

Prevalence of dental caries among 16-year-olds in Troms County, Northern Norway

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Abstract

© The investigation documents caries prevalence and associated factors in a sample of 16-year-olds from Troms County, Northern Norway. DMFT/S-values were 4.2/6.1, indicating dental health being similar to the south of Norway and the rest of Scandinavia. No ethnic differences were recorded. Out of a total of 22 tested variables, the following nine showed an independent strong association ($p=0,001$) with prevalence of dental caries: parental education, tooth brushing frequency, parental control of oral hygiene in young age, dental fear, self-rated dental health, BMI, self-rated general health, use of smokeless tobacco, and initial approximal caries. The final multivariate regression analysis indicated that use of smokeless tobacco, dental fear, self-rated dental health and initial approximal caries showed a strong independent association with prevalence of manifest dental caries. In addition, parental education and sugar consumption appeared to be of importance. Sedentary lifestyle with low level of physical activity or hours spent in front of a TV/computer screen did not show any correlation with prevalence of dental caries. Tooth brushing frequency, gingival bleeding, obesity and aspects of general health showed a strong bi-variate association that disappeared when controlling for other variables in a multivariate regression model. The results highlight the importance of including attitude and lifestyle modifiable factors in oral and general health education approaches. Additionally, focus should be set on the management of dental fear in the context of targeted oral health strategies. Finally, it would be beneficial to include initial approximal caries, life style factors, and perception and attitudes to general as well as dental health in caries prediction models.

Key words

Dental caries, adolescents, oral health, initial approximal caries

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Kariesförekomst hos 16-åringar i Troms fylke, nord-Norge

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Sammanfattning

⊙ Avsikten med denna studie var att beskriva tandhälsan hos 16-åringar i nord-Norge och relatera den till allmänhälsa, livsstil och hälsoattityder. Studien är en ungdomsdel av ett fortlöpande medicinskt epidemiologisk forskningsprojekt som har pågått sedan 1974 och där odontologiskt deltagande nu ingick för första gången. En allmän uppfattning är att, i jämförelse med övriga Norge och Skandinavien i stort, såväl allmänhälsa som tandhälsa generellt är sämre i nord-Norge och kanske speciellt för den etniska minoritet som den samiska populationen utgör. Samtliga 1301 ungdomar i första klass på gymnasiet i två kommuner i Troms fylke inviterades. Av dessa valde 1010 (78 %) att delta varav de 869 som var födda 1994 inkluderades i denna studie. Från september 2010 till maj 2011 genomfördes en fullständig klinisk undersökning, kompletterad med "bite-wings", studiemodeller och intraorala foton. Dessutom genomfördes en medicinsk undersökning och två omfattande frågeformulär besvarades. De innefattade tand- och allmänhälsa, socio-demografi, livsstil, kunskaper och attityder.

Ett DMFS-medelvärde på 6,1 hos dessa 869 16-åringar antyder klart att tandhälsan i nord-Norge närmar sig samma nivå som övriga Norge (Skandinavien) och resultaten kunde inte påvisa några etniska skillnader i tandhälsa. Av totalt 22 testade oberoende variabler (omfattande socio-demografi, livsstil, allmänhälsa, tandhälsa, uppfattningar och attityder till tand- och allmänhälsa) uppvisade följande 9 ett signifikant samband med DMFS på högsta nivå ($p=0,001$): föräldrars utbildningsnivå, tandborstningsfrekvens, föräldrars hjälp och kontroll vid tandborstning i unga år, tandvårdsrädsla, självuppfattad tandhälsa, BMI, självuppfattad allmänhälsa, bruk av snus och antal initiala approximala kariesangrepp. Den slutgiltiga multivariata regressionsanalysen indikerar att bruk av snus, tandvårdsrädsla, självuppfattad tandhälsa och initiala kariesskador visade ett oberoende starkt samband med prevalens av karies. Dessutom syntes föräldrars utbildningsnivå och sockerkonsumtion vara av betydelse. Resultaten från denna studie indikerar betydelsen av att inkludera livsstilsfaktorer tillsammans med uppfattningar och attityder till vård och hälsa när nya tandhälsostراتيجier utformas.

Introduction

Over the last 40 years there has been a marked improvement in dental caries status in developed countries (25, 28). In the Nordic countries, a reduction in average DMFT-scores during that period is well documented both for children and adolescents (5, 13, 37). In Norway, national data on caries experience recorded at dentin level (DMFT) for age groups 5, 12 and 18 have been collected annually at county level since 1985 (23). These data confirm the internationally reported decrease in caries prevalence.

This positive development is, however, not shared by all. Many risk factors for the development of caries are well known although caries etiology is complex and to some extent still not fully understood. Dental health varies with socio-economic background and dental caries still remains high in risk groups (17). Parental migration and immigrant background are associated with higher risk for caries in children and adolescents (18, 39). Furthermore, higher caries prevalence has been reported for children and adolescents in Northern Norway compared with the rest of the country (23, 38). Compiled national data on caries among adolescents with Sami background are lacking.

As the prevalence of manifest caries has declined, initial enamel caries has received increased focus in order to give a comprehensive picture of dental health in children and adolescents and consequently a better picture of the complete need for dental treatment including non-operative as well as operative treatment (14). Initial caries is, however, not included in the Official Statistics of Norway (33). It is therefore considered of interest to record initial caries and compare the prevalence of initial and manifest (DMFT/S) caries and how the DMFT/S index will vary according to the threshold used (32). Based on this background information, the aims of the present investigation were:

To record the prevalence of initial and manifest dental caries in a sample of 16-year-olds in Troms County, Northern Norway

To investigate if adolescents with immigrant or Sami background present with higher caries scores

To examine variation in caries prevalence related to selected, independent variables including lifestyle, oral health attitudes and perceptions, oral health parameters and general health.

Material and Methods

The present cross-sectional oral health study, carried out from September 2010 to May 2011, was part

of a larger epidemiological general health project, Tromsø epidemiological study (15, 40). All first year high-school students in Tromsø city (7 schools) and Balsfjord municipality (1 school), both located in Troms county, Northern Norway, were invited. Of a total of 1301 registered students, 1010 volunteered to participate in the oral part (78% attendance rate). Out of these 1010 students, all subjects born in 1994 (869) were included in the present analysis.

Recruitment took place at the schools and information was presented orally, electronically and by distributing a brochure for students and parents/guardians. Students interested in attending confirmed on internet by a link sent to their personal e-mail address and signed a written consent on arrival for the examination. In order to obtain a high participation rate, the survey was conducted during school hours. The participants were transported from the schools to the examination stations at the university by mini-buses, and a 200 NOK (35 \$ US) bonus check was handed out.

The project was approved by the Regional Committee for Medical Research Ethics (2012/1197 REK Nord) and the Norwegian Data Protection Authority (07/00886-11).

The oral health part of the study included a clinical examination and two bite-wing radiographs, impressions of the upper and lower jaws, eight intraoral clinical photographs and a questionnaire. The oral examination was performed at the University Dental Clinic, The Arctic University of Norway, Tromsø, and was carried out by an experienced dentist (IDJ) assisted by dental assistants. The clinical examination replaced the annual dental examination at The Public Dental Health Service (PDHS).

The variables used in the present study are shown in Table 1. Approximal caries was assessed radiographically and scored according to a scale 1 – 5 for increasing depth of radiolucency. Occlusal lesions were diagnosed and scored in a similar 5 graded scale with a combination of clinical and radiographic criteria, while buccal and lingual caries were diagnosed and scored in a 5 graded scale based on clinical criteria only (1). Grade 3, 4 and 5 lesions reaching into dentine (manifest lesions) were included in the DMF-scores, while grade 1 and 2 (enamel lesions) were assigned to initial caries and not included in the DMF-scores. The DMF index values were calculated by adding all “decayed”, “missing” and “filled” (due to caries) permanent teeth/surfaces. For initial caries, only approximal lesions registered from bite-wing radiographs were used as an independent vari-

© **Table 1.** Characteristics of the study population with regard to DMFS index values used as a continuous variable. Bi-variate analysis of variation (ANOVA) Study population: n = 869, mean DMFT/S = 4.16/6.09 (SD = 6.88)

Independent variables					
Socio-demographic		N (%)	DFMS mean	SD	P value
gender	male	449 (51.7)	5.79	6.93	0.189
	female	420 (48.3)	6.40	6.82	
ethnicity	Norwegian	715 (82.3)	6.12	6.96	0.892
	Sami	31 (3.6)	5.52	4.76	
father's education	immigrants	114 (13.1)	6.13	6.79	0.004
	college	287 (33.0)	4.90	5.98	
	high school	247 (28.4)	6.61	6.89	
mother's education	9 years or less	70 (8.1)	7.16	7.55	0.040
	don't know	237 (27.3)	6.64	7.52	
	college	363 (41.8)	5.32	6.07	
parents attended college/university	high school	231 (26.6)	6.49	6.80	0.001
	9 years or less	47 (5.4)	7.21	7.87	
	don't know	213 (24.5)	6.7	7.90	
family parental status	both	208 (23.9)	4.54	5.50	0.002
	one	234 (26.9)	6.19	6.77	
	none	239 (27.5)	7.23	7.51	
family parental status	don't know	188 (21.6)	6.21	7.29	0.002
	both parents	463 (53.3)	5.33	5.90	
	one parent	235 (27.0)	6.81	8.25	
family parental status	none of parents	162 (18.6)	7.25	7.00	0.002
	one parent	235 (27.0)	6.81	8.25	
	none of parents	162 (18.6)	7.25	7.00	
Lifestyle					
smoking	no	772 (88.8)	5.88	6.72	0.009
	yes	86 (9.9)	7.92	7.79	
snuff use	no	617 (71.0)	5.37	6.45	0.001
	yes	241 (27.7)	7.91	7.52	
sugar consumption	low	744 (85.6)	5.77	6.69	0.002
	high	107 (12.3)	7.95	7.06	
physical activity (intensity)	high	176 (20.3)	5.72	6.96	0.225
	moderate	234 (26.9)	5.97	6.85	
	low	272 (31.3)	5.84	6.01	
physical activity (frequency)	sedentary	178 (20.5)	7.04	7.93	0.298
	≥ 4 days/week	224 (25.8)	5.50	6.60	
	2-3 days/week	293 (33.7)	6.19	6.95	
leisure screen time (weekdays)	≤ 1 day/week	341 (39.2)	6.41	6.99	0.584
	<4 hours/day	514 (59.1)	5.99	6.88	
leisure screen time (weekends)	≥4 hours/day	344 (39.6)	6.25	6.88	0.090
	<4 hours/day	353 (40.6)	5.63	6.54	
	≥4 hours/day	503 (57.9)	6.44	7.09	0.090

© Table 1. Continuation.

Independent variables					
Socio-demographic		N (%)	DFMS mean	SD	P value
Dental health related perceptions and attitudes					
Tooth-brushing frequency	twice or more daily	555 (63.9)	5.28	6.12	0.001
	once daily	198 (22.8)	6.64	7.57	
	less than once daily	103 (11.9)	9.18	7.91	
parental control of oral hygiene	yes	698 (80.3)	5.70	6.61	0.001
	no	164 (18.9)	7.65	7.51	
dental fear	no	801 (92.2)	5.71	6.63	0.001
	yes	56 (6.4)	11.02	7.73	
self-rated dental health	very good, good	493 (56.7)	4.44	5.69	0.001
	neither good nor bad	292 (33.6)	7.29	6.81	
	bad, very bad	77 (8.9)	11.90	9.17	
Dental health parameters					
initial approximal caries	<6	482 (55.5)	3.81	5.14	0.001
	≥6	387 (44.5)	8.92	7.68	
number of teeth with gingival bleeding	<4	148 (17.1)	5.05	5.30	0.017
	≥4	718 (82.6)	6.28	7.15	
General health status					
BMI	normal weight	620 (71.3)	5.63	6.56	0.001
	underweight	50 (5.8)	5.02	5.21	
	overweight	139 (16.0)	7.55	7.94	
chronic diseases/allergy	obese	59 (6.8)	8.44	7.88	0.255
	no	621 (71.5)	5.92	6.84	
self-rated general health	yes	245 (28.2)	6.51	7.00	0.001
	very good, good	635 (73.1)	5.51	6.39	
	neither good nor bad	180 (20.7)	7.43	7.47	
	bad, very bad	41 (4.7)	9.56	9.40	

able in the present analyses.

Periodontal status was measured according to the Community Periodontal Index for Treatment Needs (CPITN) index system. Due to low age of the participants, a simplified version including only six index teeth (16, 11, 26, 36, 31 and 46) was used (41). The scores registered were: number of teeth with presence of gingival bleeding and number of teeth with periodontal pockets 4-5mm or >5mm.

Body mass index was calculated by the formula weight/height². The adolescents were classified into four groups (underweight / normal weight / overweight / obese), according to the Extended Interna-

tional Body Mass Index by Cole and Lobstein (7).

The participants answered two closed questionnaires. One included questions concerning oral hygiene habits and oral health knowledge and attitudes as well as how they perceived parents (or guardians) dental health-related attitudes. The other questionnaire was covering family demographics, current psychological and physical health status, pain, medication, dietary habits and information on lifestyle.

Ethnicity was classified as being Norwegian, Sami or immigrant. Immigrants of Western or non-Western (countries outside EU, North America, Australia and New Zealand) background were identified.

Parents educational level was stratified according to years of schooling as: low (0-9 years), medium (high school or equal) and high (college or university). Family structure was identified based on living with both, one or none of the biological parents. Lifestyle habits covered use of snuff, smoking, sugar consumption, physical activity and time in front of the TV/computer screen. Sugar consumption was based on intake frequency of sweets and soft drinks with sugar. Scores were recorded for the two items in a scale from 1 (minimal - no consumption) to 5 (maximal consumption). The 9 resulting groups based on a combined score for sugar intake were further merged into 2 groups: score 2-6 (low)/score 7-10 (high).

Physical activity (frequency and intensity), based on participants' leisure activities, was registered and graded as sedentary, low, moderate or high. Frequency of actively doing sports or physical activities outside school hours was recorded in a 6-interval scale from "never" to "almost every day". The 6 categories were further converted into three (≤ 1 day a week, 2-3 days a week or ≥ 4 days a week). Time in front of a TV/computer screen was recorded for weekdays and weekends in a 7-graded scale from "none" to ≥ 10 hours/day and dichotomized in < 4 hours/day or ≥ 4 hours/day.

Information on dental health-related variables such as tooth-brushing frequency, parentally controlled oral hygiene and self-rated oral health were also recorded. The students reported whether their parents/caregivers supervised their tooth-brushing in young age recorded in "yes" or "no". Tooth-brushing frequency was given in a 6-graded scale from less than once a week to ≥ 2 times a day. Dental fear was measured based on missed dental appointments due to fear and recorded as "yes" or "no".

Self-rating of dental and general health were classified as "good" or "neither good nor bad" or "bad". In addition, chronic diseases including allergy-related conditions were registered.

Calibration

The principal examiner (IDJ) was calibrated with two experienced dentists. For calculation of inter-observer agreement regarding radiographic examination, BW-radiographs from 88 patients (10% of the study sample) were randomly selected. The three dentists independently examined the approximal surfaces from mesial surface of second molar to the mesial surface of first premolar in each quadrant, altogether 28 surfaces per patient, making a

total of 2464 surfaces and scored them in a scale of 0 (no finding) 1, 2 (enamel caries) 3, 4, 5 (dental caries). On average, the calculated kappa value between recordings of three examiners, was 0.61 (0.71). The linear weighted kappa score is given in parenthesis. Weighted kappa values are higher because some credit is given for differences in recordings when scores are close to each other. Kappa values were calculated by the statistical software MedCalc® version 12.4.0.0 (Ostend, Belgium). Intra-examiner agreement was also calculated between the two registrations of the principal examiner. Kappa value was 0.58 (0.63) comparing all grades and increased to 0.70 when all positive caries scored were pooled into one category (dichotomized). Corresponding calculation based on dichotomized scores for the BW examinations of 88 patients by three observers, showed a kappa value of 0.69.

Data Analysis

All statistical analyses were performed using SPSS 22.0. Students t-test and ANOVA were applied to test differences between groups using DMFS-scores as a continuous dependent variable. The DMFS-scores were then dichotomized at the mean and all independent variables with p-value ≤ 0.05 in the bivariate test (Table 1) were selected to be included in a multivariate regression model (parental education level was used instead of father's and mother's separately). A p-value ≤ 0.05 was considered statistically significant.

Results

Dependent variable - dental caries

The prevalence of dental caries according to the DMF-index was 82.7% in this sample of 16-year-olds. The distribution was highly skewed (skewness = 2.036). Mean DMFT of the sample was 4.16 (± 3.78), range 0-19, while a mean DMFT > 9 was recorded for 9.8%. Mean DMFS was 6.09 \pm 6.88, (range 0-48). For further details, see Table 1.

Independent variables

Socio-demographic

Boys had lower DMFS scores than girls but the difference was not statistically significant (Table 1). Norwegian adolescents constituted a majority of our sample (82.3%) with adolescents of immigrant or Sami background representing 13.1% and 3.6% respectively. There was no statistically significant difference in DMFS score between Norwegian and adolescents with immigrant or Sami background.

© **Table 2.** Multivariate logistic regression analysis including factors with p-values ≤ 0.05 from the bi-variate analysis (Table 1) included in the final model. DMFS-scores are dichotomized with cut-off point DMFS = 6.

Independent variables		Bi-variate p value	Multivariate OR (95% CI)	Multivariate p value
parents attended college/university	both	P = 0.001		P = 0.092
	one			
	none			
parental family status	don't know	P = 0.002		P = 0.133
	both parents			
	one parent			
smoking	no	P = 0.009		P = 0.962
	yes			
snuff use	no	P = 0.001	1	P = 0.010
	yes			
sugar consumption	low	P = 0.002	1.57 (1.12-2.21)	P = 0.084
	high			
tooth-brushing frequency	twice or more daily	P = 0.001		P = 0.798
	once daily			
	less than once daily			
parental control of oral hygiene	yes	P = 0.001		P = 0.222
	no			
dental fear	no	P = 0.001	1	P = 0.001
	yes			
self-rated dental health	very good, good	P = 0.001	1	P = 0.001
	average			
	bad, very bad			
initial approximal caries	<6	P = 0.001	1	P = 0.001
	≥ 6			
teeth with gingival bleeding	<4	P = 0.017	3.25 (2.39-4.43)	P = 0.553
	≥ 4			
BMI	normal weight	P = 0.001		P = 0.623
	underweight			
	overweight			
	obese			
self-rated general health	very good, good	P = 0.001		P = 0.734
	average			
	bad, very bad			

Adolescents where both parents had either college or university education had lower caries score compared to those having one or none of the parents with high education. Adolescents living with both parents had lower DMFS-score compared to those living with one or none of their biological parents. Recordings regarding these two parameters showed statistically significantly different values (Table 1).
Lifestyle

About 10 % of the adolescents reported to smoke

while 28 % reported regular use of snuff. Both groups of tobacco users had significantly higher caries score than non-users (Table 1). More boys than girls reported regular use of tobacco (12.4% vs 7.5% for smoking and 34% vs 21.8% for use of snuff). Regarding sugar intake, 12.5% of the adolescents reported frequent consumption. This was significantly associated with higher caries prevalence (Table 1). Frequent sugar consumption was more than twice as common in boys as in girls (17% vs 8%). Intensity

and frequency of physical activity and time spent daily in front of the TV/computer screen during weekdays or weekends were not associated with differences in caries scores (Table 1).

Dental health-related perceptions and attitudes

A majority of girls (80%) were brushing their teeth at least twice a day compared to 50% of the boys. There was a considerable difference in mean DMFS score between the three tooth brushing frequency groups ($p < 0.001$) (Table 1). Over 80% of the parents used to control oral hygiene of their children. These adolescents had significantly lower DMFS scores than adolescents without parental control of oral hygiene ($p = 0.001$) (Table 1).

Dental fear was highly significantly associated with higher mean DMFS scores and adolescents who rated their oral health as bad had almost 3 times higher mean DMFS scores than those who rated their oral health as good ($p < 0.001$) (Table 1).

Dental health parameters

Only 5.6% (49) of the adolescents were recorded completely caries free (DMFS = 0, and no initial approximal lesions), and 11.5 % (101) had only initial approximal lesions. About 23 % (196) had more than 9 surfaces with initial approximal caries. The prevalence of dentinal caries was statistically significantly associated with initial approximal caries scores (Table 1). Number of teeth with gingival bleeding showed an association with caries prevalence in the bi-variate analysis ($p = 0.017$) (Table 1) that disappeared in the multivariate model. Only 2.3% (20) of the participants had periodontal pockets ≥ 4 mm and only one presented with a pocket > 5 mm.

General health

Over 70% (620) of the students had normal weight, while 6.8 % (59) were obese. There was a statistically significant association between BMI and DMFS score ($p = 0.001$) due to higher caries prevalence linked to overweight/obesity (Table 1). Most of the recorded chronic diseases were allergy-related conditions. No association between DMFS scores and chronic diseases was detected. Adolescents who rated their general health as bad had almost 2 times higher mean DMFS scores than those who rated their general health as good ($p < 0.001$).

The final multivariate regression model comprised only the variables snuff use, dental fear, self-rated dental health and initial approximal caries, while the impact of the other selected disappeared

(Table 2) indicating substantial co-variance among the parameters included. However, parents education level and sugar consumption were close to statistical significance. Having ≥ 6 dental surfaces with initial approximal caries increased the chances to have high DMFS scores by O.R. 3.28.

Discussion

In Norway, the dental caries status in children and adolescents is regularly monitored through data collected annually at county level, reported by the PDHS (33). However, these data are collected in patient care settings by non-calibrated dental personnel and the criteria applied are mainly based on evaluation of operative treatment need. This differs from the criteria applied in epidemiological surveys (3). An epidemiological approach is therefore relevant and necessary for proper oral disease surveillance.

Adolescents were included in the latest series of repetitive cross-sectional Tromsø Health Studies (15), named “Fit Futures” (40). This gave a unique opportunity not only to examine the caries status of about 900 16-year-olds from Northern Norway, but also to relate the variation in caries prevalence to numerous variables representing socio-demographic and lifestyle-related factors including dental health perception and attitudes and aspects of general health.

The oral investigation was performed in a clinical setting and the principal investigator (IDJ) was thoroughly calibrated with experienced clinicians reaching acceptable intra- and inter-observer agreement (Kappa=0.63 and 0.71 respectively) securing reliability.

Parametric statistical tests (Students t-test and ANOVA) were applied for descriptive purposes (Table 1) using DMFS scores as a continuous variable. Although the caries data were skewed, these parametric tests are robust and acceptable considering the large number of observations (9). Multivariate regression analyses were used in order to estimate major effects (odds ratio) of selected independent variables (Table 2).

The prevalence of manifest dental caries in our sample of 16-year-olds was 82.7% with a mean DMFT/S of 4.2/6.1. Regarding the previously documented higher caries prevalence in the North of Norway (23, 37) comparable data from the South of Norway are not available due to the age of target groups used by Statistics Norway (5, 12 and 18 years of age). According to data from Statistics Norway (33)

the prevalence of caries-free (DMFT=0) 18-year-old individuals in the South of Norway was 17.5% in 2011. This was almost identical to our finding in 16-year-olds from Troms (17.3%). Furthermore, the mean DMFT score of 18-year-olds from the South of Norway was reported to be 4.4, while in our sample the mean value was 4.2. With the possible impact of methodological differences, the present data was in agreement with other comparable Scandinavian findings (13) and indicate that a regional difference between North and South of Norway is disappearing.

Investigations have documented that immigrant background in general and non-Western background in particular are associated with higher caries prevalence in children and adolescents. (16, 18, 39). In the present study, we did not find a difference in caries prevalence between ethnic 16-year-old Norwegians and 16-year-olds of Western or non-Western immigrant background. Neither was there any difference between ethnic Norwegians and adolescents of Sami background. This might indicate that these groups are well assimilated in society despite some minor socio-demographic differences detected in the study.

Parents socio-economic status was decided based on years of education, as information on parental position/income based on the participants own information was considered uncertain. There was a statistically significant association between parental level of education and DMFS-scores when relevant variables were considered independently. This is in agreement with previous studies (6, 17). However, this association disappeared in the multivariate regression analysis. The high percentage of students who did not report the education level of father (27%) or mother (25%) may represent a knowledge bias contributing to this result.

Regarding family status, living with both parents seems to be beneficial regarding caries status. This is in agreement with the results from other investigations (5, 6, 35). A functioning family environment is found to be associated with positive oral hygiene habits and attitudes, and lower frequency of dental problems among preschool and school children (24) and oral health related behaviors were found to be inferior among adolescents not living with both parents (19). Indeed, in the present study, adolescents living with both parents had fewer missed dental appointments due to dental fear and a lower percentage among them were snuff users or frequent sugar consumers. However, the impact from this variable

disappeared when controlling for other independent variables (Table 2) probably due to free dental treatment with emphasis on prevention up to 18 years of age.

Use of tobacco in general and smokeless tobacco (snuff) in particular show an association with caries prevalence. This is in agreement with the results from some studies (11), but not in agreement with others (12). The anecdotal assumption that snuff might have an antibacterial, caries-preventive effect is not supported. Our findings (Table 2) seem to confirm the argument that smoking is not associated directly with caries but is more a covariate to caries risk factors (2).

Sugar consumption is considered to be among the most important causal factors for dental caries (31). In the present study, the variable "sugar consumption" was a combination of quantity and frequency of consumption of candies and sugar-containing soft drinks. This variable showed a statistically significant association with caries prevalence. However, this association was reduced to a level slightly below the estimated level of significance ($p=0.08$) when included in the multivariate model (Table 2). The last finding may contribute to the discussion concerning the strength of association between high sugar consumption and caries in a modern, fluoride-exposed society (4).

One of our hypotheses was that a sedentary lifestyle possibly facilitate high snack consumption and use of soft drinks associated with higher caries prevalence. However, our results show that intensity and frequency of physical activity or hours spent in front of a TV/PC screen were not associated with caries prevalence.

Tooth-brushing frequency and plaque control are considered to be important caries-etiological factors (17, 22). It is, however, questionable whether these effects are due to plaque control or to fluoride exposure through dentifrices (30). In the present study we found an association between tooth-brushing frequency and caries prevalence that disappeared in the multivariate analysis (Table 2). The same pattern was detected for the impact of parental control of oral hygiene in young age. Gingival bleeding, an indicator of dental cleanliness, also showed a bi-variate association with the DMFS-level which was not confirmed in the multiple regression analysis indicating a high degree of covariance related to tooth-cleaning variables.

Gingival bleeding was very frequently recorded among the adolescents, particularly among males,

in the present investigation. This finding suggests the need for different dental health education approaches in males and females (8, 10). Our finding that a high percentage of the adolescents (about 80%) brushing their teeth at least two times a day presented with gingival bleeding, may indicate the need for preventive measures (10, 20).

The strong association between self-rated dental health and DMFS-scores indicates that 16-year-olds have a reliable concept of own oral health conditions (35). The strong association between dental fear and dental caries prevalence, was expected (17, 34). Frequently missing dental appointments due to dental fear is considered a caries predictor in caries prediction models (29).

Initial approximal dental caries was found to be strongly associated with prevalence of manifest caries. This is in agreement with previous findings (14, 26, 27, 42) and indicates that number of initial lesions might be an important predictor for further progression.

Our findings indicate that extreme overweight (obesity) might be a caries risk factor while underweight did not show any association with caries prevalence. However, the variable did not enter the final multivariate model (Table 2). Finally, our results could not demonstrate any association between chronic diseases/allergy and dental caries, while self-rated general health showed an impact that disappeared in the multivariate model (Table 2).

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