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ORIGINAL ARTICLE

Risk factors and risk indicators associated with high caries experience in Swedish 19-year-olds

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Abstract

Objective. To study the risk factors and risk indicators associated with high caries experience (DMFS $\geq$10) in 19-year-olds. ***Material and Methods.*** The subjects (n = 800) lived in seven suburbs of Stockholm and answered a structured questionnaire about their parents' education, occupation, and country of birth, as well as their dietary habits, oral hygiene habits, and attitudes to dental care. Dental caries was assessed by clinical and radiographic examination using the decayed, missing, filled teeth (DMFT), and surfaces (DMFS) indices. Dental plaque (VPI%) and gingival bleeding (GBI%) indices were recorded. ***Results.*** A total of 696 subjects (364 M, 332 F) participated in the study. The mean DMFT and DMFS were 3.9 and 5.1, respectively. In 81% of subjects, the DMFT was $\geq$1 and 15% had DMFS $\geq$10. In the multivariate analysis, the variables significantly associated with high caries experience were: dental fear (p <0.001, odds ratio (OR) 2.8), GBI $\geq$15% (p = 0.003, OR 2.1), mother born abroad (p = 0.007, OR 2.0) and irregular toothbrushing at night (p = 0.008, OR 1.9). When all significant variables in the multivariate analysis were present, the cumulative probability of DMFS $\geq$10 was 52%. ***Conclusions.*** Dental fear, gingival inflammation, a foreign-born mother, and irregular toothbrushing at night are variables that are strongly associated with high caries experience in 19-year olds. The study indicates that foreign-born parents, oral hygiene habits, and behavioral factors still have a strong impact on dental health in late adolescence.

Key Words: *Caries, dental fear, immigrant background, late adolescence, oral hygiene*

Introduction

In recent decades, there has been a marked improvement in the oral health of Swedish children and young adults, particularly with respect to dental caries. However, around 10% of Swedish adolescents still exhibit high caries experience and there is evidence of an increasing skewness of the distribution of the disease [1]. During the same period, Sweden has become progressively multicultural through immigration. The migration process involves changes in living conditions, adoption of new lifestyles, and socio-behavioral factors, which are reported to be associated with a negative effect on the dental health of children in migrant families [2,3].

Not only risk factors but also risk indicators of dental caries are described in the literature. Well-known risk factors for the development of dental caries are cariogenic diet, microflora, and a susceptible host [4]. In children, important risk indicators are low socio-economic status and immigrant background, factors that indirectly influence dietary habits, oral hygiene standards, and attitudes to dental care [5–9].

In adolescents, however, there are several published studies concerning the risk indicator, immigrant background, in relation to dental caries, although the results are contradictory [10–12]. Furthermore, there is evidence that even in late adolescence, low socio-economic status is still associated with dental caries, although the relationship seems to be weaker than in preschool children [13]. Additional risk indicators of dental caries reported among adolescents are dental fear, irregular toothbrushing habits, and gingival inflammation [14–17].

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Our knowledge of risk factors and risk indicators specifically associated with high caries experience and the effect of these factors on the probability of caries in early adulthood is limited. The objective of the present investigation was therefore to study the risk factors and risk indicators associated with high caries experience in Swedish 19-year-olds and to analyze the probability of each factor being associated with high caries experience.

Material and methods

The study was designed as a cross-sectional study and approved by the local ethics committee at Karolinska Institutet, Huddinge University Hospital. A power analysis was performed and the following assumptions were made: 2.5% significance level, 90% power and one-sided hypothesis; required sample size: $2 \times 400 = 800$. The study population comprised 800 19-year-olds from seven suburbs of Stockholm, representing different socio-economic profiles. A letter of information about the purpose of the investigation was enclosed with the annual recall notices sent to the subjects by seven public dental clinics. The recall examinations were conducted between 1 March and 30 November 2001. In total, 696 subjects (364 M, 332 F) participated in the study. Of the drop-outs ($n = 104$), 56% failed to keep their appointment, 33% had technical reasons, and 11% refused to participate. Of the participants ($n = 696$), 557 were born in Sweden, 28 in other European countries, and 111 outside Europe (Table I).

At each of the public dental clinics ($n = 7$), the clinical examinations were undertaken by two or three dentists. Prior to the study, all the examiners ($n = 17$) were invited to attend a day-long course of training in caries diagnostic criteria and interpretation of responses to the questionnaire. The mean value for the inter-examiner test was 95% agreement.

Table I. Characteristics of the subjects ($n = 696$)

Subjects	*n*	%
Examined	696	87
Male	364	52
Female	332	48
Chronic disease	18	3
Allergy	173	25
Medication	111	16
Country of birth		
Sweden	557	80
Europe	28	4
Outside Europe	111	16
Years living in Sweden		
<10 years	35	5
≥ 10 years	661	95
Parents (at least one or both)		
Born in Sweden	390	56
Born abroad	306	44

Questionnaire

The subjects answered a structured questionnaire and an interpreter assisted those who did not understand the Swedish language. The questionnaire covered such topics as socio-economic status and country of birth of the subjects' parents, and with respect to the subjects themselves, general health, medication, dietary habits, oral hygiene habits, and use of fluoride toothpaste and fluoride supplements. There were also questions about attitudes to dental care.

Socio-economic status was described in terms of the parents' educational level and occupational status. Educational level was stratified according to years of schooling as: 1) low (≤ 9 years), 2) medium (10–12 years), and 3) high (>12 years). Occupational status was assessed and stratified according to the Swedish socio-economic classification [18]: 1) unemployed, 2) laborer, and 3) semi-skilled and skilled white-collar workers.

Country of birth of the parents was coded on a geographic basis: born in Sweden (S), born in Europe (E), and born elsewhere (not S or E). In the bi- and multivariate analyses, the categories (E) and (not S or E) were combined into one group, *born abroad* (Table I).

Dietary habits were described in terms of consumption of fast food, starch-based snacks, sweet beverages, and sweets. The frequency of consumption was recorded on a four-level scale: never, seldom, sometimes, or often. In the statistical analysis, "never" and "sometimes" are combined under the heading "seldom".

Toothbrushing habits were described in terms of morning and evening toothbrushing, use of dental floss, and use of fluoride toothpaste. The frequency of each habit was expressed on a five-point scale: never, seldom, sometimes, often or daily. In the statistical analysis, the categories "never", "seldom", "sometimes", and "often" were combined and referred to as "irregular" toothbrushing.

Dental fear was assessed according to the subject's response to the question as to whether the subject was afraid of visiting the dentist.

Missed dental appointment was assessed according to the subject's response to the question regarding whether the subject sometimes missed their dental appointment.

Clinical and radiographic examination

Dental caries. The number of decayed, missing and filled teeth/surfaces was registered and expressed as DMFT/S indices. Manifest caries lesions were registered according to Koch's criteria [19]: on smooth

surfaces, the minimal level that can be verified as a cavity, detectable by probing, and in fissures, a catch of the probe under slight pressure. Initial caries, defined as a demineralized surface with loss of translucency on smooth surfaces, was not registered. The clinical examination was supplemented by radiographic examination (two bitewing radiographs). Approximal caries on the radiographs was registered as initial or manifest caries: initial caries – a lesion in the enamel which has not reached the dentinoenamel junction or a lesion which reaches or penetrates the dentinoenamel junction, but does not appear to extend into the dentin; manifest caries – a lesion which clearly extends into the dentin.

To assess inter-examiner agreement, an inter-examiner reproducibility test was conducted for two of the investigators (AJ and MBA) and the examining dentist at each of the seven participating clinics. The distal surface of the second premolar on radiographs from 70 subjects was classified according to the following criteria: sound, filled, initial, or manifest caries. Mean inter-examiner reproducibility was 87% with a mean kappa [20] of 0.62.

Plaque and gingival inflammation. The presence of dental plaque was recorded when clearly visible and expressed as the Visible Plaque Index (VPI) [21].

Gingival inflammation was based on bleeding on probing in the gingival sulcus and expressed as the Gingival Bleeding Index (GBI) [21]. The proportion of surfaces (%) with dental plaque and gingival inflammation was estimated for each individual.

Statistical analysis

Cross-sectional analysis of the data was conducted using the statistical software package SPSS 13.0. Statistical analyses included Student's independent *t*-test, the chi-square test, and the chi-square test for trend and logistic regression. The cut-off point (DMFS of ≥ 10) was chosen to be the final outcome. Bi- and multivariate logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (95% CI) [22]. Bivariate analyses of associations were carried out between DMFS ≥ 10 and the potential predictor variables by applying the Pearson chi-square test. Inter-correlations between the independent variables, significant in the bivariate logistic regression analyses, were studied in order to detect possible multi-colinearity between factors. The result showed only weak associations between these factors and dental caries. The strongest correlation ($R^2 = 7.7\%$) was between the variables, father's education and foreign-born father. A multivariate analysis was carried out in a stepwise logistic regression. Factors significant in the bivariate analyses were competed in the multivariate analysis. Variables significant in the multivariate analysis were further analyzed in an "interaction model". In the logistic regression, the following pairwise interaction terms were included: toothbrushing at night and dental fear, toothbrushing at night and mother born abroad, toothbrushing at night and GBI $\geq 15\%$, dental fear and mother born abroad, dental fear and GBI $\geq 15\%$, and mother born abroad and GBI $\geq 15\%$. None of the pairwise interaction terms was significant in the interaction model. Logistic regression analyses were also used to calculate the cumulative probability (%) of DMFS ≥ 10 [23].

Results

Of the subjects, 44% had parents born abroad and 56% had parents born in Sweden. The characteristics of the subjects with respect to gender, birthplace, years of living in Sweden, and occurrence of chronic disease are listed in Table I.

Caries indices and oral hygiene variables of the subjects are presented in Table II. The number of subjects according to DMFS is demonstrated in Figure 1. In 81% of the subjects, DMFT was ≥ 1. The mean values of DMFT and DMFS were 3.9 and 5.1 respectively. In one subject, one first molar had been extracted owing to caries.

The variable DMFS was dichotomized into DMFS < 10 and DMFS ≥ 10. The latter group, i.e. 15% of the subjects, represents high caries

Table II. Caries indices and oral hygiene variables in 19-year-old adolescents ($n = 696$)

Variables	Adolescents %	Mean value/SD
Caries Index		
DMFT ≥ 1	81	3.9/3.4
DMFS ≥ 1	81	5.1/5.3
DMFSa ≥ 1	43	1.5/2.8
DSa ≥ 1	23	0.5/1.2
CIa ≥ 1	59	3.0/3.9
Oral hygiene variables		
VPI		
0–14%	57	
15–24%	31	
25–50%	9	
>50%	3	
GBI		
0–14%	58	
15–24%	30	
25–50%	9	
>50%	3	
Toothbrushing in the morning		
Never	1	
Daily	75	
Irregular	24	
Toothbrushing at night		
Never	1	
Nightly	71	
Irregular	28	

D = decayed; M = missing; F = filled; T = teeth; S = surfaces; a = approximal; CI = caries initial; VPI = Visible Plaque Index; GBI = Gingival Bleeding Index.

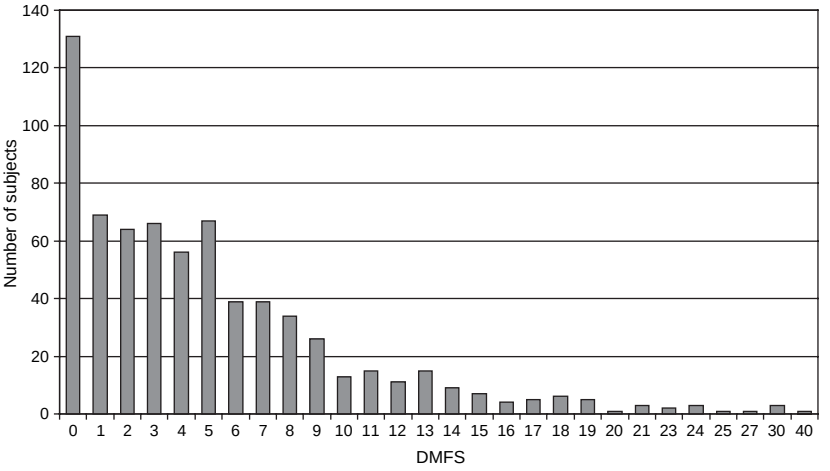

Figure 1. Number of subjects ($n = 696$) according to decayed, missing, filled surfaces (DMFS).

experience. In this group, there was no significant difference in the number of males and females (data not shown). Furthermore, there were no significant associations of gender and the dependent variables tested.

Subjects with or without high caries experience

Subjects with high and low caries experience, i.e. DMFS ≥ 10 or < 10 were compared with respect to their parents' educational level, occupational status, and country of birth. The subjects' birthplace, occurrence of chronic disease, medication, dietary habits, oral hygiene habits, and attitudes to dental care were also analyzed. In the bivariate analysis, the following variables with respect to the parents were significantly associated with DMFS ≥ 10: mother born abroad ($p < 0.001$), father born abroad ($p < 0.001$), father's education ($p = 0.004$), mother's occupation ($p = 0.005$), and father's occupation ($p = 0.007$). With respect to the subjects themselves, the following variables were also significantly associated with high caries experience: irregular toothbrushing at night ($p < 0.001$), VPI $\geq 15\%$ ($p < 0.001$), GBI $\geq 15\%$ ($p < 0.001$), dental fear ($p < 0.001$), and consumption of sweet beverages ($p = 0.025$) (Table III).

The variables in Table III, significant at the 5% level, were included in a multivariate logistic regression analysis with DMFS ≥ 10 as the dependent variable. The OR and the 95% CI were determined for each variable (Table IV). The variables most strongly associated with a DMFS ≥ 10 were: dental fear ($p < 0.001$), GBI $\geq 15\%$ ($p = 0.003$), mother born abroad ($p = 0.007$), and irregular toothbrushing at night ($p = 0.008$). The OR for each of the variables was 2.8 for the variable dental fear, 2.1 for GBI $\geq 15\%$, 2.0 for mother born abroad, and 1.9 for irregular toothbrushing at night. The logistic regression analysis was also used to estimate the probability of DMFS ≥ 10 for the given profile of independent variables (Figure 2). In the absence of all the significant variables, the estimated probability of a DMFS ≥ 10 in adolescents was 4.7%. When all significant risk factors and risk indicators were present, the cumulative probability was 52%.

Discussion

The results disclose that dental fear, gingival inflammation, a foreign-born mother, and irregular toothbrushing at night are factors strongly associated with high caries experience in late adolescence. The final cumulative probability estimated the risk of high caries experience to 52%.

The study subjects were residents of different suburbs of Stockholm representing low, medium, and high socio-economic levels, and in this respect the study population is representative for the County of Stockholm as a whole. The magnitude of drop-outs (15%) is normal for a group of adolescents, but no caries data are available for these subjects. An inter-examiner test was performed to check the validity among the examiners participating in the study. The reproducibility values represent good agreement [24] and show that the estimates of caries are reliable even when several examiners are used.

The mean DMFT was 3.9, which is somewhat higher than the number for 19-year-olds in Sweden as reported by the National Board of Health and Welfare, 2003 [25]. The frequency of 19-year-olds with a DMFT ≥ 1 (81%) is in good agreement with overall figures for the County of Stockholm [25], and confirms that with respect to dental caries the study population is representative for the County. DMFS ≥ 10 was recorded in 15% of the subjects. However, it is not possible to compare this group of patients with data from the reports of the Swedish National Board of Health and Welfare because only the mean value of approximal DMFS is calculated.

The association between dental fear and high caries experience disclosed in the present study

Table III. Comparison of 19-year-olds with DMFS <10 or DMFS ≥10 (n =696)

Variables	DMFS <10 (n =591) %	DMFS ≥10 (n =105) %	p
Parents			
Country of birth			
Mother			
Sweden	59	35	
Abroad	41	65	<0.001*
Father			
Sweden	61	40	
Abroad	39	60	<0.001*
Educational level			
Father			
≤9 years	30	45	
10–12 years	32	28	
>12 years	38	27	0.004**
Occupational status			
Mother			
Unemployed	18	30	
Labourer	25	33	
White collar	57	37	0.005**
Father			
Unemployed	14	22	
Labourer	35	47	
White collar	51	31	0.007**
Subjects			
Dietary habits			
Consuming sweet beverages			
Seldom	59	47	
Often	41	53	0.025**
Oral hygiene			
Tooth-brushing at night			
Irregular	25	43	
Nightly	75	57	<0.001*
VPI			
<15%	60	38	
≥15%	40	62	<0.001*
GBI			
<15%	62	39	
≥15%	38	61	<0.001*
Attitudes to dental care			
Dental fear			
No	80	63	
Yes	20	37	<0.001*

DMFS =decayed, missing, filled surfaces; VPI =Visible Plaque Index; GBI =Gingival Bleeding Index.
*Chi-square test; **chi-square test for trend.

supports a similar association reported in a number of clinical studies [14,26].

GBI ≥15% and irregular toothbrushing at night were also significant variables associated with high caries experience. The association between gingival inflammation (GBI ≥15%) and high caries experience is in agreement with a previous report stating that GBI was the only variable that could explain variations in DMFS among 14-year-olds [17]. Gingival inflammation is a result of plaque accumulation on the tooth surfaces owing to inadequate oral hygiene. That gingival inflammation is a significant determinant of high caries experience is compatible with the finding that irregular toothbrushing was also associated with high caries experience. The association between inadequate oral hygiene habits and caries has previously been reported by Källestål et al. [16], who demonstrated a higher caries increment during adolescence among subjects who brushed their teeth less frequently than twice a day. However, the association between oral hygiene and dental caries is a controversial issue and there are conflicting reports in the literature [27].

With respect to the variable toothbrushing, the results were intriguing and somewhat unexpected. In contrast to irregular toothbrushing in the morning, irregular toothbrushing at night was significantly associated with a DMFS ≥10. This finding is not in agreement with Bruno-Ambrosius et al. [28] who found no correlation between irregular toothbrushing habits, night or morning, in relation to caries increment. Thus, while toothbrushing with fluoride toothpaste twice a day is acknowledged as an effective caries-preventive measure [29], the results of the present study highlight the particular importance of regular nightly toothbrushing. This finding is interesting but needs further investigation.

The close association between a foreign-born mother and dental caries is compatible with a previous study by Locker et al. [12], reporting a higher DMFT among foreign-born than among Canadian-born adolescents. However, studies of the association between immigrant background and dental caries in adolescents have yielded somewhat contradictory results [10,11,30]. In contrast to Dahllöf et al. [10] and Wang [11], the present study discloses that even in late adolescence, the parents' socio-economic background, especially foreign-born parents, remains an important risk indicator of dental caries. This is difficult to explain because both the subjects and their parents had lived in Sweden for many years and had received the same extensive dental health education as those with Swedish-born parents.

Table IV. Multivariate logistic regression analysis with DMFS ≥10 as the dependent variable (n =696)

Variables	Beta coefficient β	OR (Multiple)	p	95% CI
Dental fear	1.03	2.8	<0.001	1.73–4.51
GBI ≥15%	0.72	2.1	0.003	1.27–3.30
Mother born abroad	0.68	2.0	0.007	1.21–3.21
Irregular toothbrushing at night	0.65	1.9	0.008	1.19–3.13

β =regression coefficient; OR =odds ratio; p =significance level of β; CI =confidence interval; DMFS =decayed, missing, filled surfaces.

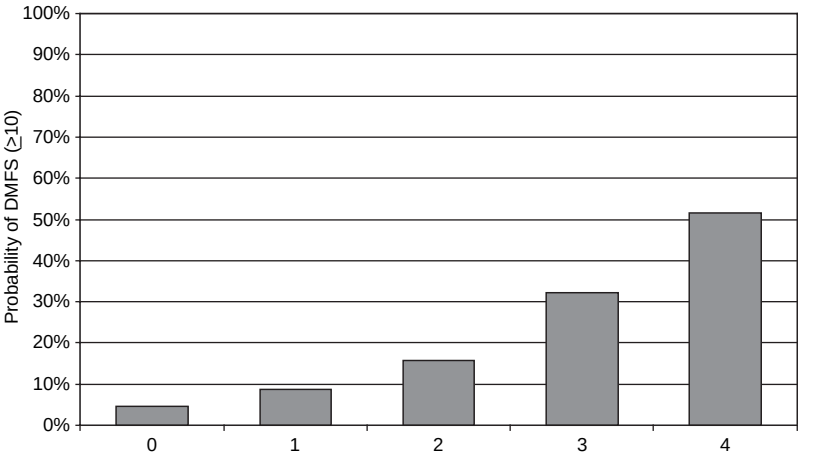

Figure 2. Cumulative percentage probability of decayed, missing, filled surfaces (DMFS) ≥10 at 19 years of age in relation to the number of significant variables in the multivariate analysis. 1 = mother born abroad; 2 = mother born abroad + irregular toothbrushing at night; 3 = mother born abroad + irregular toothbrushing at night + dental fear; 4 = mother born abroad + irregular toothbrushing at night + dental fear + Gingival Bleeding Index (GBI) ≥15%.

Our results indicate that in order to reverse the present trend of higher caries activity among children/adolescents of foreign-born families, resources need to be directed to this group of patients and preventive strategies tailored to meet their particular needs.

It is recognized that there tends to be a strong correlation between educational level and occupational status, etc. Therefore, in an inter-correlation matrix, we analyzed all the independent variables in the bivariate analysis. The result showed only weak associations between these factors and dental caries. The strongest correlation ($R^2 = 7.7\%$) was between the variables father's education and foreign-born father. However, in the multivariate analysis, the socio-economic variables education and occupation did not emerge as significant variables.

The present study also included an estimation of the impact of both risk factors and risk indicators on the probability of high caries experience. In the absence of any significant variables, the probability of a DMFS ≥10 was estimated to be 4.7% and when additional variables were added, the probability of high caries experience increased. When all the significant risk factors and risk indicators were present, the cumulative probability was 52%. A search of the literature concerning the probability of caries in early adulthood failed to disclose any published studies with which these results could be compared. However, in preschool children, Grindefjord et al. have shown that the cumulative probability of manifest caries at 3.5 years of age was 87% when all significant risk factors and risk indicators were present at 1 year of age [31].

In conclusion, the study discloses that the following variables are strongly associated with high caries experience in 19-year-old residents of Stockholm: dental fear, gingival inflammation, a foreign-born mother, and irregular toothbrushing at night. The study indicates that foreign-born parents, oral hygiene habits, and behavioral factors still have a strong impact on dental health in late adolescence.

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