with higher frequency of decayed teeth.

Results from the hierarchical logistic regression analysis are presented in Table III. First, the association of significant background variables ($p < 0.2$) with the presence of decayed surfaces was assessed (block I). When variables with the highest *p*-values were removed one by one from the analysis, low income was the only background variable significantly associated with the presence of decayed surfaces, indicating a much higher frequency of untreated caries among those with low family income (OR = 4.5, CI (1.9; 10.2)). After the significant behavioral variables were entered in regression analyses (block II), the effect of income became non-significant, indicating that effect has probably been mediated through behavioral variables. When the variables with highest *p*-values were removed from the analyses, being a present or former smoker and irregular dental user were determinants associated with $D_3S \geq 2$.

Discussion

The present study focuses on identifying determinants associated with sound teeth and decayed surfaces in a random sample of 35-year-olds in Oslo. Determinants associated with health and disease in the present study were different, emphasizing the notion that sound teeth (health) and untreated decay (disease) represent two different dimensions.

The number of sound teeth was chosen as the outcome variable representing the health dimension that develops through life, while the presence of decayed surfaces was chosen as a measure reflecting

Table II. Factors associated with the number of sound teeth (ST). Hierarchical linear regression analysis.

	Block I		Block II	
Variable	Beta	*p*-value	Beta	*p*-value
Marital status: single versus married/partner	0.245	0.004	0.251	0.001
Region of birth: non-Western versus other	0.388	0.000	0.381	0.000
Education: university versus other	0.149	0.093	0.181	0.028
Family income: low versus medium/high	0.004	0.968		
Dental anxiety score: high versus low	−0.093	0.237		
Previous dental visit: >1 year ago versus other			0.059	0.455
Model summary	Adj. $R^2 = 0.172$		Adj. $R^2 = 0.173$	

Table III. Factors associated with the presence of $D_3S \geq 2$. Hierarchical logistic regression analysis.

Variable	Block I		Block II	
	Odds ratio	95% CI	Odds ratio	95% CI
Region of birth: non-Western versus other	1.9	(0.6; 6.7)		
Education: university versus other	0.8	(0.3; 2.1)		
Family income: low versus medium/high	2.7	(0.9; 8.1)	2.1	(0.8; 5.8)
Dental anxiety score: high versus low	2.4	(0.7; 8.6)		
Toothbrushing frequency: more than once a day versus other			0.6	(0.2; 1.6)
Dental visits: irregular versus regular			4.1	(1.5; 11.4)
Previous dental visit: >1 year ago versus other			1.0	(0.4; 2.6)
Smoking (reference: non-smoker)				
Smoker			4.5	(1.6; 12.6)
Former smoker			2.8	(1.0; 8.2)
Model summary	Nagelkerke R^2 =0.151		Nagelkerke R^2 =0.317	

current presence of disease. Although the DMF index has been most extensively used as a dental caries measure, for adults it is largely affected by treatment history. In the light of changing disease patterns during past decades and the minimal invasive treatment philosophy, the focus on health has become increasingly relevant. FST (functional sound teeth) has been suggested by Sheiham et al. [22] as an alternative index to DMFT; however, this index was not suitable in our study because the variation in the FST scores was minimal. Although number of sound teeth, as other dental health indicators, can also be affected by treatment philosophy, the ST variable was chosen because of considerable variation and its normal distribution. It could be argued that when a long-term result of disease is considered, missing teeth might be an important dental disease measure. However, in the present study more than half of all missing teeth were missing for reasons other than caries (orthodontics, congenitally missing teeth, and dental trauma) and therefore alternative parameters had to be chosen.

The decayed surfaces variable was chosen as a second outcome variable in order to represent a proximal outcome of caries experience. The variable was dichotomized because of skewness. Since caries treatment strategies have become less interventional in recent decades [23], participants with two or more dentine lesions were chosen to represent the group with untreated disease. The number of participants above this cut-off point ($D_3S \geq 2$) was also appropriate for statistical analysis; with a higher cut-off point ($D_3S \geq 3$), the disease group would be too small for analysis.

In our study, non-Western country of birth, being single, and having a university education were positively associated with higher number of sound teeth. The finding that a higher educational level was related to more favorable dental health is in concert with the results of several other studies [8,24–26]. It has been suggested that high educational attainment improves health both directly and indirectly, i.e. through work and economic conditions, social-psychological resources, and healthy lifestyle [27].

The association between a higher number of sound teeth and being single was unexpected. In the literature, marital status has been related to better general health due to healthier behavior and social support [28]. There are no specific mechanisms describing how marital status influences dental health, and the impact of marital status on dental health reported in different studies is contradictory. While a significantly higher caries incidence rate has been reported for married compared to unmarried 50–64 year-olds by Hawkins et al. in Canada [29], Turunen et al. in Finland showed that poor dental health is associated with living alone [24]. Since the participants in our study were relatively young and their time married or cohabiting could be rather short, it is difficult to find a sensible explanation for this association.

From all socio-demographic variables assessed in the present study, non-Western region of birth was the indicator most strongly associated with number of sound teeth. Low caries experience among adult immigrants from developing countries has been reported previously [30,31]. Although this group was quite small ($n=23$) and heterogeneous in our study, participants from a non-Western background obviously had different dental health patterns compared to the others. Stratified analyses which could reveal relevant determinants in this group were not possible due to the small sample size.

Decayed surfaces in dentine were chosen as a second outcome variable. This variable was dichotomized because of skewness, and having two or more dentine caries surfaces was considered an indication of the presence of untreated disease. Bivariately, both education and family income variables were associated with presence of decayed surfaces, and

participants with lower family income and lower education more often had untreated disease. This finding could indicate the presence of social differences in relation to untreated caries among 35-year-olds in Oslo. However, in multivariate analyses, only association between caries and low family income remained significant. Moreover, the contribution of income became non-significant when behavioral variables were entered in the model. It appeared that irregular dental visits attenuated the effect of income, i.e. the largest part of the effect that low income has on decayed teeth seems to be mediated through irregular dental visits. After adjustment for socio-demographic variables, behavioral factors (smoking and irregular dental visits) contributed significantly in explaining the presence of decayed surfaces. An association between smoking and caries has been reported previously [32–34]. Since there is little evidence of a biologic mechanism explaining the role of smoking on caries, an indirect explanation, e.g. differences in oral care behavior between smokers and non-smokers, is more likely [35].

Although there were more than twice as many non-Western participants with two or more D_3S compared to the others, this association disappeared in multivariate analyses controlling for low family income. One possible explanation could be that the majority in this group reported low family income, which again seemed to be associated with irregular dental visits.

When multivariate regression analyses were performed only on participants born in Norway (data not shown), the impact from income and education observed in the entire sample became non-significant. Higher number of sound teeth was associated with being single and having low dental anxiety scores, while presence of dentine caries was associated with being present or former smoker as well as having high dental anxiety scores. This may indicate that dental anxiety appeared to be a stronger determinant than social variables in the Norwegian group. The association between dental anxiety and poor dental health has been reported previously in several studies [10,36,37]. Dental anxiety has been shown to be related to less frequent dental visits and symptomatic dental visiting patterns [38]. In the present study, 69% of the participants with high anxiety scores were irregular dental users and 23% had visited a dentist during the past year. These findings may suggest that for young adults representing the fluoride generation and receiving regular dental care through their life, dental anxiety may be an important dental disease determinant.

Our sample of 35-year-olds may be considered representative of this age cohort among Oslo citizens. However, owing to the higher proportion of participants with high education compared to the general population of 35-year-olds in Oslo, some underestimation of caries prevalence is likely [3]. A higher proportion of smokers and irregular dental users among the non-attenders could further bias the results towards underestimation, since both smoking and irregular dental visits are important determinants for the presence of caries. On the other hand, when examining associations between the variables, this should not interfere with the importance of the association as such.

The relatively small sample size is a limitation in the present study and therefore some associations might be non-significant because of the small number of participants. Power analysis calculations for the least detectable difference in the mean number of sound teeth between non-Western participants and the rest of the sample demonstrated that in order to have 80% test power the true difference in the mean values between the groups must be at least 3.6. This was also the case with the dental anxiety variable, which showed a tendency toward association in bivariate and multivariate analyses of the entire sample but did not reach statistical significance. This illustrates the limitations that sample size sets on the interpretation of identified non-significant associations. On the other hand, studies using clinical data from randomly selected adults of working–age are relatively rare in the dental literature. Therefore, the present study may give some indication of the factors related to variations in dental health and disease in an adult working-age population. However, the cross-sectional design precludes any causal interpretations of the observed associations.

A hierarchical approach was chosen in the present study when performing multivariate analyses. This was done under the assumption that the determinants chosen in the study operated at different levels. The approach allowed quantification of the contribution of variables at each level of adjustment and showed how determinants at different levels could interact with each other [39]. In the present study, the effect of background variables seemed to be mediated through behavioral determinants. Obviously, this approach would have profited from a larger sample size and a higher number of potential determinants.

The results of the present study indicate that education, region of birth, and marital status are associated with number of sound teeth. For presence of untreated decay, important determinants were low family income, smoking, and irregular dental visits.

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