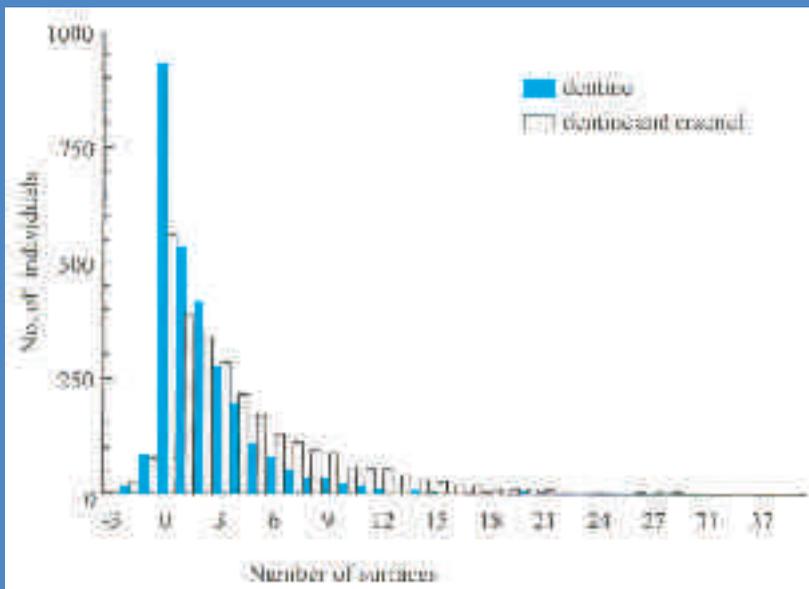# Swedish Dental Journal

Scientific Journal of The Swedish Dental Association

A four-year cohort study of caries and its risk factors in adolescents with high and low risk at baseline **page 11**

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Instructions to authors

Introduction

Swedish Dental Journal, the scientific journal of The Swedish Dental Association and the Swedish Dental Society, is published 4 times a year to promote practice, education and research within odontology. Manuscripts containing original research are accepted for consideration if neither the article nor any part of its essential substance has been or will be published elsewhere. Reviews (after consultations with the editors), Case Reports and Short Communications will also be considered for publication. All manuscript will be exposed to a referee process.

The Manuscript

Three complete copies of the manuscript should be sent to the Editor-in-chief Professor Göran Koch at the Editorial address (see beside). The paper should be in English using English spelling, be typed double-spaced with one-inch margins. The format of the manuscript should be arranged as follows:

Title Page, Abstract, Sammanfattning (in Swedish including title), Introduction, Material and Methods, Results, Discussion, Acknowledgements, References, Figures Legends, and Tables.

The letter attached to the manuscript should be signed by all the authors. When the paper has been accepted for publication the author will be asked to supply an updated final manuscript on disk together with two complete manuscripts.

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The Abstract should be short and concise and not exceeding 300 words. The Swedish Sammanfattning can be somewhat more extensive.

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In the reference list the references should be arranged in alphabetical order and numbered consecutively by Arabic numerals. Indicate references in the running text by using the Arabic numeral within brackets.

Abbreviations should follow "List of Journals indexed in Index Medicus". (http://www.nlm.nih.gov). Examples of references are presented below.

Article:
Helm S, Seidler B. Timing of permanent tooth emergence in Danish children. Community Dent Oral Epidemiol 1974; 2:122–9

Book:
Andreasen JO, Petersen JK, Laskin DM, eds. Textbook and color atlas of tooth impactions. Copenhagen: Munksgaard, 1997

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Relationship between tooth loss/probing depth and systemic disorders in periodontal patients

MARIA LAGERVALL, LEIF JANSSON

Abstract

◎ During the last decades, many published studies have focused on the associations between periodontal disease and different systemic disorders. The purpose of the present investigation was to study the relationship between occurrence of systemic disorders and the two variables mean number of teeth and periodontal probing pocket depth after stratification according to smoking habits.

The study was conducted as a retrospective study based on consecutive selection of patients at a specialist clinic of Periodontology. The study population consisted of 1854 individuals. Of these, 797 were males, and 1057 were females. Multiple regression analyses were adopted in order to calculate the partial correlations between the number of remaining teeth/the relative frequency of periodontal probing depths ≥ 5 mm and presence of systemic disease for different strata according to sex and smoking habits with age included as an independent variable.

Non-smoking men with cardiovascular disease, diabetes and rheumatoid disease had significantly fewer teeth compared to non-smoking men without systemic disorder. In conclusion, cardio-vascular disease, diabetes and rheumatoid disease may be regarded as risk indicators of tooth loss in men. However, in order to investigate hypotheses concerning potential risk factors, emerging from cross-sectional studies, being true risk factors of tooth loss, longitudinal prospective studies including established risk factors along with new exposures of interest as covariates are required.

Key words

Cross-sectional study, probing pocket depth, systemic disease, tooth loss

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Sambandet mellan tandförluster/fickdjup och systemsjukdomar hos parodontitpatienter

MARIA LAGERVALL, LEIF JANSSON

Sammanfattning

◎ Under senare år har många publicerade studier undersökt sambandet mellan parodontal sjukdom och allmänsjukdomar. Syftet med denna studie var att undersöka sambandet mellan förekomst av systemsjukdomar och de två variablerna antal kvarvarande tänder och parodontalt fickdjup efter stratifiering med avseende på rökvanor.

Studien utfördes retrospektivt och materialet utgjordes av patienter remitterade till en specialistklinik i parodontologi. Studiepopulationen bestod av 1854 individer, varav 797 män och 1057 kvinnor. Multipel regressionsanalys användes för att beräkna korrelationen mellan kvarvarande tänder/relativa frekvensen parodontal fickor med sonderingsdjup $\geq$ 5 mm och närvaro av allmänsjukdom efter stratifiering med avseende på rökning och kön och med ålder inkluderad i analysen som oberoende variabel.

Icke-rökande män med hjärt-kärlsjukdom, diabetes och reumatisk sjukdom hade signifikant färre kvarvarande tänder i jämförelse med icke-rökande män utan allmänsjukdom. Slutsatsen var att hjärt-kärlsjukdom, diabetes och reumatisk sjukdom kan betraktas som potentiella riskfaktorer för tandförlust hos män. Longitudinella, prospektiva studier, som inkluderar kända riskfaktorer i analysen, krävs dock för undersöka om den potentiella riskfaktorn utgör en sann riskfaktor.

Introduction

During the last decades, many published studies have focused on the associations between periodontal disease and different systemic disorders (for review, see 12). The role of periodontal disease as a potential risk factor of cardio-vascular disease is controversial with contradictory results in different publications. Significant, positive correlations between periodontal disease and cardio-vascular disease have been reported in cohort studies (2, 10) and case-control studies (24, 33), while other cohort or case-control studies did not find an increased risk for cardio-vascular disease in patients with periodontitis (14, 16, 17, 25, 36). Epidemiological studies have reported a significant association between both types of diabetes and periodontal disease (for review, see 35) and the results suggest that diabetes is a risk factor for periodontal disease (12, 35). The likelihood of periodontal problems is suggested to be increased in individuals suffering from advanced rheumatoid arthritis (27).

Smoking appears to be a true risk factor of periodontal disease (for review, see 32). The significant association between smoking and periodontal disease necessitates that statistical analyses, exploring the relationship between smoking-related systemic disorders and periodontal disease, control for the confounding effects of smoking. The risk of a biased association between periodontal disease and systemic disease often still remains after statistical adjustment for smoking (13).

In an earlier study (19), the association between systemic disorders and periodontal conditions in terms of number of remaining teeth and periodontal probing depth, was studied. The population consisted of patients referred to a specialist clinic and two inclusion criteria were at least 20 remaining teeth and a minimum age of 40 years. The number of remaining teeth were found to be significantly and positively correlated to presence of cardiovascular disease, diabetes and rheumatoid disease after adjustment for age, sex and smoking. The relative frequency of diseased sites, however, was not significantly correlated to anyone of the investigated systemic health disorders.

The purpose of the present investigation was to study the relationship between occurrence of systemic disorders and the two variables mean number of teeth and the relative frequency of periodontal probing depths ≥5 mm, after stratification according to smoking habits in order to eliminate the risk of confounding effects by smoking, within the same population of patients as the earlier study but after increasing the sample and with a minimum age of 30 years in dentate individuals as inclusion criteria.

Material and Methods

The study was conducted as a retrospective study based on consecutive selection of patients at the Department of Periodontology at Skanstull, Folktandvården i Stockholms län AB. Patients referred during the time period from 1995 to 2002 were included in the study if they fulfilled the following inclusion criteria at the time of admission:
• At least 5 teeth with periodontally diseased sites with a probing depth of 5 mm or more
• A minimum age of 30 years
• An adequately completed health questionnaire.

The study population consisted of 1854 individuals, who met the above criteria. Of these, 797 were males, and 1057 were females. The following variables were recorded from the dental records and the health questionnaires:
• Age, sex and smoking habits
• Number of remaining teeth
• Number of periodontally diseased sites with a probing depth of 5 mm or more
• Self-reported presence of cardiovascular disease, diabetes, rheumatoid disease, psychogenic disorders and self-perceived state of health.

At the first clinical examination, the self-perceived state of health was evaluated by the patient by choosing one of three alternatives in the health questionnaire: good, moderate or bad.

Statistical analysis:

Descriptive statistics and statistical analyses were performed with a software package (SPSS PC+ 4.0, SPSS, INC., Chicago, IL). In order to investigate any differences between sexes within age groups according to smoking habits and occurrence of systemic disorders, the chi-square test was used. The mean number of teeth and the relative frequency of periodontal probing depths ≥5 mm were compared between groups within different strata by Student's t-test analyses. Multiple regression analyses were adopted in order to calculate the partial correlations between the number of remaining teeth/the relative frequency of periodontal probing depths ≥5 mm and presence of systemic disease/self-perceived state of health for different strata according to sex and smoking habits with age included as an independent variable. A good state of health was coded 0, while a bad or a moderate state of health was coded 1. In addition, the self-reported diseases were coded

◎ **Table 1:** Occurrence of systemic disorders and self-perceived state of health according to age group and sex.

Age	Sex	Cardiovascular disease (%)	Diabetes (%)	Psychogenic disorders (%)	Rheumatoid disease (%)	Bad or moderate self-percieved state of health (%)
30-	Male	2.6	3.8	6.4	5.1	15.4
40	Female	3.0	0.0	8.1	4.0	14.1
41-	Male	9.8	6.6	7.6*	3.0	11.3
60	Female	7.2	4.7	15.0*	4.7	16.1
61-	Male	27.9**	16.2	9.5	5.0	18.2
82	Female	13.7**	9.3	9.4	6.4	14.1
Total		10.2	5.2	11.0	4.4	14.6

* p<0.05 between sexes, **p<0.01 between sexes

◎ **Table 2:** The relative frequencis (%) of smokers according to age group, sex occurrence of systemic disorders and self-perceived state of health.

Age	Sex	n	Cardiovascular disease	Diabetes	Psychogenic disorders	Rheumatoid disease	Bad or moderate self-percieved state of health
30-40	Male	74	50	33.3	100	50	63.6
	Female	97	66.7	0.0	57.1	50	71.4
41-60	Male	521	48.0	31.6	65.0	31.2*	62
	Female	788	52.8	40.0	59.8	71.0*	62.7
61-82	Male	202	18.4	26.7	29.4	22.2	17.2
	Female	172	7.4	7.7	31.6	38.5	20.8

* p<0.05 between sexes

◎ **Table 3:** The mean number of teeth and the relative frequency (%) of periodontal probing depth ≥5mm for the age group 41-60 yrs.

A. Non-smokers

Self-reported disease	Mean number of teeth (S.D)	Relative frequency (%) of periodontal probing depth ≥5 mm (S.D)
No systemic disease	26.3 (3.41)	22.0 (14.0)
Cardiovascular disease	24.8 (3.81)	21.6 (14.0)
Diabetes	23.6 (3.85)**	27.4 (14.7)
Psychogenic disordes	25.5 (3.27)	23.2 (18.1)
Rheumatoid disease	24.1 (2.41)*	24.6 (13.0)
Bad or moderate self-percieved state of helth	25.5 (3.04)	22.4 (12.3)

* p<0.05 between absence and presences of systemic disease
**p<0.01 between absence and presences of systemic disease

B. Smokers

Self-reported disease	Mean number of teeth (S.D)	Relative frequency (%) of periodontal probing depth ≥5 mm (S.D)
No systemic disease	25.1 (3.79)	31.6 (17.4)
Cardiovascular disease	23.6 (4.23)*	35.1 (21.9)
Diabetes	21.1 (6.84)*	32.1 (14.4)
Psychogenic disordes	24.4 (4.38)	31.8 (17.5)
Rheumatoid disease	24.5 (3.31)	23.0 (13.7)**
Bad or moderate self-percieved state of helth	24.7 (3.56)	31.0 (1.77)

* p<0.05 between absence and presences of systemic disease
**p<0.01 between absence and presences of systemic disease

as dichotomous variables (0=no disease, 1=self-reported disease). Results were considered statistically significant at *p*<0.05.

Results

The mean age of the patients in the studied population was 50.2 years (range 30-86 years). A majority of the patients (70.6%) belong to the age group 41-60 years. The relative frequency of smokers was 51.1% and 10.9% reported that they were former smokers. In the age group 41-60, significantly more females were smokers compared to the males (61.2% and 52.8%, respectively). The number of teeth did not significantly differ between sexes, while the relative frequency of periodontal pockets ≥5 mm was significantly increased for males older than 40 years (p<0.001). The mean number of remaining teeth was 24.7 (range 5-32) and about 60% of the subjects had at least 25 remaining teeth. For 61% of the patients, more than 20% of the tooth surfaces had periodontal probing depths ≥5 mm, while for 38% of the sample, the corresponding relative frequency was 30%.

The occurrence of systemic disorders and self-perceived state of health according to age group and sex is presented in Table 1. In patients older than 60 years, significantly more males reported presence of cardiovascular disease compared to the females (27.9% and 13.7%, respectively). Presence of diabetes type 1 or 2 was reported by 5.2% of the subjects, while the corresponding relative frequencies for psychogenic disorders and rheumatoid disease was

11.0% and 4.4%, respectively (Table 1).

In the group of subjects who reported occurrence of diabetes, 29.3% were smokers, while among patients who reported presence of psychogenic disorder, 56.6% were smokers (Table 2). Smoking was significantly (p<0.05) more frequent in females (71.0%) than males (31.2%) in the age group 41-60 years with rheumatoid disease (Table 2). Among subjects who reported presence of cardiovascular disease, 35.9% were smokers (Table 2).

In the age group 41-60 yrs, smoking as well as non-smoking patients with diabetes or cardiovascular disease had significantly fewer teeth than individuals without systemic disorders (Table 3A, B). Non-smoking individuals who reported presence of rheumatoid disease had significantly fewer remaining teeth compared to those without systemic disorder (p<0.05, Table 3A).

The number of lost teeth was more pronounced with increasing age for non-smoking males with cardiovascular disease compared to smoking males and non-smoking males without cardiovascular disease (Fig. 1).

The results of the multiple regression analyses, using the number or remaining teeth and the relative frequency of periodontal probing depths ≥5 mm as dependent variables, are presented in Table 4. Non-smoking men with cardiovascular disease, diabetes and rheumatoid disease had significantly fewer teeth compared to non-smoking men without systemic disorder (p<0.05, Table 4). Cardiovascular disease was significantly and positively correlated
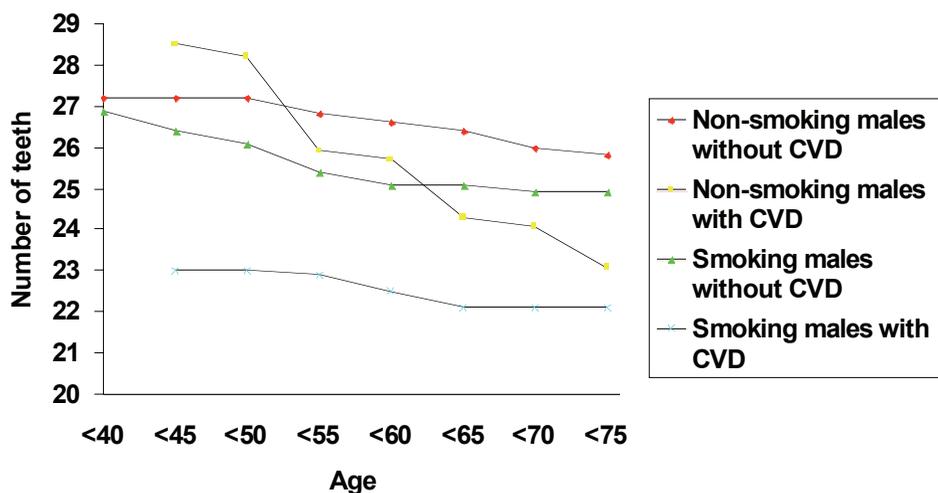
◎ **Figure 1:** The mean number of teeth for males with or without cardio-vascular disease according to age and smoking habits.

Table 4: Partical correlations between investigated variables and the number of remaining teeth/ the relative frequency (%) of periodontal probing depth ≥5 mm for different strata according to sex and smoking habits in a stepwise multiple regression model with age included as an independent variable. Significant (p<0.05) correlations are presented.

Sex	Smoking habits	Independent variable	Number of teeth	Relative frequency periodontal probing depth ≥5 mm
Male	Nonsmoker	Cardiovascular disease	-0.125 (p=0.027)	-
		Diabetes	-0.131 (p=0.021)	-
		Rheumatoid disease	-0.117 (p=0.040)	-
Male	Smoker	Cardiovascular disease	-0.171 (p=0.001)	0.157 (p=0.003)
Male	Former smoker	None	-	-
Female	Nonsmoker	None	-	-
Female	Smoker	Diabetes	-0.110 (p=0.007)	-
		Reumatiod disease	-	-0.109 (p=0.009)
Female	Former smoker	Diabetes	-0.261 (p=0.007)	-
		Rheumatoid disease	-0.244 (p=0.011)	-
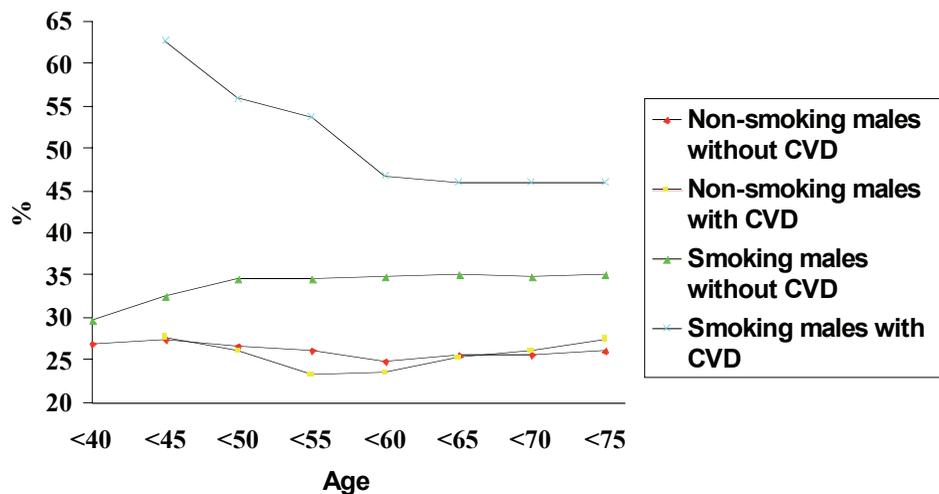
Figure 2. The relative frequency (%) of periodontal probing depth ≥5 mm for males with or without cardiovascular disease according to age and smoking habits.

to number of lost teeth (Table 4, Fig. 1) and the relative frequency of periodontal probing depths ≥5 mm (Table 4, Fig. 2) for smoking males. Smoking or former smoking females who reported presence of diabetes had significantly fewer teeth compared to those without systemic disorder (p<0.01).

Within the group of females who reported presence of rheumatoid disease, smokers had significantly less periodontal probing depths ≥5 mm (p=0.009), while former smokers had significantly fewer teeth (p=0.011).

Discussion

In the present study, the associations between systemic disorders and the clinical assessments number of remaining teeth/periodontal probing depth were studied in a retrospective investigation. The subjects included belong to a referral population of patients at a specialist clinic of Periodontology. An earlier study on the same population indicated that the investigated individuals belong to a periodontitis-prone population (15). Consequently, any conclusions based on the results of the present study, should not be extrapolated to a general population.

The purpose of the present investigation was to study the relationship between occurrence of systemic disorders and the two variables mean number of teeth and the relative frequency of periodontal probing depths ≥5 mm, after stratification according to smoking habits. These two measures and periodontal attachment loss are the most common methods assessing cumulative effects of periodontal disease. However, recent studies have suggested that measures of infectious exposure and host response including measures such as inflammatory biomarkers may be more relevant variables to correlate to systemic diseases (3, 4, 30).

In the present study, periodontal probing depth was registered before the periodontal treatment started at the specialist clinic and it is likely that a majority of the measurements were performed at sites with untreated periodontal lesions. This indicates that the probing depth may be regarded as an estimate of the distance between the gingival margin and the location of the most coronal insertion of intact connective tissue fibers along the root due to a penetration of the probe into the inflammatory infiltrate of connective tissue (6, 21). Thus, the periodontal probing depth may be regarded as a variable correlated to the degree of inflammation in the soft tissues (6, 21).

Tooth mortality has been regarded as a variable depending on social-behavioural factors as well as oral disease characteristics (8). In multiple regression models, tooth loss has been shown to be significantly correlated to periodontal attachment loss (8, 22), periodontal probing depth (9), and number of teeth at baseline (9). In patients with periodontal disease, the majority of teeth lost during the maintenance period was lost due to periodontal disease (18, 23, 26).

The results were based on self-reported data and this may lead to limitations regarding the validity when interpreting the results. Some previous studies have explored the validity of medical questionnaires in dentistry (7, 11, 20). The validity has been reported to vary within a rather wide range (66% - 95%) for different disorders and studies.

In order to eliminate the risk of confounding effects by smoking, *Hujoel et al* (13) have suggested that periodontitis-systemic disease associations are studied among never-smokers. The risk of bias still remains after statistical adjustment or control for confounding depending on the lack of a detailed measure of the life-long smoking exposure (13). In the present study, the subjects have been stratified according to smoking habits, sex and smoking history in order to analyse the relationship between systemic diseases and the oral variables separately within the strata. Multiple regression analyses were performed within strata with age and the investigated systemic diseases included as independent variables to eliminate possible interactory effects of these factors on the investigated relationship between one specific systemic disease and periodontal conditions. However, the risk of bias in the present study due to lack of life-long smoking measures in the patient groups former smokers and smokers still remains and the most reliable results should be expected in the group of non-smokers.

Several studies indicate that number of lost teeth is positively correlated to presence of systemic diseases and smoking (19, 28). Among the subjects in the present study, 4.4% reported presence of rheumatoid disease, while approximately 1% of the population worldwide is affected by this disease (27). About 50% of the individuals of the sample were smokers and cigarette smoking has been found to be associated with the severity of rheumatoid disease in a dose dependent fashion (1, 34). Thus, rheumatoid disease is positively related to smoking as well as to periodontal disease (27, 31).

The prevalence of diabetes was found to be 5.2% in the present population, which was higher than prevalences in epidemiological studies in Sweden reporting prevalences between 2.0 and 3.2% (5). The number of adults who are smokers in Sweden has decreased since 1980 and 14% of the men and 19% of the women smoked on a daily basis in 2004 (29). The percentage of smokers in the sample of the present study is higher (51%) than in a general population and significantly more women were smokers in the age group 41-60 years. Since smoking and diabetes are established risk factors of periodontal disease (for review, see 32), the increased proportions of subjects with diabetes and smokers which were found in the

present sample with periodontitis-prone individuals could be expected.

Non-smoking males had lost significantly more teeth in presence of cardio-vascular disease, diabetes and rheumatoid disease, while the relative frequency of periodontal probing depths ≥5 mm was not significantly associated to presence of systemic disease in non-smoking subjects. Since smoking is related to life style factors and social factors, the exclusion of smokers in exploring the relationship between oral status and systemic diseases, possible effects of identified and unidentified factors related to smoking may be eliminated.

In conclusion, cardio-vascular disease, diabetes and rheumatoid disease may be regarded as risk indicators of tooth loss in men. However, in order to investigate hypotheses concerning risk indicators, emerging from cross-sectional studies, being true risk factors of tooth loss, longitudinal prospective studies including established risk factors along with new exposures of interest as covariates are required.

Acknowledgments

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A four-year cohort study of caries and its risk factors in adolescents with high and low risk at baseline

CARINA KÄLLESTÅL[1], ANNA FJELDDAHL[2]

Abstract

◎ Aim: To report and compare risk and preventive factors for caries in high- and low-risk adolescents, from a 4-year cohort study on commonly used preventive measures for caries in adolescents in the Swedish Public Dental Service.

Subjects and methods: In 1995 a cohort of 12-year-olds was examined for caries and completed a questionnaire. This procedure was repeated at age 14 and 16. The group identified as being at high risk was examined every year and this group was randomly assigned to one of four preventive programs. The outcomes examined were the caries increments using the DMF-indices. Poisson regression was used to assess risk and preventive factors.

Results: The number of 12-year-olds participating was 3,373 in 1995 and 2,848 were still participating in 1999. A higher risk of caries increment was observed for adolescents from working-class homes, from outside Western Europe, and for those who often ate candy and did not brush their teeth twice a day. Important findings were the different results for the preventive factors when different DMF-indices were used as outcome measures and the fact that there was no difference between the high-risk group and the total group when it came to risk or preventive factors. The clinically tested prevention had a low effect i.e., the semi-annual application of fluoride varnish prevented 10% of the dentine and enamel caries development over 4 years.

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Fyra års kohortstudie avseende karies och dess riskfaktorer

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Sammanfattning

◎ Syfte: Att rapportera och jämföra förebyggande- och riskfaktorer för karies i hög- och lågrisk ungdomar från en 4 års kohortstudie om vanligen använda förebyggande metoder för ungdomar i den svenska Folktandvården.

Deltagare och metoder: 1995 undersöktes karies i en kohort av 12-åringar samtidigt som de svarade på en enkät. Denna procedur upprepades när ungdomarna var 14 och 16 år. Den grupp som identifierades som att ha hög risk för karies undersöktes varje år och de blev slumpmässigt förda till en av fyra förebyggande program. Utfallet var kariesökning mättes med DMF-indices. Poisson regression användes för att bedöma risk- och förebyggande faktorer.

Resultat: Antalet 12-åringar som deltog 1995 var 3 373 och 2 848 deltog fortfarande 1999. Högre kariesökning sågs hos ungdomar från arbetarklasshem, de som kom från länder utanför Västeuropa och för dem som ofta åt sötsaker och inte borstade tänderna två gånger om dagen. Viktiga fynd var att vi fick olika resultat för de förebyggande faktorerna beroende på vilket utfallsmått (DMFS eller D_eMFS) som användes och att det inte fanns någon skillnad på förekomst av risk- eller förebyggande faktorer mellan högriskgruppen och den totala gruppen. De kliniskt testade förebyggande programmen hade en låg effekt där den bästa var den uppmätta för fluoridlackning var sjätte månad som förebyggde 10% av dentin och emaljkaries över 4 år.

Introduction

During the 1970s and 1980s, the national public dental health service in Sweden was focusing on the whole population and on the prevention of oral diseases. According to the Swedish Dental Services Act of 1985, it is the responsibility of the County Councils (presently 21 in a country of ten million inhabitants) to organize free dental treatment prioritizing preventive services for all children and adolescents up to the age of 19. Oral health was checked at annual dental health examinations and preventive measures were mainly aimed at the whole population, but included individual measures after assessment of disease risk. In view of the decreasing incidence of caries and the increasing financial pressure on the dental care institutions during the late 1980s and early 1990s, several dental health care models were tried out. Furthermore, the former rather uniform dental care program for children and adolescents was largely dismantled, resulting in considerable local variation in the intervals between dental health checks and some variation in the application of different preventive strategies and methods. Today, preventive measures are mainly aimed at the high risk group in combination with some population strategies (31). Reports on caries prevention have shown that the implementation is non-specific (20, 11), not always directed to those most at need (11, 34) and that certain national practices evolve (12).

To justify care models using screening and assessments of health risks, there must be carefully evaluated and proved efficient methods to prevent caries in adolescents believed to belong to the high-risk group (25). Today it is uncertain whether additional effects are obtained by using current prevention methods in a selected high-risk group (7). A recent systematic review from the Swedish Council on Technology Assessment in Health Care (3) states that preventive programs seem to be effective if they include fluoride in any form. On the other hand, the review also points to the lack of evidence of efficient methods for a selected high-risk group.

Furthermore, it is not known what the effect would be if preventive measures were only applied to high risk groups, in contrast to prevention directed at the whole population or a mix of the strategies. A worry we had when planning the present study (1994) was that using a high-risk strategy might increase the well known social gradient of dental health (15, 8). This could happen if the selected high-risk group does not comply with the clinically based prevention, i.e., the prevention method is not designed and

tested to be efficient for the risk group. The population strategy does not have this possible drawback and does not stigmatize anybody since it is the same for everyone (26). To address these issues, we planned the research project "Evaluation of dental caries prevention measures" in close collaboration with the Public Dental Service in several counties around the country. In 1995, we started to collect data in order to assess the efficiency of a high-risk strategy for the prevention of caries in adolescents including preventive measures commonly used. The evaluation covered the oral health impact and the health economic impact. It also examined the social determinants for preventive action.

The aim of this paper is to report and compare preventive and risk factors for caries in high-and low-risk adolescents at base line, from a 4-year cohort study performed in adolescents within the Swedish Public Dental Service system using a nested experiment: a randomized clinical trial on commonly used preventive measures for caries.

Subjects and methods

Study population and design of the project

All 12-year-old children (i.e. born in 1983) from 26 Swedish public dental health clinics, located throughout the country, a total of 4,355 children, were invited and 3,373 (79%) agreed to participate in the study. All medical ethics committees in Sweden approved the study. Further information on the sampling and examination procedure is available in another report from the study (13). The initial study group (3,373) came from different regions of Sweden, including large cities, towns and rural areas. The social strata represented the distribution across regions and were similar to those of the Swedish population as a whole, as shown by a comparison with statistics from the 1990 Population and Housing Census.

Teams constituted at each clinic (N=26) were instructed in data-collection methods and took an active part in consensus discussions and calibration. The dentists were trained in the diagnosis and assessment of caries and on how to record findings, using C.K.'s assessment as the standard (13, 5). Dentists received training in calibration technique twice before the study started. Over the course of the study, inter-examiner reproducibility was tested twice each year using bitewing radiographs. About 10% of the children at each examination were re-examined as a test of intra-examiner reproducibility.

Examination for dental caries was carried out using a mirror and with good operating light, com-

Surface and diagnostic method	Proximal surfaces Radiolucency	Occlusal surfaces Radiolucency and clinical estimate	Smooth surfaces radiolucency and clinical estimate
Score 0	intact surfaces distinct demineralisation in the enamel	intact surfaces or indistinct demineralisation in the enamel	intact surfaces or indistinct demineralisation in the enamel
Score 1	enamel lesions but no evidence of dentinal involvement	not used	not used
Score 2	lesions extending into the dentine but not more than halfway through to the pulp	distinct radiolucency underneath the enamel, demineralisation of the enamel	demineralisation of the enabel
Score 3	lesions extending into the dentine more than halfway throught to the pulp	not used	not used
Score 4	caries with pulp involvement	caries with pulp involvement	caries with pulp involvement

◎ **Figure 1.** Diagmostic criteria.

pressed air, and cotton rolls. Two bitewing radiographs were taken up to the age of 14, and thereafter four bitewing radiographs were taken at each examination in order to judge dentine and enamel lesions on proximal surfaces. No probe was used and occlusal and smooth surface caries was diagnosed by assessing enamel demineralization. When an enamel demineralization was clinically detected, the lesion was judged to extend into the dentine. Consequently, enamel lesions on occlusal and smooth surfaces are not included in the caries scores. Caries in buccal/lingual fissures and pits was considered to be occlusal caries. The material used in sealants was assessed by the examiner as either glass-ionomer cement or resin. Sealants were reported separately from fillings and caries.

Identification of high-risk group
If a child had more than one decayed proximal surface, enamel or dentine caries, a filled proximal surface, or a missing tooth because of caries ($D_eMFS_p > 1$), he or she was allocated to the high-risk group. If the dentist found that a patient had a high risk of caries because of mental or physical disability or chronic disease, this individual was also assigned to the high-risk group. After restoration of any caries lesions in the permanent and deciduous teeth, the amount of lactobacilli in the saliva was examined in the remaining patients using what is termed a dip slide test (Dentocult®, Orion Diagnostica, Helsinki, Finland). All children who had a CFU$>10^5$ were allocated to the high-risk group. The lactobacillus test was used since it could be used in all the clinics without any help from laboratories.

Prevention programmes
Each high-risk child was randomly assigned to one of four preventive programs (A-D). These programs were designed to be similar to the methods used in clinical settings. Every child and guardian was informed of the fact that the child had a high risk of developing caries.

The content of each method was as follows:
Group A (Tooth-brushing). A letter was sent with instructions on when and how tooth-brushing with fluoridated toothpaste should be done. The tooth-brushing was to be performed according to the toothpaste technique (27) in which the tooth-paste foam is kept in the mouth and not rinsed away. This information was repeated at each dental health examination (i.e. once per year).
Group B (Fluoride lozenges). Information about fluoride lozenges and a prescription for them was given (0.25 mg x 3, daily up to 16 years and thereafter 0.25 mg x 4-6 daily). A check-up of the patient's use of the fluoride lozenges was done at each subsequent dental health examination (i.e., once per year).
Group C (Fluoride varnishing). After professional cleansing of the patient's teeth, fluoride varnish (Duraphat®) was applied. The application was performed 3 times during 1 week. This was repeated every 6 months.
Group D (The individual program). The oral hygiene status was established and, where necessary, the patient was given counseling in dental hygiene, as well as information on the connection between food intake and caries. Finally, the patient's teeth were professionally cleansed, and fluoride varnish was applied. Oral hygiene and diet were checked every 3 months, and if necessary, the instructions were repeated. Fluoride varnish was applied each time.

For all high-risk children, sealants were placed in second molars with deep fissures. The children in all four experimental groups were examined every year. At the ages of 12, 14 and 16 years, the total study group was examined and the children/adolescents filled in an extensive questionnaire.

The study design required that all previous programs be discontinued, as no preventive programs including sealant placement were to be conducted other than those randomly assigned within the study. Important factors in the development of caries – such as fluoride levels in drinking water, oral hygiene habits, use of fluoride, and snacking – were

followed throughout the study by using the questionnaire and through reports from each clinic.

Variables

Dependent variables

Caries experience was calculated using the indices 'decayed', 'missing due to caries', and 'filled surfaces' (DMFS) and D_eMFS (i.e., enamel caries on proximal surfaces was included in the index). The dependent variable increment was computed as the net increment of DMFS and D_eMFS. Reversals were included in the net increment, meaning that they were subtracted from the crude increment. This is based on the assumption that examiners made an equal number of false positive and false negative errors in both the baseline and follow-up examinations.

Independent variables

Sex: Boy or girl, as stated by the adolescents in the baseline questionnaire.

Ethnicity: The children declared their ethnicity, by stating in the questionnaires what they considered themselves to be.

Socio-economic level (SEL): The SEL was determined using the occupation of the father and mother as given by the adolescent in the 1999 questionnaire. The household SEL code was based on the parent whose occupation gave the highest SEL according to the socio-economic classification of Statistics Sweden (29).

Fluoride in drinking water: Nurses at each clinic reported fluoride concentration at the individual level on the basis of reports from the community water source and reports on private wells. The concentrations were categorized into two groups: < 1.0 ppm and ≥ to 1.0 ppm.

Earlier preventive programs: Before the study started, as well as at each examination, every clinic had to indicate whether they had any population-based preventive program that included fluoride administration in operation for the study group, and if so, what kind. Although such programs were supposed to have been abandoned for the duration of the study, it is possible that this was not the case for some individuals. The variable was set to 'none' or 'any kind of preventive program'.

Self-administered fluoride; This was defined as some kind of fluoride taken on the individual's own initiative as distinct from that given in the study. In the questionnaire, participants were asked to indicate whether they used: no extra fluorides; fluoride rinses more than once a month; 1–3 pieces of fluoride che-

wing gum a day at least 4 days a week; or 1–3 fluoride lozenges a day on at least 4 days a week. The variable was clustered for each year into 'none' or 'any kind of self-administered fluoride', and was then further categorized by whether these conditions existed at only one, or two, or three examinations.

Sealants: Sealants were judged to be present if one or more surfaces had a sealant and was set as 'present' if at least one surface had a sealant.

Candy and soft drinks: The questionnaire included questions on consumption of candy and soft drinks. The alternatives given were: 'never'; 'once a month' (this option was dropped in the 1999 questionnaire); 'once a week'; 'several times a week'; 'daily'; or 'several times a day'. Children could also indicate whether they drank only sugar-free beverages. The variable *eating candy* was clustered so that the alternatives were 'never or seldom' (maximum a few times a week at three examinations), 'often at one examination' (several times a day at a maximum of one examination), or 'often at 2–3 examinations' (several times a day at 2–3 examinations). The consumption of soft drinks was categorized as 'seldom' (once a week or less than once a week) or 'often' (more than once a week), and thereafter as seldom or often at one, two or three examinations.

Tooth-brushing: Children were asked how often they brushed their teeth. The alternatives given were 'more than twice a day', 'twice a day', 'once a day', 'less than once a day', or 'irregular'. The variable was set to 'less than twice a day' or 'at least twice a day'. The final variable is given as less than twice a day for all years of the study or at least twice a day at one, two or three examinations. As almost all tooth-pastes in Sweden contain fluoride, tooth-brushing implies tooth-brushing with a fluoridated tooth-paste.

Preventive programs (A–D): Enrolment in a preventive program was considered, regardless of compliance.

Statistical methods

The data were analyzed using the statistical packages EpiInfo 6.0, SPSS 11.0 and STATA 6.0. The Poisson regression with over-dispersion was used to analyze the incidence rate. The Poisson regression model can be expressed as follows:

$$\ln (\text{rate}) = \alpha + \beta_1 x_1 + \beta_2 x_2 \ldots + \beta_n x_n$$

where;

$$\text{rate} = \frac{\text{number of increments}}{\text{sum of individual risk times (years in study)}}$$

Since the results of increments included nega-

◎ **Table 1.** Number of individuals participating and the attrition for every study year.

Age	Total group (n)	High risk (n)	(%)	Attrition total group	(%)	Attrition high risk	(%)
12	3373	1134	(34)				
13		1118				16	(1)
14	3109	1061	(34)	264	(8)	57	(5)
15		1018				43	(4)
16	2848	956	(34)	261	(9)	62	(6)
Total 12-16 years				525	(16)	178	(16)

tive values due to reversals and misclassifications, the increments were shifted to positive values. The dependent variable is assumed to be generated by a Poisson-like process, except that the variation is greater than that of a true Poisson as was shown when tested on other caries data (30). This extra variation is referred to as over-dispersion and is in the case of caries most probably due to dependency of caries surfaces within an individual. The rate ratios (RR) represent a comparison of the increment in various groups relative to a reference group assigned a risk of one. Groups with a RR greater than one are at higher risk, and those under one have less risk (the variable is preventive or resulting in a reduced risk). For the RR analyses the significance is based on 95% confidence intervals. The uni-variable RR:s shows each variable's effect on the outcome, while the multi variable analysis shows effect in a model including all the variables significant in the univariable analysis, giving information on possible confounding.

Results

The study group
For all four study years, the loss to follow-up was (16%) 525 and 178 for the total study group and the high-risk group respectively. The most common reason for dropping out was that a child had moved from the area (32%) or did not want to change dentist (9%) (5). The numbers of participants and the attrition for every study year are given in Table 1. The attrition was analyzed (30% of the examination records were located), and the mean caries incidence over the whole study period was the same as that of the study group, although the drop out pattern was different for individuals in the low- and high-risk groups; during the first year of the study some from the low-risk group left and in the two last years some from the high-risk group.

Caries experience and sealants
The results of inter- and intra-examiner reproduci-

◎ **Table 2.** Results of inter- and intra-examiner reproducibility tests on proximal enmel and dentine caries.

	Intra-examiner		Inter-examiner	
Year	P_0	κ	P_0	κ
1995	99	0.82	88	0.78
1996	99	0.82	85	0.74
1997	99	0.76	91	0.75
1998	97	0.88	92	0.80
1999	99	0.83	86	0.64

P_0=percentage agreement, κ=kappa value.

bility tests on caries diagnoses are shown in Table 2. One and the same dentist served as examiner at each site, except for three sites where the original examiner was replaced because of retirement or leave for training. The new examiners were individually trained and calibrated with the same methods as at study start. At all sites, children in each risk group were examined in equal proportions by all the examiners. At the start of the study, the caries experience in the high-risk group was approximately twice that in the low-risk group. The mean and range for caries indices in the low-risk group, high-risk group and for the total study group are given in Table 3. The distribution of dentine caries was skewed. 47, 34 and 24% of the 12, 14, and 16-year-olds, respectively had DMFS=0.

In the high-risk group, the distribution was also skewed; 28, 18 and 10% of the 12, 14, and 16-year-olds, respectively had DMFS=0.

The proportions having at least one sealant were 39, 51 and 54% in the examination years 1995, 1997 and 1999, respectively. The mean sealants present in each adolescent 1999 were 3.7 (SD 2.36) in the high-risk group and 1.31 (SD 1.94) in the low-risk group. The sealants were mainly present in first and second molars where 34% of the total study group had at least one sealant whereas less than 1% of the premolars were sealed. Almost the same proportion, 35% of first molars, was sealed in both the low- and high-

◎ **Table 3.** Mean and range for caries.

Study group	12 years old (1995)						14 years old (1997)						16 years old (1999)					
	LR		HR		TOTAL		LR		HR		TOTAL		LR		HR		TOTAL	
	mean	range	mean	range	mean	range	mean	range	mean	range	mean	range	mean	range	mean	range	mean	range
DMFT	1.03	0-11	2.39	0-16	1.48	0-16	1.63	0-14	3.46	0-22	2.26	0-22	2.31	0-20	4.48	0-27	3.00	0-27
DMFS	1.08	0-14	2.87	0-27	1.67	0-27	1.73	0-19	4.42	0-35	2.65	0-35	2.51	0-27	5.95	0-44	3.69	0-44
DeMFS	1.27	0-18	4.67	0-36	2.40	0-36	2.57	0-26	7.08	0-46	4.11	0-46	4.54	0-38	10.03	0-52	6.42	0-52
DMFSp	0.06	0-6	0.77	0-10	0.30	0-10	0.20	0-5	1.41	0-18	0.61	0-18	0.48	0-14	2.27	0-27	1.10	0-27
DeMFSp	0.26	0-10	2.58	0-20	1.02	0-20	1.03	0-20	4.06	0-29	2.07	0-29	2.51	0-26	6.36	0-36	3.83	0-36
DMFS-incr							0.70	-4-15	1.56	-9-23	1.00	-9-23	1.52	-4-23	3.13	-5-38	2.07	-5-38
DeMFs-incr							1.36	-4-21	2.42	-8-31	1.71	-8-31	3-39	-3-33	5.44	-6-45	4.09	-6-45
DMFSp-incr							0.15	-1-6	0.64	-5-15	0.32	-5-15	0.43	-1-13	1.52	-5-23	0.81	-5-23
DeMFSp-incr							0.81	-1-19	1.51	-6-24	1.05	-6-24	2.30	-1-26	3.83	-4-29	2.83	-4-29

e=including enamel caries, p=proximal, LR= low risk group, HR=high risk group
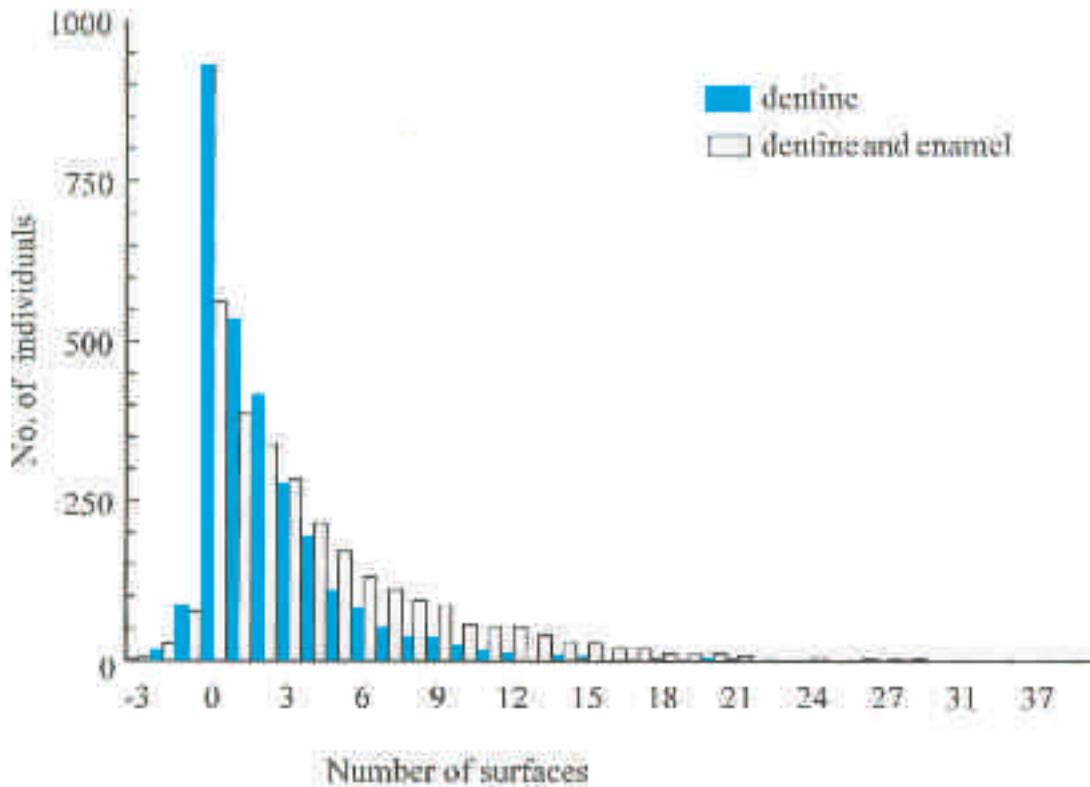
◎ **Figure 2.** Distribution of 4-year caries increment, total study group. Observe the intervals on x-axis are different between Figs 2 and 3 (31-37)

risk group, whereas the proportion of sealed second molars in the low-risk group was 10% compared to 82% in the high-risk group.

Caries increment

The two- and four-year increments in DMFS and D$_e$MFS in the low-risk, high-risk and total study group are shown in Table 3. The mean dentine caries increment every second year was similar: 0.98 surfaces, between 12 and 14 years and 1.04 between 14 and 16 years. The yearly increment in dentine caries was 0.5 surfaces per year, and when enamel was included the increment was 1 surface per year. More than a third of the 4 year DMFS increment (0.81) and more
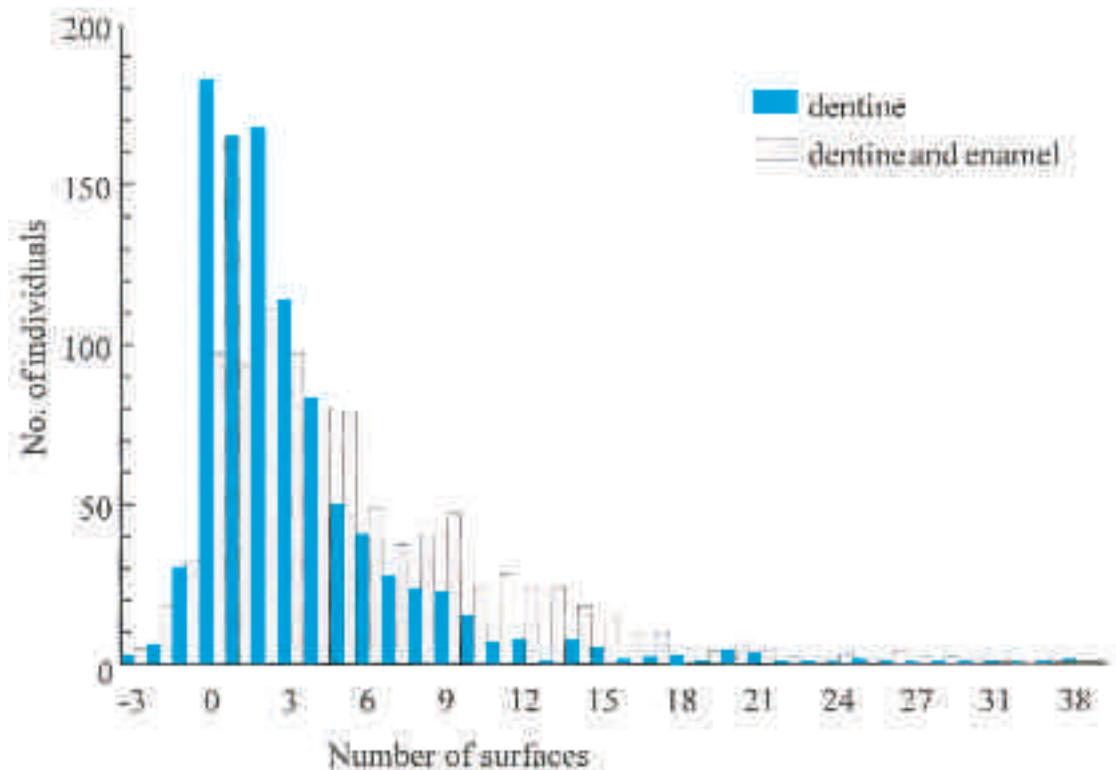
◉ **Figure 3.** Distribution of 4-year caries increment, the high-risk group. Observe the intervals on x-axis are different between Figs 2 and 3 (31-38)

than two thirds of the D$_e$MFS increment (2.83) was due to proximal caries increment.

The distribution of four-year caries increment was skewed (Fig. 2). Nine hundred and thirty (34%) of the adolescents had no dentine caries increment. When enamel caries was included, 561 (21%) had no increment.

In the high-risk group, the yearly dentine caries increment was almost the same; 1.5 surfaces per year and when enamel was included, 2.5 and 3 surfaces per year, respectively. About half of the dentine caries increment (1.52) and 70% (3.83) of the dentine and enamel caries was due to proximal caries increment. The distribution of caries increment within the high-risk group was skewed (Fig. 3). About 200 (23%) of the adolescents had no dentine caries increment over four years. When enamel caries was included, 152 (16%) had no lesions during four years.

Compliance with the prevention programs
In the four different experimental programs (A-D), the number of individuals participating was reduced by 14-16%, and the compliance varied from 25-62%

during the first year, being highest for the fluoride varnishing group (C) and lowest for the fluoride lozenges group (B). The compliance increased to 70% for the tooth brushing group (A) and to 65% for the individual program (D) while it was reduced to 6% for group B and 15% for group C respectively, during the four study years.

Distribution of independent variables
SEL: The distribution of the parents' professional status/SEL in the total study group was civil servants 44%, business people 15% and workers 42%. The majority of the group considered them selves to be Swedes (93%), 2% from Western Europe, 1% from Eastern Europe and 4% from other parts of the world.

Fluoride: Most of the adolescents (96–98%) lived in areas with low fluoride levels and this distribution did not change over the study period. Of the children participating in this study, 1,165 (34%) had taken part in population-based preventive programs before the study started. The most common population-based preventive program was application

Table 4. Rate ratio for the increment DMFS, the total study group.

Variable	Category	N	Uni	CI	Multi	CI
SEL	Civil servant	1153	1.00		1.00	
	Business people	403	1.02	(0.99-1.06)	1.02	(0.98-1.06)
	Workers	1103	**1.05**	**(1.03-1.08)**	**1.04**	**(1.02-1.07)**
Ethnicity	Swedish	2606	1.00		1.00	
	Nordic/Western Europe	51	1.04	(0.96-1.12)	1.04	(0.96-1.14)
	Eastern Europe	35	**1.29**	**(1.18-1.41)**	**1.25**	**(1.12-1.40)**
	Other	119	**1.10**	**(1.04-1-16)**	**1.07**	**(1.01-1.14)**
Fluoride conc. in water	≥ 1.0 ppm	212	1.00		1.00	
	< 1.0 ppm	2633	**1.05**	**(1.01-1.09)**	**1.05**	**(1.00*-1.10)**
Sealants	At least in one surface	1543	1.00		1.00	
	None	1304	**0.97**	**(0.95-0.99)**	0.98	(0.96-1.00*)
Eating candy	Never or seldom	1786	1.00		1.00	
	1.ex often	659	1.01	(0.99-1.04)	1.01	(0.98-1.04)
	2-3 ex. often	325	**1.04**	**(1.01-1.08)**	1.03	(1.00*-1.07)
Tooth-brushingintevall	3 ex. tb, ≥ twice daily	2070	1.00		1.00	
	2 ex. tb, ≥ twice daily	398	**1.06**	**(1.03-1.09)**	**1.05**	**(1.02-1.09)**
	1 ex. tb, ≥ twice daily	192	**1.11**	**(1.07-1.16)**	**1.09**	**(1.05-1.14)**
	All years < twice daily	105	**1.06**	**(1.01-1.12)**	1.05	(0.99-1.12)
Earlier preventive programs	Any kind	1025	1.00		1.00	
	None	1820	**1.02**	**(1.00*-1.05)**	1.02	(0.99-1.04)

Bolded = significant, Uni = uni variable statistics, Multi = multi variable statistics, CI = 95% confidence interval,
SEL = Socio economic level, ex. = examination, tb = tooth-brusching. *rounded value

of fluoride varnish, which 768 (67%) had received and the second most common program was fluoride-rinsing which had been used by 295 (25%) of the children. The remaining 8% had either brushed their teeth with fluoridated toothpaste according to the 'toothpaste technique' (27) or taken fluoride lozenges or used fluoridated chewing gum. By the start of the study, almost all adolescents had abandoned the population-based preventive program, and only 2% were still taking part. Extra preventive programs including fluoride in any form were given to 1–2% of the participants during the study mainly for orthodontic treatment. Thus; almost no prevention outside the study was performed in any of the study sites. One-third of the adolescents stated that they used some kind of self-administered fluoride and this proportion did not change during the study years.

*Oral health behavior:*Tooth-brushing at least twice a day was practiced by 84-87% of the adolescents over the study years. Eating candy became less common over the four study years. When the children were 12 and 14 years old, 20% reported eating candy once or less than once a week. By the time they were 16, 64% reported eating candy at most once a week.

The high-risk individuals did not differ with respect to the independent variables when compared to the total study group. Furthermore, the distribution of the independent variables was not significantly different between the four prevention groups.

Comparisons between caries increment in the total study group and in the high-risk group
There seemed not to be any confounding or interactions as the RRs were more or less the same in the univariable and the multi variable analysis (Tables 4-7). We will comment in the discussion on the exceptions in the sealants variable that show a strange pattern. Some variables lost their significance in the multi-variable model due both to weak significances and in some cases to the low number included in the subgroup, i.e. the group brushing their teeth less than twice daily all years.

For the total study group, Table 4 shows that the RR for dentine caries increment during the study period was higher for those whose parents were working class, and for those who came from outside Western Europe. Those having low fluoride levels in their drinking water (< 1.0 ppm) were also at higher risk of dentine caries increment. For those who did

Table 5. Rate ratio for the increment DeMFS, the total study group.

Variable	Category	N	Uni	CI	Multi	CI
SEL	Civil servant	1153	1.00		1.00	
	Business people	403	1.03	(0.99-1.07)	1.04	(0.97-1.11)
	Workers	1103	**1.05**	**(1.02-1.08)**	**1.06**	(1.01-1.12)
Ethnicity	Swedish	2606	1.00		1.00	
	Nordic/Western Europe	51	1.08	(0.99-1.18)	1.18	(0.97-1.45)
	Eastern Europe	35	**1.22**	**(1.10-1.35)**	**1.25**	(1.03-1.50)
	Other	119	**1.14**	**(1.07-1-21)**	**1.12**	(1.01-1.25))
Fluoride conc. in water	≥ 1.0 ppm	212	1.00		1.00	
	< 1.0 ppm	2633	**1.10**	**(1.05-1.16)**	1.08	(0.98-1.21)
Sealants	At least in one surface	1543	1.00		1.00	
	None	1304	**0.94**	**(0.92-0.96)**	**1.09**	**(1.02-1.16)**
Eating candy	Never or seldom	1786	1.00		1.00	
	1 ex often	659	1.00	(0.97-1.03)	1.01	(0.96-1.07)
	2-3 ex. often	325	**1.05**	**(1.01-1.09)**	**1.09**	**(1.02-1.17)**
Tooth-brushingintevall	3 ex. tb, ≥ twice daily	2070	1.00		1.00	
	2 ex. tb, ≥ twice daily	398	**1.11**	**(1.08-1.15)**	**1.15**	**(1.07-1.22)**
	1 ex. tb, ≥ twice daily	192	**1.19**	**(1.14-1.25)**	**1.17**	**(1.07-1.27)**
	All years < twice daily	105	**1.09**	**(1.02-1.16)**	0.99	(0.87-1.12)
Preventive programs	A	247	1.00		1.00	
	B	224	0.97	(0.91-1.03)	0.94	(0.89-1.01)
	C	224	**0.93**	**(0.88-0.99)**	**0.90**	**(0.85-0.96)**
	D	241	0.94	(0.89-1.00*)	0.95	(0.89-1.01)

Bolded = significant, Uni = uni variable statistics, Multi = multi variable statistics, CI = 95% confidence interval, SEL = Socio economic level, ex. = examination, tb = tooth-brusching. *rounded value

not brush their teeth twice a day at all examinations, the risk was increased. As Table 5 shows, the risk of caries increment, including enamel caries, was also higher for adolescents from working class homes and for those from outside Western Europe. For those who ate candy often throughout the study period and for those who did not brush their teeth twice a day at all examinations, the risk was increased. Less risk was shown for those taking part in preventive program (C), the fluoride varnishing group, and for those having at least one sealant.

The same pattern was evident in the high-risk group (Table 6) as the RR for dentine caries increment was higher for adolescents from working-class homes and for those from Eastern Europe as well as for those who did not brush their teeth twice a day at all examinations. Those who had at least one sealant ran a lower risk of dentine caries increment as did those who had received some prevention before the study started. Girls also ran a higher risk. And again, for dentine and enamel caries increment, as seen in Table 7, a higher risk was evident for those from working-class homes and from outside Wes-

tern Europe. Furthermore, the risk was increased for those who ate candy often throughout the study period and who did not brush their teeth twice a day at all examinations. Less risk was shown for those taking part in preventive program (C), the fluoride-varnishing group and for those having at least one sealant.

Comparisons of DMF-index increment and D_eMFS-index increment as outcome measures

For the total study group, the fluoride level in the drinking water was significant when the DMFS-index was the outcome but not when the D_eMFS was used. Not having sealants was a risk for a higher D_eMFS index but not for the DMFS index. Eating candy often was a risk for D_eMFS but not for DMFS and taking part in preventive program C seemed to be preventive when the enamel fraction of caries was included (D_eMFS), see Tables 4 and 5. For the high-risk group (Tables 6 and 7), girls showed a higher risk for caries when measuring the DMFS but this disappeared when measuring D_eMFS as the outcome. Eating candy often was a risk for higher caries

◎ **Table 6.** Rate ratio for the increment DMFS, the high-risk group.

Variable	Category	N	Uni	CI	Multi	CI
Sex	Boy	563	1.00		1.00	
	Girl	555	**1.04**	**(1.00*-1.08)**	**1.05**	**(1.01-1.09)**
SEL	Civil servant	370	1.00		1.00	
	Business people	140	**1.04**	**(0.98-1.11)**	1.03	(0.97-1-09)
	Worker	386	**1.08**	**(1.04-1.13)**	**1.06**	**(1.02-1.11)**
Ethnicity	Swedish	876	1.00		1.00	
	Nordic/Western Europe	11	1.11	0.93-1.31	1.10	(0.93-1.31)
	Eastern Europe	21	**1.33**	**(1.19-1.50)**	**1.30**	**(1.12-1.50)**
	Other	55	**1.16**	**(1.07-1-25)**	1.09	(1.00*-1.19)
Sealants	At least in one surface	824	1.00		1.00	
	None	151	**1.15**	**(1.09-1.21)**	**1.15**	**(1.09-1.21)**
Tooth-brushing intevall	3 ex. tb, ≥ twice daily	699	1.00		1.00	
	2 ex. tb, ≥ twice daily	139	1.08	**(1.03-1.14)**	**1.08**	**(1.02-1.14)**
	1 ex. tb, ≥ twice daily	73	1.14	**(1.07-1.23)**	**1.14**	**(1.06-1.23)**
	All years < twice daily	35	1.01	(0.91-1.12)	1.00*	(0.90-1.12)
Earlier preventive programs	Any kind	328	1.00		1.00	
	None	646	**1.04**	**(1.00*-1.00)**	1.05	**(1.00*-1.09)**

Bolded = significant, Uni = uni variable statistics, Multi = multi variable statistics, CI = 95% confidence interval,
SEL = Socio economic level, ex. = examination, tb = tooth-brusching. *rounded value

◎ **Table 7.** Rate ratio for the increment DeMFS, the high-risk group.

Variable	Category	N	Uni	CI	Multi	CI
SEL	Civil servant	370	1.00		1.00	
	Business people	140	1.06	(0.99-1.13)	1.04	(0.97-1.11)
	Workers	386	**1.07**	**(1.02-1.12)**	**1.06**	**(1.01-1.12)**
Ethnicity	Swedish	879	1.00		1.00	
	Nordic/Western Europe	11	1.16	(0.95-1.41)	1.18	(0.97-1.45)
	Eastern Europe	21	**1.21**	**(1.05-1.40)**	**1.25**	**(1.04-1.51)**
	Other	55	**1.21**	**(1.11-1-33)**	**1.12**	**(1.01-1.25)**
Sealants	At least in one surface	151	1.00		1.00	
	None	824	1.10	(0.00*-1.04)	**1.08**	**(1.02-1.15)**
Eating candy	Never or seldom	113	1.00		1.00	
	1 ex often	223	1.02	(0.96-1.07)	1.01	(0.96-1.07)
	2-3 ex. often	611	**1.08**	**(1.01-1.16)**	**1.09**	**(1.02-1.17)**
Tooth-brushingintevall	3 ex. tb, ≥ twice daily	699	1.00		1.00	
	2 ex. tb, ≥ twice daily	139	**1.16**	**(1.09-1.23)**	**1.15**	**(1.08-1.22)**
	1 ex. tb, ≥ twice daily	73	**1.22**	**(1.12-1.32)**	**1.17**	**(1.07-1.27)**
	All years < twice daily	35	1.02	(0.91-1.15)	0.99	(0.87-1.12)
Preventive programs	A	247	1.00		1.00	
	B	224	0.97	(0.91-1.03)	0.95	(0.89-1.01
	C	224	**0.93**	**(0.88-0.99)**	**0.90**	**(0.85-0.96)**
	D	241	0.94	(0.89-1.00*)	0.95	(0.89-1.01)

Bolded = significant, Uni = uni variable statistics, Multi = multi variable statistics, CI = 95% confidence interval,
SEL = Socio economic level, ex. = examination, tb = tooth-brusching. *rounded value

increment when the enamel fraction was included (D_eMFS) but not when only the dentine caries was the outcome (DMFS). Having taken part in preventive programs before the study start was preventive for DMFS development but not for D_eMFS and taking part in preventive program C during the study was preventive for the development of D_eMFS but not for DMFS.

Discussion

Voluntary participation by children and clinics was necessary for both ethical reasons (e.g., risk of harm to the individual child due to participation in the proposed study) and organizational reasons. Consequently, the sample of children studied was a convenience sample, and the study design should be described as a prospective cohort study with a nested randomized experiment. This is an epidemiological study, meaning it was population-based and the results (i.e. the RRs, showing preventive factors or risks) should hence not be inferred to individuals but to groups of adolescents. Bearing this in mind, the study aimed to evaluate common preventive practice and not the efficiency of a new drug, treatment or method. The design is different from that usually recommended in so-called clinical trials as suggested by several authors in a recent proceedings reporting on the development and adjustments needed in clinical caries trials (28, 4). In line with these recommendations, this study nests a randomized trial within a cohort study in order to increase efficiency, using the high risk group as an experimental group because caries develops slowly in the total population. In addition, it is performed within and together with the Public Dental Service, meaning that the design and content of the whole study, as well as the experiment (i.e. the four preventive experimental groups), were agreed upon through consensus discussions. Furthermore, the results were discussed before they were fed back to the adolescents, the clinics participating and to the scientific community. The collaboration with the clinicians and their crucial contribution to the data collection made it impossible to register the caries in a blinded fashion. This could have introduced bias but we are quite sure that the clinicians did not favor any special preventive program. The dentists who were examiners answered the same questionnaire as used for assessing preventive methods in the Nordic countries (12) and showed the same preferences of programs using fluoride and dietary advice as the sample of Swedish dentists reported in that study.

For ethical reasons, we could not have a control group and this prevents us from making inferences about what would have happened if no clinical prevention had taken place. However, we consider group A to be very close to a zero-group as the tooth brushing measure is close to what is performed by almost 90 per cent of this population. Furthermore, the low-risk group is in a way a large control group as they perform a lot of preventive measures themselves. This was precisely in line with the goals of the research project as our aim was to evaluate, using basic epidemiological measures of inference, all preventive measures and not just those performed within the limits of the clinic (conventional therapy and prevention methods used within the Swedish Public Dental Service, programs A-D).

The distribution of social strata in the study group was similar to the distribution among Swedes in general. The loss to follow-up was 16% (525), which we considered to be low. All in all, the results can be considered representative of Swedish adolescents. The caries diagnostic methods used are reported to be the best available at present for epidemiological studies (1, 35). Although agreement with the 'examiner standard' declined over time, the reproducibility was fair to good, so the results can be considered reliable. The independent variables were derived from the questionnaires and thus shared the weaknesses of all questionnaire data. However, the loss of data due to incomplete questionnaires was low, 10% at most. The National Board of Health and Welfare annually reports the mean DMFT values for 6-, 12- and 19-year-olds in Sweden. When the present study began, they reported a mean of 1.5 DMFT for 12-year-olds (32), which is comparable with the mean value of 1.48 found in this study.

The different drop out patterns for individuals in the two risk groups was probably due to the following. Children (and their guardians) who had very low risk, and were aware of the importance of taking part in preventive programs and of having their teeth checked every year left the study in the beginning. Some from the high-risk group left at the end, probably tired of being checked upon and called back to the clinic so often. This altered our first stated impression in the intermediate analyses (15, 5) that the reported caries level was underestimating the population level. We now believe that the study estimate of the increments does mirror the true caries development in the population

Like others (9, 21) we have used the Poisson regression and have earlier shown its appropriateness

for caries data (30). We showed that the binominal Poisson regression with overdispersion is the type of statistical analysis most suitable for longitudinal caries data. The use of increments as a measure of caries development in the present study, instead of survival analysis, is due to an earlier reported study on our data showing that results from the two analytic approaches do not differ much in our data (16). While lacking the precision of the survival analysis at the surface level, the increment analysis does allow us to take care of data from all individuals independent of when they left the study. This increases the use of data in comparison with other statistical methods (21). When making inferences, one has to bear in mind that no rate ratios (RR) in the multi-variable models are greater than 1.30 or less than 0.90. Thus, no risks of caries increment are greater than 30% and no preventive factor for caries increment decreases the risk more than 10%, - in all a limited preventive impact.

The results show that effects of the structural factors, social class and ethnicity are still influencing the development of caries as are the individual behaviors of frequency of snacking and tooth brushing. The pattern showing that children/adolescents from working-class homes were at higher risk of caries increment agrees with earlier results from this study (15) as well as from other studies on dental caries prevalence (2, 23, 33). This pattern is the strongest in all analyses performed within this longitudinal study. This suggests a need to understand the mechanisms behind this sturdy phenomenon present all over the western hemisphere, as we have tried to do in two other reports from the same project (14, 18).

The heightened risk for adolescents from Eastern Europe may be explained by the fact that the majority of these adolescents were newly arrived refugees from the war in the former Yugoslavia. One must also bear in mind that the excess risk for non-Swedish adolescents was based on only some 150 individuals.

Most of the findings point towards the difference between the old scars of the caries disease already present at the age of 12 (fillings) and the existing caries in different stages included in the DMF indices when followed over time (fillings placed and new caries developed during the study). Caries develops slowly in this population with a mean of about 4-8 years from enamel caries to dentine caries (22, 6, 19) and a higher proportion of the DMFS index compared to the D_eMFS index is due to caries developed earlier and has benefited from a lifelong higher wa-

ter fluoride exposure and this is most probably the reason for this variable to be significant when DMFS is used as outcome but not in D_eMFS. Furthermore, not having been included in a preventive program before the study started is a risk for DMFS increment but not for D_eMFS increment in the high-risk group. Similarly, the fact that taking part in preventive program C during the study is preventive for the D_eMFS increment but not for DMFS increment points in the same direction. In the high-risk group, girls are at higher risk for caries in terms of DMFS but not in terms of D_eMFS. This is probably due to their earlier maturing with the earlier eruption of almost all teeth, another point towards the difference of the indices measuring more of formerly experienced caries (DMFS) and existing caries (D_eMFS). This makes it important to discuss the use of different outcome measures and analytical tools when estimating effects of preventive measures on the population level in the future.

The results of the different analyses using the sealant variable are difficult to judge as sealants were not included in the experiment as a program to evaluate. Sealants as well as all other treatments (mainly for caries, trauma and orthodontic problems) were performed according to each dentist's judgment. Since the 1980s, sealants have been recommended by the Swedish National Board of Health and Welfare mostly for children regarded as having high caries risk and deep fissures and most often in first molars at their eruption, i.e., long before the present study started. Some are however also placed in second molars and, because of the study design, only in the high-risk group. Depending on when the sealants are placed, they could be an indicator of actual high risk or be seen as fillings, i.e. a measure of earlier treatment. In addition, they are probably preventive. All these facts make it difficult to judge the reason for the lower risk seen in the univariable analysis for those without sealants in the total study group, a risk that changes in the multivariable model when enamel caries is included. These facts also make it difficult to determine why there is a higher risk in those without sealants in the high risk group, although they point in the same direction as the above discussion on the differences in results of the caries outcomes, when including or not including the enamel caries.

The fact that not brushing the teeth twice a day increased the risk for all subjects at all examinations (and more so when measuring also enamel caries) and that eating candy was a risk for higher D_eMFS

increments points to the persisting need to prevent caries by permanent behavioral change and modification towards persistent habits.

The analysis shows that there are no major differences between the two risk groups when it comes to the measured independent variables. The risk estimate was crude and the study design prevented us from changing the single stated risk estimate at 12 years of age, which would have been done in real life. However, it has been shown many times that our tools for estimating risks do not have the predictive power to be really useful (10) in clinical practice. This fact, coupled with the low effect of the prevention, at most 10%, casts doubt on the usefulness of a strategy that includes special prevention targeted to risk groups. The population-based prevention is probably equally effective as long as traditional prevention methods are used.

In conclusion, the effect of the structural factors social class and ethnicity are still influencing the development of caries, as are the individual behaviors of frequency of candy intake and tooth brushing. Of those investigated in this study, the only clinically administered preventive methods able to reduce the risk for caries increment were semi-annual fluoride varnish application and placement of sealants for the high-risk group. It seems that a high-risk approach to delivering preventive measures is not efficient as the efficacy of the preventive methods used is not high enough for a caries active group. Moreover, nothing points towards these methods being able to lessen the social gradient. A population strategy that reaches all, irrespective of class or ethnicity, as well as a thorough treatment along the lines of modern cariology for those affected with the disease would in this population be more cost effective, at least until more efficient preventive methods having been invented and tested in real life. For the development of the population strategy, it is worth pointing to the fact that a high proportion of the adolescents take care of their own prevention. This proportion could probably easily be augmented if the dental community began using the tools, long since provided within modern health promotion, that draw on the will and power of each individual as well as of groups to change oral health behavior and prevent oral diseases (24).

Acknowledgements

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Patients' health in contract and fee-for-service care
I. A descriptive comparison

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Abstract
◎ Fee-for-service care, paying afterwards for services provided, is the traditional adult patient financial system in dentistry in Sweden. The public dental health service (PDHS) in the county of Värmland has since 1999 also an alternative system, contract care. There, a fixed sum of money is paid annually for dental care, which then is received without additional costs. This study compares the demographics, general health and oral health-related quality of life (OHRQoL) in the patient financial systems fee-for-service and contract care in the PDHS in Värmland. A questionnaire was answered by 1,324 patients, response rate 57 %. A non-response analysis was undertaken. The non-response analysis showed that the likelihood for answering the questionnaire was higher for women, for respondents in contract care and for increasing age. Further analyses revealed that the non-respondents were healthier than the respondents and that experience of pain in the mouth was the only variable increasing the likelihood of response. General health was studied with the SF-36 and OHRQoL with the OHIP-14. The demographics studied were gender, age, birth country, marital status, education and social network. The results showed that there were differences in patients' health between the patient financial systems. Respondents in contract care had better OHRQoL than those in fee-for-service care. They also had better general health in four of the dimensions of SF-36, were younger, better educated, born in Sweden and were married/living with somebody to a larger extent than fee-for-service care respondents. Fee-for-service care respondents experienced higher social affinity with their housing area. In conclusion, patients in contract care had better general health and OHRQoL than patients in fee-for-service care. There were social differences in choice of financial system and biased non-response.

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Patienters hälsa i kontrakts- och åtgärdstandvård
– en deskriptiv jämförelse

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Sammanfattning

◉ Åtgärdstandvård, att i efterhand betala för utförda åtgärder, är det traditionella patientfinansieringssystemet inom vuxentandvården i Sverige. Folktandvården i Värmland har sedan 1999 ett alternativt finansieringssystem, kontraktstandvård. Inom detta betalar man årsvis en given summa och erhåller sedan den tandvård man behöver utan extra kostnad. Denna studie beskriver demografi, allmänhälsa och oralhälsorelaterad livskvalitet (OHRQoL) i patientfinansieringssystemen kontraktstandvård och åtgärdstandvård i Folktandvården i Värmland. En enkät besvarades av 1,324 patienter, en svarsandel av 57 %. Bortfallsanalys utfördes. Bortfallsanalysen visade att sannolikheten för att besvara enkäten var högre för kvinnor, för kontraktstandvårdspatienter och ökade för varje levnadsår. Vidare analys visade att icke-respondenterna var friskare än de som besvarat enkäten och att upplevelse av smärta i munnen var den enda variabel som ökade sannolikheten för att besvara enkäten. Allmänhälsa studerades med SF-36 och OHRQoL med OHIP-14. Demografiska faktorer som studerades var kön, ålder, födelseland, civilstånd, utbildning och socialt nätverk. Resultaten visade att patienter i kontraktstandvård hade bättre OHRQoL än de i åtgärdstandvård. De hade även bättre allmänhälsa i fyra av SF-36's dimensioner och var yngre, mer välutbildade, födda i Sverige och gifta/sammanboende i större utsträckning än respondenterna i åtgärdstandvård. De senare upplevde dock högre samhörighet med sitt bostadsområde. Konklusionen var att patienterna i kontraktstandvård hade bättre allmänhälsa och OHRQoL än patienterna i åtgärdstandvård. Det fanns sociala skillnader i val av finansieringssystem och bias i bortfallet.

Introduction

In Sweden, dental care is provided by the public dental health service (PDHS) or by private practitioners. The PDHS is run by county councils, regional political authorities responsible for health care.

Since 1974, Sweden has a general dental care insurance, which reimburses public and private caregivers for provided services. Dental care for children and adolescents up to the age of 19 years old is publicly funded, free of charge for the patient (28). The general dental care insurance reimburses the caregiver with a fixed amount of money per child/adolescent enrolled. For adults, dental care is generally subsidized on a fee-for-service basis. The subsidy is discounted from the total cost for dental care, the patient paying the remaining, predominant, portion of the total cost (7). The Social Insurance Agency, a government agency administering all social insurances, determines the subsidized fee depending on the dental service provided, and reimburses the caregiver (8).

The traditional way for adult patients to pay for dental care (*patient financial system*) is by fee-for-service, where, after completed treatment, the patient pays for the services that have been provided, the subsidy discounted. In 1999, an alternative patient financial system was introduced: *subscription care* (24), where the patient pays a fixed sum of money annually, and then receives needed dental care without additional costs. The sum the patient pays depends on his/her dental health and care needs, which are assessed through risk classification (24). Subscription care is also subsidized by the general dental care insurance, with a set subsidy per patient enrolled with the caregiver (8). Where subscription care is offered by the PDHS, the choice of patient financial system is voluntary, decided by both patient and caregiver. As of yet, no private practitioner in Sweden offers subscription care.

In 1999, the PDHS in the county council of Värmland implemented subscription care under the name *contract care*. The contract care system was based on a risk group classification and a contract between caregiver and patient. The contract offers basic dental care and odontologically motivated prosthodontics and orthodontics (5). The risk group classification consists of four categories: general, technical, caries, and periodontal risk, see table 1. There are a total of 16 risk groups (0-15), to which a payment schedule is linked. The patient's contract care fee is determined by his or her risk group classification.

In 2000, a limited study on the implemented contract care system was undertaken. Dental health was measured as average number of teeth, and number of filled and decayed teeth. The patients enrolled in contract care had slightly better dental health than patients in fee-for-service care (6). However, the results could only be interpreted as tentative, because of the short time span since contract care was introduced.

In 2003, a survey was undertaken in Värmland to study how the patient financial systems affect the dental care situation and the patients' oral health-related quality of life (OHRQoL). This paper is the first in a series of reports from this survey.

The aims of this paper were to compare the demographics, the general health and the OHRQoL in the patient financial systems fee-for-service and

Table 1: The risk indicators of each category in the risk classification [a]

General risk (G)	Technical risk[b] (T)	Caries risk (C)	Periodontal risk (P)
1. General disease	1. Morphological occlusion	1. Activity/ prophylactic needs	1. Activity/ prophylactic needs
2. Occlusion	2. Attrition	2. Saliva	2. Difficulty scaling
3. Dental Anxiety	3. Fillings	3. Prevalence	3. Prevalence
4. Cancellations/failed atteadance	4. Endodontics	4. Diet	4. Smoking
5. Communication/ cooperation	5. Fixed prosthodontics	5. Oral hygiene	5. Oral hygiene/ gingivitis
6. Use of tobacco	6. Post	6. Other	6. Other
7. Oral mucosa	7. Removable prosthodontics		
8. Other, age	8. Third molars		
	9. Other		

Risk group classification: G+2*T+C+P

[a] Each risk category is assessed from 0 (no risk) to 3 (severe risk)

[b] Considered to be more severe risk, therefore multiplied by two in the risk group classification

contract care in the PDHS in Värmland, also accounting for non-response.

Material and methods

Participants
Of nearly 80,000 patients enrolled with the PDHS in Värmland on one-year basis, some 16% belonged to contract care. The PDHS provided names, birth dates and addresses of 1,200 patients in each financial system, consecutively selected from patient lists.

Material
The participants were sent a questionnaire about patient financial systems, OHRQoL, dental anxiety, humanism of caregiver, general health, multidimensional health locus of control, sense of coherence, self-esteem and demographics. For the purpose of this study, only the measurements of general health, OHRQoL and demographics are described.

General health was measured with the Swedish version of the SF-36, which measures general health in eight dimensions: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. After weighting, all dimensions range from 0 to 100, where higher scores indicate better health (27).

OHRQoL was measured with the short-form Oral Health Impact Profile (OHIP-14), developed by Slade (22) from the original, long-form OHIP (23). Based on Locker's model of oral health (12), the OHIP measures seven dimensions of oral health impact: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap. The scores are summed up to an overall OHIP score ranging from 0 to 56, with a lower score indicating better OHRQoL. For this study, the Swedish translation (11) and the additive method of calculating scores (1) were used.

The demographic questions were "birth country" (Sweden; other country), "marital status" (married/living with somebody; unmarried/living alone), "education" (primary education, secondary education, college/university) and two questions measuring social anchorage, an indicator of social network (29): "social affinity with neighbourhood" and "social affinity with housing area" (strongly; to a certain extent; not especially; not at all).

Method/Analysis of data
The material was analysed using SPSS 13.0 for Windows. Non-response was analysed with logistic regression analysis. The special non-response study was analysed with contingency tables χ^2, Mann-Whitney non-parametric test and logistic regression analysis. Gender, birth country, marital status, education, and social network were analysed with contingency tables χ^2. Age was normally distributed and analysed with independent-samples t-tests. The OHIP-14 and the SF-36 were highly skewed and analysed with Mann-Whitney non-parametric test. A significance level of $p \leq 0.05$ was set.

Results

Non-response analysis
Of the provided sample of 2,400 patients, 80 patients were unreachable (3%). The total sample was thus 2,320 patients: 1,158 in contract care and 1,162 in fee-for-service care. The response rate was moderate (57%) which motivated an extensive non-response analysis. A logistic regression analysis was performed with response/non-response as the dependent variable. All variables at our disposal for non-response analysis were used as independent variables: gender, patient financial system and age. All three were significant ($p<0.01$). The likelihood for responding was higher for women (OR=1.27), for respondents in contract care (OR=1.43) and for each additional life year (OR=1.02). Non-response was thus not random, motivating a special study of non-respondents.

In each patient financial system, 40 consecutively selected non-respondents were interviewed by telephone. They were asked about their financial system, educational level and four questions from the OHIP: if they had had painful aching in the mouth, had been self-conscious, had had difficulty doing their usual jobs, or if they had felt that life in general was less satisfying because of problems with their teeth or mouth. All questions were fetched from the questionnaire, providing a basis for comparison between the non-respondents and the respondents. There were three significant differences: the non-respondents had experienced less pain in the mouth ($p<0.001$), less difficulties doing their usual jobs ($p=0.03$) and had found life more satisfying ($p=0.045$) than the respondents. There were no significant differences in gender, age or education. The results indicated that the non-respondents had better OHRQoL than the respondents. A logistic regression analysis was conducted, where non-response/response was set as the dependent variable, with age, gender, education, and the four OHRQoL variables as the independent ones. Only pain was statistically significant (OR=1.69; $p=0.001$), meaning that expe-

rience of pain in the mouth increased the likelihood of response.

Demographics

There were 1,324 returned questionnaires. Of these, 52% were from patients in contract care and 48% from fee-for-service care, 46% men and 54% women. There was no difference between the financial systems as to gender distribution. The age range in the systems was similar, with the youngest participants in both systems being 21 years old. The highest age in contract care was 87 years, while it was 89 years in fee-for-service care. However, there was a significant difference (p<0.001) in mean age between contract care (42 years, SD 13) and fee-for-service care (52 years, SD 17). There was also a difference in birth country (p<0.001), with 96% of the contract care respondents born in Sweden, compared to 91% in fee-for-service care. Marital status was also different (p=0.011), 76% in contract care were married or living with somebody, 70% in fee-for-service care.

Significant results concerning education and social network are presented in Table 2.

Table 2. Distribution of educational level and social affinity with housing area

	Contract care	Fee-for-service care
Educational level	(n=686)	(n=625)
Primary Education	14%	36%
Secondary Education	51%	42%
College/University	35%	22%
χ^2/df^a=90.4 / 2, p<0.001		
Social affinity with		
housing area	(n=672)	(n=607)
Strongly	42%	49%
To a certain extent	35%	34%
Not especially	19%	14%
Not at all	4%	3%
χ^2/df^a=7.2 / 2, p=0.049		

[a] Pearson χ^2, df[a]=degrees of freedom

Oral health-related quality of life

As to OHRQoL, the descriptive statistics for the dimensions are presented in table 3. There were statistical differences between the patient financial systems on all dimensions but psychological discomfort. For contract care, the mean of the total OHIP-14 score was 4.9 (CI 95%=4.53-5.33; SD 5.3). Fee-for-service care had a mean of 6.9 (CI 95%=6.22-7.54; SD 8.3). Both had a median of 4.0. The difference

Table 3. The OHIP dimension statistics for contract and fee-service care. Range: 0-8

	Contract (680≤n≤684) Mean (SD) CI 95% Median	Fee-for-service (616 ≤n≤624) Mean (SD) CI 95% Median	p
Function limitation	0.3 (0.8) 0.27-0.39 0	0.6 (1.3) 0.53-0.73 0	<0.001
Physical Pain	1.9 (1.5) 1.81-2.03 2	2.2 (1.8) 2.03-2.31 2	0.023
Psychological discomfort	1.1 (1.5) 1.03-1.25 1	1.4 (1.9) 1.28-1.58 1	0.063
Physical disability	0.3 (0.8) 0.27-0.39 0	0.7 (1.3) 0.55-0.75 0	<0.001
Psychological disability	0.7 (1.1) 0.60-0.76 0	1.0 (1.5) 0.88-1.12 0	0.003
Social disability	0.2 (0.7) 0.18-0.28 0	0.4 (1.0) 0.34-0.50 0	0.007
Handicap	0.3 (0.8) 0.23-0.35 0	0.6 (1.2) 0.49-0.69 0	<0.001

between the systems was significant (p=0.019): the patients in contract care had better OHRQoL.

General health

As to general health, the descriptive statistics for the patient financial systems are presented in Table 4. There were differences between the patient financial systems on half of the dimensions. Each patient financial system was also compared with the norms for the general Swedish population (27), see Table 4.

There were several differences between the financial systems and the norms. Contract care patients were healthier than the general Swedish population as to physical functioning and general health, but less healthy as to vitality and mental health. The fee-for-service care patients had a more stable pattern: they scored significantly lower than the general Swedish population on six of the dimensions. This indicated that, except for bodily pain and role-emotional, the fee-for-service care patients were less healthy than the general population.

Table 4. The SF-36 statistics for contract care, fee-for-service care and norms for the general Swedish populaion. P-values for difference between the financial systems * for difference between the norms for the general Swedish population and the financial systems. Range: 0-100

	Contract (678≤n≤685) Mean (SD) CI 95% Median	Fee-for-service (604≤n≤628) Mean (SD) CI 95% Median	p	Norms N=8.930 Mean (SD) CI 95% Median
Physical Functioning	92.7 (13.6) 91.7-93.8* 100	84.6 (21.8) 82.9-86.4* 95	<0.001	87.9 (19.6) 87.5-88.3 95
Role-Physical	84.5 (29.6) 82.3-86.8 100	77.0 (36.6) 74.1-80.0* 100	0.002	83.2 (31.8) 82.5-83.8 100
Bodily Pain	77.1 (24.1) 75.3-78.9 84	74.5 (26.8) 72.4-76.6 84	0.221	74.8 (26.1) 74.3-75.4 84
General Health	78.0 (19.1) 76.5-79.4* 82	72.4 (21.9) 70.7-74.2* 77	<0.001	75.8 (22.2) 75.4-76.3 82
Vitality	64.6 (23.2) 62.8-66.3* 70	65.3 (24.9) 63.4-67.3* 73.3	0.267	68.8 (22.8) 68.3-69.3 75
Social Functioning	87.8 (19.6) 86.3-89.2 100	84.9 (22.4) 83.2-86.7* 100	0.045	88.6 (20.3) 88.2-89.0 100
Role-Emotional	84.7 (30.3) 82.5-87.0 100	83.1 (32.9) 80.5-85.8 100	0.570	85.7 (29.2) 85.0-86.3 100
Mental Health	79.0 (18.2) 77.7-80.4* 84	78.5 (18.9) 77.0-80.0* 84	0.962	80.9 (18.9) 80.5-81.3 88

Discussion

Participation in the present study was moderate, despite three reminders sent to non-responders. Non-response is a serious problem in research, and Statistics Sweden reports that non-response rates of 20%, or higher, are common (18). For example, the seven surveys comprising the Swedish SF-36 Health Survey had response rates between 60% and 74% (26).

Non-response increases the probability of bias. However, research has shown that this may not always be the case (13, 15, 21), even with low response rates (13). Nevertheless, "non-response bias is a possibility whatever the response rate and should not be ruled out or assumed by investigators until non-response bias analysis has been undertaken." (13, p. 112). The non-response analysis of the present survey showed that response was not random. Non-respondents had better OHRQoL than the respondents. Thus, healthier patients may have been less interested and therefore less inclined to participate in the study, a known phenomenon in questionnaire studies (17). The size of the questionnaire may also affect response rates. The present questionnaire was substantial and non-respondents in contact with the first author primarily raised this issue as reason for non-response.

Several differences were found between the two patient financial systems. The respondents in contract care were younger, had better education, were born in Sweden and were married or living with somebody to a larger extent than those in fee-for-service care. The difference in education was compared to public statistics, with contract care respondents somewhat better educated than the average population (20). The respondents in fee-for-service care experienced greater social affinity with their housing area than the respondents in contract care did. Where differences in health existed, the respondents in contract care had better OHRQoL as well as better general health than the respondents in fee-for-service care. As a whole, there were social differences in choice of financial system.

To our knowledge, the OHIP-14 has not previously been used in Sweden for general populations. The only similar studies found concerned a German population (10), an Australian one and a population from the UK (25). The German study had a sample of 2,050 persons (age range: 16-79 years) with 75% still having their natural teeth. The median of the OHIP-14 for these was 0. In the present study, the medians were 4.0 for both financial systems. The difference in the results might not necessarily indicate that the German population was healthier than the populations in the present study. Other explanations could be possible, such as cultural differences in perception of OHRQoL. *Steele et al* (25), using data from the Australian National Dental Telephone Survey and the 1998 UK Adult Dental Health Survey, studied 3,406 dentate participants from Australia and 3,662 from the UK (age range: <30-70+ years). The means were 7.4 (SE 0.13) for the Australian sample and 5.1 (SE 0.11) for the British one. Standard deviations were not accounted for. Compared to the present study, the contract care patients had better OHRQoL than both the Australian and the UK samples. The fee-for-service care patients had only slightly better OHRQoL than the Australian sample.

Fernandes et al (4) validated the OHIP-14 with patients (age range: 18-70 years) from the Scottish Molar Actuarial Life Table (MALT) Project. The inclusion criterion was at least one pathology- and symptom-free impacted lower third molar. The OHIP-14 was distributed at baseline and at a one-year follow-up. At baseline, with 278 patients participating, the mean was 6.5 (SD 7.9). At the follow-up, 169 completed the OHIP-14. The mean was now 6.7 (SD 7.2). Comparing these results with the findings from the present survey, the patients in contract care had better OHRQoL than the participants in the Scottish MALT Project, while the fee-for-service patients were similar.

Comparing studies using the OHIP is complex. There are three methods of calculating scores: the simple-count method (OHIP-SC), the additive method (OHIP-ADD) and the weighted-standardised method (OHIP-WS) (1). The OHIP-SC dichotomises the answer alternatives of the items before adding all questions to a summary score. The OHIP-ADD simply adds up each item to a summary score. With the OHIP-WS, on the other hand, each item is multiplied with an item weight. The weighted items of each dimension are summed into summary scores standardized to means with standard deviations of 1, before finally added up to a summary score. The different scoring methods are believed to have different impacts on predictive validity and ability to discriminate between groups. However, *Allen & Locker* found that there were negligible differences between the use of OHIP-ADD and OHIP-WS, although both methods were better than the OHIP-SC (1).

Another problem is that both the long and the short versions of the OHIP might, in different languages, exist in different lengths. The original English long version has 49 items (23) while the German version has an additional 4 items (9, 10). Further, besides the OHIP-14, there are also two additional short versions in German, with 5 and 21 questions respectively (OHIP-G5 and OHIP-G21) (10). Developments of different lengths of the measurement in different languages add to the complexity of comparisons. Inclusion and exclusion of items create new instruments, making reliable comparisons of the OHIP more troublesome.

While the OHIP-14 may be one of the better OHRQoL instruments available to use in questionnaires, it is not unproblematic. The OHIP-14 has been found to suffer from "floor effects" (2, 14), i.e. "many scores pile up at the low end [of the scale] because it is impossible to have a lower score" (3, p. 19), espe-

cially with elderly populations (16). The effect may cause inability to discriminate within groups, i.e. subgroups, such as edentulous (16), and to discriminate improvements in OHRQoL after interventions (2, 14). On the other hand, it has been found to discriminate well between groups (14). There were indications of a floor effect in the present study. The OHIP-14 may have failed to discriminate subgroups with oral health issues not represented in the instrument. However, as the aim of the present study was to generally compare the patient financial systems contract and fee-for-service care, the possible floor effects were secondary to the discriminatory ability of the instrument, and differences were indeed found.

As to general health, the most interesting finding was that the fee-for-service care patients were less healthy than the general Swedish population in almost every aspect, while the contract care patients were less healthy than the general population only in two aspects and healthier in two others. As with the OHIP-14, studies with the SF-36 on general populations are rare. Besides the norms for the general population established with the Swedish SF-36 Health Survey (27), only one more study was found (19). However, comparison was not possible, since standardised maximums of 100 were not used in that study.

There could be at least two explanations to the differences in health and OHRQoL. Either there might be social selectivity of the two patient financial systems, or contract care might have positive health effects. Neither explanation can be excluded in bivariate analysis. In following papers, the differences between the patient financial systems will therefore be further investigated with multivariate analyses.

Conclusion

The patients in contract care differed in several aspects, having better general health and OHRQoL than patients in fee-for-service care. Social differences in choice of financial systems were found. There was bias in non-response, with healthier non-respondents. Several difficulties in comparing studies were identified. The findings of the OHIP and the SF-36 reveal that these HRQoL measurements mainly have been used in populations with known health issues and not in general populations.

Acknowledgements

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Subjective evaluation of orthodontic treatment and potential side effects of bonded lingual retainers

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Abstract

◉The primary aim of this study was to evaluate our patients' experience of their treatment period with a fixed appliance and their opinions about the results five years after completion of active treatment. A second aim was to assess bonded lingual retainers and their potential side effects. A final aim was to compare the results in a postgraduate clinic (Göteborg) and a specialist clinic (Vänersborg).

This study included 170 patients who finished their active treatment in 1997-1998. Eighty-three patients were from Göteborg (postgraduate clinic) and 87 from Vänersborg (specialist clinic). The patients were examined for visible calculus, approximal caries in the anterior regions, gingival recessions and the status of existing retainers in the upper and lower anterior teeth. All patients completed a questionnaire and were interviewed after undergoing a clinical examination.

The statistical methods used were descriptive analysis and the chi-square test.

The main reason for orthodontic treatment was appearance and most patients (94%) were satisfied with their treatment result. Our results showed a significantly higher frequency of loosened or fractured retainers at the postgraduate clinic compared to the specialist clinic (p<0.01), which might be explained by operator sensitivity in bonding retainers. There was a tendency for calculus to develop more easily with than without retainers.

Conclusion: Patient satisfaction of the treatment given at the postgraduate clinic was the same as at the specialist clinic except for more frequent loosening of bonded retainers.

Key words

Follow-up study, questionnaire, gingival recessions, patient opinion

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Subjektiv utvärdering av ortodontisk behandling och möjliga bieffekter av bondade linguala retainrar

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Sammanfattning

◎ Målen med denna studie var att utvärdera våra patienters egna upplevelser från sin behandlingsperiod med fast tandställning och deras åsikter om resultatet 5 år efter avslutad aktiv behandling, att bedöma kvarvarande bondade linguala retainrar avseende möjliga bieffekter samt att jämföra behandlingsresultaten mellan en specialistklinik (Vänersborg) och en utbildningsklinik för specialister i ortodonti (Göteborg).

Etthundra sjuttio patienter, vilka avslutade sin tandregleringsbehandling 1997-1998, undersöktes. Åttiotre patienter deltog från utbildningskliniken och 87 från specialistkliniken. Patienterna undersöktes med avseende på synlig tandsten, approximal karies, gingivala retraktioner och status på befintliga bondade retainrar i överkäks-och underkäks fronten. Patienterna fyllde i ett frågeformulär och blev intervjuade efter genomgången klinisk undersökning.

Resultaten visade att utseendet var den huvudsakliga anledningen till att genomgå ortodontisk behandling och de flesta patienterna (94%) var nöjda med behandlingsresultatet. Resultaten visade signifikant högre frekvens av lossade eller frakturerade retainrar vid utbildningskliniken jämfört med specialistkliniken (p<0.01), vilket kan förklaras av opertörskänsligheten i att bonda retainrar. Det fanns en tendens till att tandsten utvecklades lättare med än utan en bondad lingual retainer.

Slutsats: Patienternas belåtenhet med utförd behandling på utbildningskliniken var den samma som på specialistkliniken, förutom fler lossade bondade retainers.

Introduction

Aesthetic factors are the most frequently reported subjective reason for orthodontic treatment and every second individual considered the appearance of their teeth important for their self-esteem (10,17). From a child's point of view, the most positive motive was increased self-confidence, especially among girls. About 45% of 15-year-old teenagers felt that the result of orthodontic treatment would have a positive effect on their future (9), while individuals who did not receive orthodontic treatment because they had no access to organised orthodontic care reported a high degree of dissatisfaction with their teeth (15). They found that memories of being teased about their physical appearance might persist into adulthood, perhaps representing a general impairment of their quality of life. According to *Bergström et al.* (8) individuals who had declined treatment were more discontent with their teeth as adults than those who had been treated as a child. However, in a recent Swedish study, *Lilja-Karlander et al.* (17) found that 94% of all 19-year-olds that left public dental service were satisfied with their teeth, regardless of the presence of malocclusion. Another Swedish study (16) showed that 10% of patients treated at a specialist clinic were dissatisfied with their dental appearance after treatment and 2% expressed a desire for further orthodontic treatment. The reason for the dissatisfaction was mainly that the teeth moved back towards their original positions. *Little* (18) and *Little et al.* (19) suggest that the degree of post-retention anterior crowding in the mandible is both unpredictable and variable, and no pre-treatment variables, either from clinical findings, casts or cephalometric x-rays, seem to be useful predictors. Only 30% of the patients in premolar extraction cases demonstrated acceptable long-term results, and thus the prolonged use of retention appliances is often discussed. For the maxillary incisors it has been shown that the pattern of pre-treatment rotational displacement has a strong tendency to repeat itself after retention (27).

A bonded multistranded wire was introduced as a method of retention in the mid-1970s (31). These retainers provide an opportunity for extended periods of retention, especially in cases with a higher risk for relapse (e.g., severe rotations or general dental spacing). However, breakage and loosening of the retainer in prolonged use must be considered. Most bond failures usually occur within the first year. *Al Yami et al.* (2) showed that about half of all relapses take place in the first two years after retention. They found that all occlusal traits relapsed gradually but remained stable as of five years post-retention, except for the lower anterior teeth.

The risks of side effects (e.g. caries, gingival recession and gingival inflammation because of calculus accumulation or other damage to hard and soft tissue) from wearing long-term bonded retainers are frequently discussed in the literature.

The aims of this study are threefold:

1. Evaluate the patients' personal experiences of the treatment period and their opinion of treatment outcome, with or without retainers, five years after completion of active treatment.

2. Evaluate the side effects of bonded lingual retainers.

3. Compare the results of a postgraduate and a specialist clinic.

Material and methods

The investigation was conducted at the Specialist Orthodontic Clinic in Vänersborg (Vbg), Sweden, and the Postgraduate Clinic Department of Orthodontics, Clinic of Odontology, University of Göteborg (Gbg), Sweden.

All 113 patients treated with a fixed appliance that had finished their orthodontic treatment in 1997 (18 patients) and 1998 (95 patients) at the Postgraduate Clinic and the first 167 patients who completed their orthodontic treatment in 1998 at the Specialist Clinic in Vbg were invited to participate in the study. Eighty-three patients (49 girls and 34 boys) in Gbg and 87 patients (65 girls and 22 boys) in Vbg participated in the investigation. Thirty-three per cent were males and 67% females. The reasons for dropout in Gbg were that some patients had moved out of the area or had changed surnames and were impossible to reach (13 patients) or did not want to participate (2 patients). Despite efforts to reach all patients, 15 additional patients failed to attend. In Vbg 114 patients responded to the invitation letter and 91 were willing to participate. Four patients missed several appointments and were thus excluded. The dropout rates were 26.5% in Gbg and 48% in Vbg.

The mean age at debonding was 17.3 years (range 9.6-42.7 years). The mean treatment time was 1.7 years (range 0.4-3.5 years). Eighty-nine and 81% of the patients were treated in both arches in Gbg and Vbg, respectively.

In most patients in Vbg, the retainer wire used was 0195 Wildcat (three-stranded spiral wire) bonded canine to canine in the upper and/or lower anterior region. In Gbg, the retainer wire used was mainly

0175 or 0195 Pentaone (five-stranded spiral wire).

The Ethics Committee of the Medical Faculty, Sahlgrenska Academy at Göteborg University, approved the study. (S 024-03). Informed consent was obtained from each patient. The study was conducted in accordance with the Declaration of Helsinki.

Five years after active treatment terminated, all patients were examined and photos and study casts were taken. All patients filled in a questionnaire (see Appendix) and were interviewed at the time of the examination. The patients were examined by one dentist in each clinic for visible calculus and/or caries in the upper and lower anterior teeth, for gingival recessions and for the condition of existing retainers in the anterior region (canine to canine in the upper and lower arch). The frequency of retainer failures was checked in the patient records. Initial caries was defined as whitish enamel decalcification without cavities while manifest caries was defined as demineralisation with cavities. Gingival recession was defined as the location of the marginal tissue apical to the cemento-enamel junction with exposure of the root surface.

Interview
1. Are you satisfied with the outcome of the treatment?
2. Do you think that your teeth have moved since your orthodontist removed the fixed appliance five years ago?

Statistical analysis
Data were analysed using the Statview program (version 4.5). The mean, frequency and standard deviation were calculated for the quantitative variables.

The chi-square test was applied to test the difference between the two clinics in the qualitative variables recorded. Because of the risk of mass significance, we considered only *p-values* ≤ 0.01 as significant.

Results
All results without a statistically significant difference between the two clinics were pooled. When significant differences were found, the results were recorded separately.

Interview
Ninety-four per cent of the patients interviewed were satisfied with their treatment. Four percent of the patients reported that the result was "quite good but not 100%" because of a small relapse and food im-

Table.1 Patient response to the first question in the questionnaire.

Who introduced you to othodontic treatment?				
Your parents	General practitioner	Specialist /medical doctor	Yourself	Someone else (siblings)
38%	61%	14%	46%	2%

paction. Two per cent were dissatisfied because their teeth had moved back to their former position.

More than half of the patients (55%) felt that their teeth were stable; 43% experienced that their teeth had moved, although they were still satisfied.

Questionnaire
The general practitioner together with the patient initiated the orthodontic treatment in most of the cases. In more than one third of the cases the parents had strong opinions about their children's teeth and were responsible for initiating orthodontic treatment (Table 1).

About half of the patients (49%) felt that they could influence the decision about starting treatment; 32% thought that they could influence the decision to some extent and 13% felt that they could not. Five per cent of the patients did not remember (Question 3).

According to 81% of the patients, the principal reason for seeking treatment was to enhance their appearance. Some of the patients (7%) were teased because of their dental malocclusion and 21% considered chewing a major problem. Other reasons (25%) included tension headache, "my upper lip got stuck on my teeth", " afraid of how the future would be", "dry in the mouth – couldn't close my lips", disturbing while talking", "I was not disturbed, but my dentist was!" (Question 2).

Seventy per cent of the patients were satisfied with the information that they had received before and during treatment, whereas 22% did not answer or did not remember whether the information was adequate. The remaining 8% of the patients had trouble getting or understanding the information that was presented for various reasons (e.g. "hard to understand my English speaking dentist"; " I didn't know that I had a choice"; "I wish I'd gotten information about how long each appointment would last"/ "how many months the treatment would last"; and "I didn't know about the soreness or missed the instructions in oral hygiene") (Question 4).

A statistically significant difference was found bet-

◎ **Table 2.** Patient response to question 6 in the questionnarie.

Did you experience that the treatment caused obvious problems?						
Pain	Problems eating and chewing	Oral hygiene	Caused caries/gingivitis (a)	Appliance often broken? (b)	Time-consuming	Others (lisping, soreness
72%	58%	49%	12%	17%	31%	6%

◎ **Table 3.** Patient response to question 7 in the questionnaire.

Opinions about how the patients found the treatment time:	
-"As long as you expected":	41%
-"Longer than you expected":	34%
-"Much longer than than you expected":	8%
-"Shorter than you expected":	16%
-No answer	1%

◎ **Table 4.** Patient response to questions 9, 12 and 13 in the questionnaire.

	Yes, absolutely	Quite good /maybe	No, not at all	No answer
Has the treatment result lasted?	64%	32%	4%	0%
Do you think that you need more orthodontic treatment?	8%	6.5%	82%	3.5%
Was the result worth all the trouble?	81%	18%	1%	0%

ween the clinics in the question of whether the treatment had a negative influence on their schoolwork (p<0.01). In Gbg, 22% of the patients thought that the treatment had a negative effect on their schoolwork in contrast with 5% in Vbg (Question 5).

Examples of other activities in which the appliance proved disturbing were kissing, sleeping and eating. Moreover, some patients reported being easily irritated and that the appliance lowered their self-confidence.

Pain, eating, chewing and brushing teeth were the most obvious problems patients experienced when wearing a fixed appliance (Table 2).

The most common responses regarding treatment time were "it was as long as I had expected" or "it was longer than I had expected" (Table 3).

There was a statistically significant difference (p<0.01) between the two clinics in how the patients thought that they had reached the treatment goals. In Gbg, 82% of the patients felt that they had completely reached their goals and 18% thought they had reached their goals quite well. The corresponding values in Vbg were 56 and 44%. Accordingly, no patient from either clinic thought that the goals were not reached at all (Question 8).

Most of the patients were satisfied with the treatment result and that it was worth the effort and pain experienced (Table 4). More than half of the patients did not feel that their chewing and muscle/joint function were affected by the treatment at all (Table 5).

In question number 11, the patients were asked to describe in their own words the most important improvement that the treatment achieved. Eighty-eight percent found enhanced aesthetics and improved appearance to be the most important improvement. Eleven percent found it easier to chew and gained improved function. Other improvements were that it was easier to maintain good oral hygiene, a reduction in teeth grinding, improved self-confidence, easier to close the mouth and less muscle pain and joint clicking.

◎ **Table 5**. Patient response to question 10 in questionnaire.

How do you feel that the treatment result influenced your:	Great improvement	No influence at all	Negative influence	No answer
appearance	94%	4%	1%	1%
chewing function	35%	58%	2%	5%
muscle/jointfunction	16%	71%	4%	9%

◎ **Table 6.** Number of loosened or fractured retainers in the upper and lower jaw as a function of the clinic and how many times they had failed (percents are given in parentheses).

Loosend or fractured retainer	Upper jaw n=132		Lower jaw n=139	
	Gbg n=59	Vbg n=73	Gbg n=74	Vbg n=65
Never	19 (32)	46 (63)	29 (39)	45 (69)
One time	23 (39)	15 (21)	24 (32)	14 (22)
>One time	17 (29)	12 (16)	21 (28)	6 (9)

Gbg = Göteborg, Vbg = Vänersborg

◎ **Table 7.** Number of retainers in the upper and lower jaw as a function of the time the retainers were in the patient´s mouth before they broke (percents are given in parentheses).

Presence of retainers in the mouth	Upper jaw (n) (Gbg+Vbg) n=132	Lower jaw (n) (Gbg+Vbg) n=139
>4 years	97 (73)	104 (75)
2 to 4 years	21 (16)	27 (19)
≤2 years	14 (11)	8 (6)

Gbg = Göteborg, Vbg = Vänersborg

Retainers

A significant difference (p<0.01) was noted between the two clinics concerning loosening or fractured retainers. The most common finding was that the retainers never loosened or loosened only once (Table 6).

Seventy-four per cent of all bonded upper and lower jaw retainers were present in the mouth for more than four years (Table 7) and 8% were present for a maximum of two years. The majority of the retainers that were present for more than four years had never loosened or had loosened only once (Figures 1 and 2).

At the follow-up examination, gingival recessions (1-4 sites) were observed in 27 (16%) patients in regions 13-23 and 33-43.

The patients in Vbg had significantly more calculus, both with and without retainers (p<0.01). Among the patients in Gbg and Vbg, 45 and 72%, respectively, had visible calculus in the lower front. In Gbg, calculus was found in 19% of the patients without the retainer and in 60% of those patients that still had the retainer. The corresponding figures for Vbg were 66% without the retainer and 81% with the retainer.

Caries was studied at the Gbg clinic only. Eight patients were found to have approximal (initial or manifest) caries in the upper and lower anterior regions. Of those eight patients, only two still had the retainer. However, there is a risk that these results are biased because orthodontists choose to retain with removable retention in patients with higher caries activity.

Discussion

The main results of this investigation were that aesthetics and appearance were the primary reasons for orthodontic treatment and that improved appearance was the most satisfying outcome of treatment. These findings are consistent with other studies (1, 9, 10, 29). However, the answers to the questionnaire are based on treatment that was given more than five years earlier, which may have influenced what and how much the patients remembered. The recall of past events is affected by positive or negative experiences and the answers to the questions would thus have contained an element of bias. *Bos et al.* (11) concluded that satisfaction with dental appearance is a significant predictor of patients' expectations of orthodontic treatment. In another study (13) the respondents reported that they would rather have straight teeth than healthy ones.

Most of the patients in the present study were satisfied with the treatment outcome and thought that it was worth the trouble that is typically associated with fixed appliances. This finding is in accordance with studies showing that up to 80% of the patients were willing to undergo the same treatment again (9, 22)

Malposition of teeth is the fourth most common reason for being teased, ranked after height, weight and hair (25). In the present study, 7% of the patients had been ridiculed because of their teeth, a figure also found by *Shaw et al.* (25) and *Lilja-Karlander et al.* (17). *Shaw et al.* (25) also showed that teasing because of malocclusion caused more distress than teasing for other reasons. Those children who were
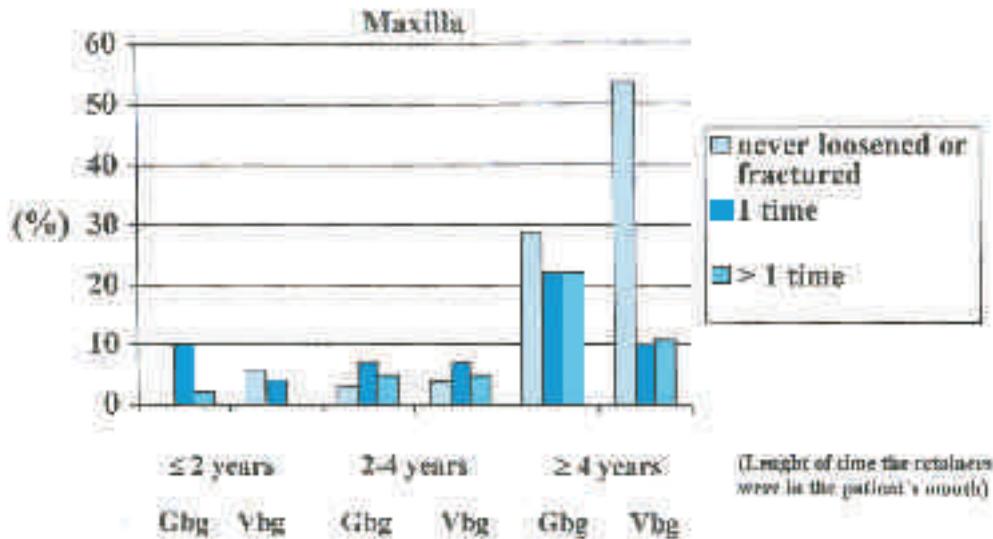
◎ **Figure 1.** Percentage of loosened or fractured bonded retainers in the upper jaw (n=132) in relation to length of intra-oral time and clinic where they were inserted (Gbg = clinic in Göteborg; Vbg = clinic in Vänersborg)
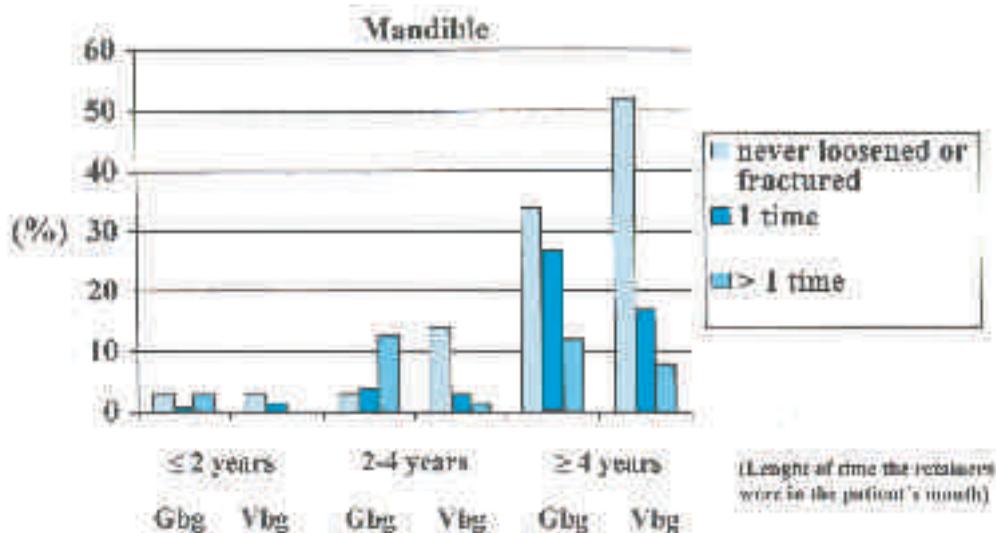
◎ **Figure 2.** Percentage of loosened or fractured bonded retainers in the lower jaw (n=139) in relation to length of intra-oral time and clinic where they were inserted (Gbg = clinic in Göteborg; Vbg = clinic in Vänersborg)

badgered about their teeth were twice as likely to suffer from harassment as those who were badgered about other features. *Helm et al. (*15) reported that schoolmates' teasing occurred seven times more often in children with malocclusion.

Psychosocial or aesthetic reasons for orthodontic treatment are dominating factors from the teenage period and onwards. According to *Mohlin & Kurol* (21), any decision to start orthodontic treatment to impro-

ve aesthetics should not be taken before the child has reached a level of maturity sufficient for serious decision making, normally after the age of 12 years.

Unfavourable perceptions of the teeth were expressed significantly more often by patients with extreme maxillary overjet, extreme deep bite and crowding (15). Every second patient with an extreme maxillary overjet had experienced some form of teasing. Among the teased patients in our study, four

of five in Gbg and five of six in Vbg suffered from a large overjet.

The general practitioners together with the patients were the most common initiators of orthodontic treatment. *Trulsson et al.* (28) found that teenagers thought that their final decision to undergo orthodontic treatment was solely their own. However, their analysis revealed that their decision was strongly impacted by several external and internal factors. However, although they were influenced by others' input (e.g. referring dentist, family members and friends), they felt that they had made an independent decision. In contrast to our findings, *Bergström et al.* (8) and *Birkeland et al.* (10) observed that dental professionals (i.e. specialists and general practitioners) were considered to have the greatest influence on a patient's decision to undergo orthodontic treatment.

Statistically significant differences between the two clinics were found in the question of whether treatment had a negative effect on the patients' schoolwork. The reasons for the differences may be the longer travel distances and longer treatment appointments in the postgraduate clinic in Gbg.

Owing to the fact that long-term stability of orthodontic treatment results is highly variable and unpredictable, it is important to inform each patient of the importance of long-term retention (20).

In the present study, a significant difference was observed between the clinics in the percentage of loosened or fractured retainers, where only half as many retainers in Vbg loosened than in Gbg. This result could be explained by the fact that the dentists in the post-graduate clinic in Gbg were inexperienced in bonding retainers. Because this is a retrospective study, it was not possible to determine the reason for the rebonding and therefore no distinction has been made between bond failure, abrasion or chipping away the composite or breakage of the retainer wire. The failure rates recorded in Vbg are similar to those found by *Andrén et al.* (5), who also followed their patients for at least five years. However, their failure rate involved only bonding failures, and fractures were not included. The failure rate for bonded multistranded retainers ranges from 6-70% in different studies (5, 7, 12, 24, 26). This variation might be due to different wire dimensions and flexibility in the retainers, the extent of the retainer, different follow-up times, whether the retainers were positioned in the maxilla or in the mandible, and an operator's skilfulness in bonding retainers.

Among the teeth with retainers that were exami-

ned, only 2% showed gingival recessions at the five-year follow-up examination, a finding in agreement with *Ruf et al.* (23). All their patients were treated with a Herbst appliance, which proclined the lower incisors during treatment. There are several reasons for developing gingival recessions. In our patients, possible reasons for gingival recession were using snuff, piercing the lower lip, piercing the tongue and intensive tooth brushing. Orthodontic treatment causing labial tooth movement out of the alveolar bone housing was the hypothesised reason in some cases. In a retrospective case-control study of adult orthodontic patients, *Allais & Melsen* (3) found that 10-15% of the patients' teeth had gingival recessions at baseline. New recessions developed in 10% of the teeth investigated but improved in 5%. In growing children, mucogingival problems such as gingival recessions often disappear spontaneously (4, 30).

We found a significant difference between the clinics in the presence of calculus around bonded retainers in the lower front, with more calculus among the patients in Vbg. One possible reason for the different results might be the long interval between regular check-ups at the general practitioner in Vbg. We also found calculus to develop more easily with retainers than without, which is in accordance with previous findings (7, 24, 31).

Very few patients in the present study showed initial approximal caries (white spots) adjacent to the retainer. This finding can be compared with other studies that have shown no demineralisation or caries lesions in teeth contacting the retainer or white spot formation on the lingual surface of the lower anterior teeth (5, 6, 14, 31). Despite occasional accumulation of plaque along the retainers, formation of caries does not normally seem to be a problem (6). The accessibility to free flow of saliva is probably a major factor precluding enamel decalcification. The presence of a retainer and accumulation of plaque along the retainer wire cause no apparent damage to the hard and soft tissue adjacent to the wire. Most patients are not disturbed by the retainers and thus prefer to keep them rather than run the risk for relapse.

The trend today of leaving the retainer bonded to the lower anterior teeth for very long periods necessitates long-term follow-up studies to investigate the durability of the retainers and the response of the adjacent tissue.

Conclusion

1. Aesthetics and appearance are the main considerations for orthodontic treatment.
2. Most patients (94%) were satisfied with their treatment.
3. Pain and problems with eating, chewing and brushing teeth were the most obvious problems that patients experienced.
4. Patients at the postgraduate clinic thought that the treatment had a negative influence on their schoolwork.
5. There were significantly more loosened or fractured retainers at the post-graduate clinic than at the specialist clinic.
6. There is a tendency for calculus to develop more easily with retainers than without retainers.

Acknowledgements

Appendix

Questionnaire

1.Who suggested orthodontic treatment?
1a) your parents, b) your general practitioner, c) specialist/medical doctor, d) yourself
e) other

2. Why were you disturbed about your teeth?
a) appearance, b) chewing, c) teased, d) other reasons

3. How much could you influence the decision to begin orthodontic treatment?
a) very much, b) to some extent, c) not much, d) don´t remember

4. How do feel today about your treatment?
a) Was there any information you lacked before treatment started?
b) Was there any information you lacked during the treatment period?
(no, yes, to some extent, no answer, don't remember)

5. Do you think that the treatment had a negative effect on:
a) your spare time/social activities, b) schoolwork, c) something else, d) no effect at all

6. Did you experience that the treatment caused obvious problems such as:
a) pain, b) problems eating and chewing, c) oral hygiene, d) caused caries/gingivitis
e) frequent breakage of the appliance, f) time-consuming, g) others

7. The treatment time was:
a) as long as you expected, b) longer than you expected, c) much longer than you expected
d) shorter than you expected

8. Did you attain your treatment goals?
a) completely, b) to some extent, c) not at all

9. Has the treatment result lasted?
a) yes, b) no, c) quite stable

10. What kind of improvement did the treatment have on your
a) appearance?
b) chewing function?
c) muscle/joint-function?
(great improvement, no effect at all, negative effect, no answer)

11. Write in your own words the most important improvements achieved by the treatment.

12. Do you think that you need more orthodontic treatment?
a) no, b) yes, c) maybe, d) no answer

13. Was the treatment outcome worth the effort?
a) yes, absolutely, b) yes, to a large extent, c) to some extent, d) not at all

More than one answer was accepted to questions (1), (2), (5) and (6).

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Oral status and treatment needs among elderly within municipal long term care 2002–2004

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Abstract

◎ A supplementary regulation in the Swedish National Dental Health Care Insurance stipulates an increased economic support to those, who are dependent permanently due to disease or handicap. Once enlisted to care, they are entitled to an annual dental examination and individual prophylactic advice free of charge, and to necessary dental treatment, offered within the ordinary medical care, regulated and funded by the county council.

A population of persons, $\geq$65 years of age and enrolled in municipal long term care (LTC) in a county in the south of Sweden, was followed regarding changes in oral status and treatment needs for two years. The number of persons examined the year 2002 was 2416 and the corresponding figure for 2004 was 2846. Totally 1170, i.e. 48.4%, of those examined 2002 were deceased two years after the initial examination. Only 914, assessed in 2002, were available for assessment with full data at follow up 2004 and the results are based upon assessments in this group.

Analyzing the assessed variables (dental status, oral hygiene status, oral mucosal inflammation, oral mucosal friction) revealed a change during these two years. Significant impairments were recognised, regarding mucosal inflammation and mucosal friction. Regarding treatment needs assessed by a dentist and a dental hygienist, there was a maintained and even increased need for extensive treatment, both by the dentist and, to a greater extent, by the dental hygienist. In sum, prevention efforts both from the dental profession and from other care providers are important to achieve and maintain acceptable oral status.

Key words

Elderly, long term care, prevention, oral treatment need.

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Munhälsa och munvårdsbehov inom kommunal äldreomsorg 2002 - 2004

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Sammanfattning

◎ Tandvårdsstödet till äldre i Sverige ändrades 1999 till att omfatta ett utökat tandvårds-stöd till personer inskrivna inom äldreomsorgen, så till vida att dessa personer erbjuds en årlig uppsökande munhälsobedömning inklusive individuell rådgivning utan kostnad samt nödvändig tandvård enligt läkarvårdstaxa.

I ett län i södra Sverige erhöll 2416 personer inom äldreomsorgen uppsökande mun-hälsobedömning år 2002, motsvarande siffra år 2004 var 2846. Totalt 1170 personer, d.v.s. 48,4 % av de, som undersöktes 2002, var avlidna två år senare. 914 personer av dem, som undersöktes 2002, var tillgängliga för undersökning 2004 och resultaten baserar sig på bedömda munhälso-förändringar i denna grupp.

Bedömningsprotokollen fokuserades på variablerna: antal tänder, beläggningsindex, slemhinneindex och spegelindex. Resultatet indikerade en försämring av munhälsan under dessa två år. Försämringen var signifikant för slemhinneindex och spegelindex.

Det av tandhygienister bedömda behovet av tandläkar- och tandhygienistbehandling visade att ett omfattande vårdbehov, d.v.s. vård överstigande 60 minuter, kvarstod hos 2 % i gruppen gällande behandling av tandläkare; motsvarande siffra för tandhygienist var 10,5 %.

Sammantaget visar resultaten på betydelsen av preventiva åtgärder från såväl tand-vårdspersonal som annan vårdpersonal för att bibehålla vårdtagarnas munhälsa.

Introduction

Since 1999, a supplementary regulation in the Swedish National Dental Health Care Insurance stipulates an increased economic support to those, who are dependent due to disease or handicap (42). The support is designed for those receiving permanent long term care (LTC), living either in nursing homes/special housing for the elderly (NH) or in their own dwellings, i.e. ordinary living within municipal home care (HC), with assistance from ambulant nursing personnel or from next of kin for their daily living-activities. All LTC is publicly financed, but some care facilities are privately operated, in free competition. Medical and social needs are decisive factors for being enlisted. Further, those enlisted are entitled to necessary dental treatment, offered within the ordinary medical care, regulated and funded by the county council. This means that the fees for necessary treatment can be reduced to 900 SEK/year at present, including the annual cost for medical visits for an enlisted patient.

Maintaining acceptable oral status in subjects in need of LTC has since long been considered an urgent concern (7,12,20,21,24,26,43), as recently also oral co-morbidities of chronic diseases are recognised (13,27,34-36,39,46,47). One way to improve oral health is through regular screening procedures including preventive measures of those enrolled in LTC (11,16,32,45). It is stated, that care providers shall actively inform the care recipients about the new regulation, mentioned above. The providers are supposed to act as a contact link towards the dental profession, take part in education in oral health, receive instructions in oral care, and also to perform oral care procedures for the care recipients, when needed (38).

To improve the efficiency in both screening and care, one must also have a clear conception of how to ascertain treatment need. Knowledge is limited and often controversial concerning treatment need in this population group (33). The persons enrolled in LTC are frail and mostly old with a decreasing general health and reduced possibility to handle oral care and endure extensive dental treatment. This worsens their oral situation. Furthermore, these patients might be reluctant or unable to seek dental care themselves (6,8). Therefore it might be of interest to examine the oral status and treatment needs in this frail elderly population within care.

Aim

The aim of this study was to follow the assessments and the possible changes in oral status and treatment needs in a population of persons enrolled in municipal LTC. The studied period was two years. The protocols from this period were examined, focusing on changes during the studied period in a group consisting of the persons, included the first and the third year

Materal and methods

Subjects

The study was carried out in a county in the south west of Sweden. The study was longitudinal. The study group was those subjects within LTC, in NH and in municipal HC, who were examined by dental hygienists in their visiting oral health examinations during the year 2002. The study group was followed during another two years; protocols from the first and the third year (2004) were included in this study.

Examination procedure

The examinations were mainly performed in the subjects' own homes (with the patient on a chair or in bed) by dental hygienists, responsible for the districts of the examined subjects. In one municipality there was access to a mobile dental unit. The examinations were blunt, as the tools used were mainly a dental mirror and a halogen lamp. Individual prophylactic advice followed the examination, when needed.

Examination protocol

Oral status was estimated by means of a validated protocol, used in previous studies (2,14,16,28), this protocol also forming the basis for epidemiological reports concerning oral assessments among elderly in a county in the south of Sweden, according to a new paragraph in the Swedish National Dental Insurance (40,41). This protocol (16,28) evaluates oral status; i.e. number of teeth, and oral mucosal status; i.e. oral hygiene status (plaque index, PI), oral mucosal inflammation (mucosal index, MI) and oral mucosal friction (mucosal friction index, MFI) (15), using blunt measurements, a necessity taking into account the circumstances under which the examination was performed. Based on these registrations, the treatment time needed for the dentist and/or the dental hygienist, was roughly estimated for each profession.

Statistical analysis

Descriptive statistics were performed by means of

◎ **Table 1.** Number of examined eldery (65 yrs old) within LTC; at baseline in 2002 and at follow-up in 2004. Among the total studied population 2002 (n=2416) only 914 were aviable for assessment with full data at follow up.

	Totally examined		The study group	
	Year 2002	Year 2004	Year 2002	Year 2004
Men n (%)	732 (30.3)	899 (31.6)	234 (25.6)	234 (25.6)
Mean age (S.D.)	83.7 (7.0)	84.1 (7.1)	82.8 (7,1)	84.8 (7.1)
Women n (%)	1684 (69.7)	1947 (68.4)	680 (74.4)	680 (74.4)
Total n	2416	2846	914	914

◎ **Table 2.** Changes in the examined variables, plaque index (A), mucosal index (B) and mucosal friction index (C), concerning assessed oral health in the cohort (n=914) in 2002 and 2004, respectively. persons, in whom assessments of these variables were not able to perform, are excluded.

2 A. Oral hygiene, expressed as plaque index (PI). N=877.

		Oral Hygiene 2004					
		Good, acceptable oral hygiene		Less good, poor oral hygiene		Total	
		n	%	n	%	n	%
Oral Hygiene 2002	Good, acceptable oral hygiene	411 (76.8%)	79.0	133 (23.3%)	41.7	574 (100%)	65.5%
	Less good, porr oral hygiene	117 (38.6%)	21.0	186 (61.4%)	58.3	303 (100%)	34.5%
Total		558 (63.6%)	100	319 (36.4%)	100	877 (100%)	100%

p=0.343. OR=5.3

2 B. Mucosal inflammation, expressed as mucosal index (MI). N=867.

		Mucosal Index 2004					
		No, mild inflammation		Moderate, severe inflammation		Total	
		n	%	n	%	n	%
Mucosal Index 2002	No, mild inflammation	669 (87.2%)	93.0	98 (12.8%)	66.2	767 (100%)	88.5%
	Moderate, severe inflammation	50 (50%)	7.0	50 (50%)	33.8	100 (100%)	11.5%
Total		719 (82.9%)	100	148 (17.1%)	100	867 (100%)	100%

p<0.000. OR=6.8

2 C. Mucosal friction index (MFI). N=855.

		Mucosal Friction Index 2004				
		No, some dryness		Obvious dryness		Total
		n	%	n	%	n
Mucosal Friction Index 2002	No, some dryness	714	96.1	91	81.2	805
	Obvious drynéss	29	3.9	21	18.8	50
Total		743	100	112	100	855

p<0.000. OR=5.7

cross-tabulation and frequency tables, and analytical statistics were calculated employing the Mc Nemar Test, with p< 0.05 being considered statistically significant.

Results

The number of persons, ≥65 years of age and within long term care, examined year 2002 was 2416. There were 732 men with an age of 83.7 (S.D. 7.0) and 1684 women, aged 86.1 (S.D. 6.4). The corresponding figures regarding 2004 and the studied group are shown in Table 1. Totally 1170, i.e. 48.4%, of those examined 2002 were deceased two years after the initial examination. Only 914 were available for assessment with

◎ **Table 3.** The assessedneed of treatment by the dentist (A) and the dental hygienist (B) in the cohort 2002 and 2004, respectively. Persons, in whom assessments of these variables were not able to perform, are excluded.

3 A.

		Assessed treatment need by dentist 2004				
		No need and need ≤60 min		Need >60 min		Total
		n	%	n	%	N
Assessed treatment need by dentist	No need and need ≤60 min	648	93.6	59	79.7	707
	need >60 min	44	6.4	15	20.3	59
Total		692	100	74	100	766

p=0.16. OR=3.7

3 B.

		Assesseed tretment need by dental hygienist 2004				
		No need and need ≤60 min		Need >60 min		Total
		n	%	n	%	N
Assessed treatment need by dentist hygienist 2002	No need and need ≤60 min	634	91.9	81	47.1	715
	need >60 min	62	8.9	91	52.9	153
Total		696	100	172	100	868

p=0.13. OR=11.5

full data at follow up and the results are based upon assessments of these persons.

Regarding dentition, totally 36.6% of all those examined in 2002 had 10 or more teeth; two years later, 39.8% had 10 or more teeth. However, of those studied at both occasions, the share with < 10 teeth increased by about 1 percent unit (from 20.6 to 21.7%). Similarly, those with ≥ 20 teeth decreased as much (from 16.2% in 2002 to 15.3% in 2004). There was an increase, as to implants, in all the examined elderly, twice as many in 2004 as in 2002, but still a low share, about 0.3%.

The result of the assessed variables, i.e. modified plaque index (PI), mucosal index (MI), and mucosal friction index (MFI), revealed a significant impairment as to MI and MFI from 2002 to 2004 (Table 2). On the other hand, 50% of those examined had a persistent good or acceptable oral hygiene and 77% were registered with acceptable mucosal conditions, whereas 84% showed no/some dryness.

The assessed need of treatment by the dentist and the dental hygienist on an individual basis in the study group is shown in Table 3. In 2002, the assessed number of examined persons without need to be seen by the dentist was 450, i.e. 49.2%; this figure being 578, i.e. 63.2%, two years later. The corresponding figures for the dental hygienist were 296; i.e. 32.4%, and 341; i.e. 37.3%, respectively.

In another view, 85% in the study group had a persistent registered need of no need/need ≤ 60

minutes for measures by the dentist; the corresponding figure for treatment by the dental hygienist was 73%.

Discussion

For the elderly patient, activities of daily living decline with increasing age (4). There might be a long duration of progressive cognitive decline and loss of functional tasks (29), prior to enrolment in care. The fragility of this studied population was obvious, as almost half of those examined 2002 were deceased two years after the first examination. Therefore, this study focused on variables, aiming at maintaining or achieving acceptable oral conditions.

Regarding number of teeth in the study group, the increase during the observation years for dentate persons with 1-9 and 10-19 teeth, might be explained by dental treatment given, thus increasing the amount of teeth (as decayed roots were not counted as teeth). Regarding the whole group, examined in 2002 respectively 2004, there was a decline registered in being dentate, from 56% to 52%, but an increase in persons having more than 10 teeth, from 37% to 40%. The tendency of increasing number of teeth in this population, indicates a growing demand for oral/dental care in this population, to be met primarily by nursing personnel and oral hygienists, but also by dentists.

Further, the impact of measures from the dental profession is not obvious. The results indicated that

the variables MI and MFI were significantly impaired on an individual level during the studied years (Table 2). Regarding oral hygiene, expressed as PI, no significant difference was noted in time. The dental profession announced their visits in advance, which may have increased the temporary efforts in oral hygiene. This may contribute to explain why no correspondent improvement in mucosal inflammation was registered.

Regarding assessed treatment need by a dentist and a dental hygienist (Table 4), there was a maintained and even an increased need for extensive treatment, i.e. treatment need >60 minutes, both by the dentist and, to a greater extent, by the dental hygienist. The assessed persistent need for extensive treatment was more pronounced for measures by the dental hygienist than by the dentist. This increased need might mirror problems in making visits to a dental clinic as well as difficulties in performing daily oral care due to a declining general health in this population (37). Prophylactic measures would benefit from being repeatedly discussed with the nursing personnel during the assessment visits. The care providers would need this continuous support, being responsible for the daily care of the care recipients, often too frail to perform oral care themselves.

It is important with a positive attitude from those in charge of special housing for the elderly, recognising its impact on general health (5,23,25,31). This could result in more time given to the providers to perform oral care. There must also be a feeling of responsibility in the personnel in providing oral care (44). Still, one has to bear in mind that the examined persons were two years older and that their general health might have become further impaired and their medication increased in the third year.

Regarding treatment needs, it is expressed in one regulation (18), that necessary dental care is to be performed, considering the condition and need of the patient; i.e. a holistic view of the life-situation and medical status of the patient within LTC. That means refraining from extensive treatment unless aiming at improving quality of life, i.e. a limited or comprehensive intention. Further, it is stated, that necessary dental treatment is to be based on long term planning. The dentist is to adopt a wait-and-see policy of the care recipient's medical status and demand of dental care. Dental care is to be performed in stages, with a palliative or limited intention. Necessary dental treatment should aim at decreasing oral pain and infection, i.e. an emergency or palliative intention.

Oral health care providers, when focusing on prevention, might help to improve quality of life within elderly care (9,10,19,22). Poor dental health, linked to increased mortality among elderly, supported in studies by Hamalainen (13), is to be considered.

The growing emphasis on the concept of "successful" aging with retention of natural dentition (17) ought to increase the demand for oral care within municipal care (32) in years to come. This underlines the statement by Nordström (30), who "emphasises the importance of improving dental status while the elderly patient is still able to adopt to a new situation and thereafter maintain the oral function for life", also expressed by Ahluwalia and Sadowsky (3).

Conclusion

The application of The Swedish National Dental Health Care Insurance from 1999, aiming at maintaining or achieving an acceptable oral health in subjects in need of LTC, is to become a part of the care of the elderly within LTC. This two years-analysis of visiting activity exposes an impairment in variables concerning oral status, and also a persistent need of extensive care by the dentist and the dental hygienist.

In sum, the study shows the importance of maintaining regular cooperation between the nursing and the dental profession within elderly care, to maintain/achieve an acceptable oral status in the elderly within LTC. The fragility of the elderly within LTC, indicated by a high mortality figure, further makes it important to primarily stress the need for oral prophylaxis in order to avoid extensive dental treatment, and, especially, emergency dental need.

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