Institute of Dentistry, Department of Oral Public Health, University of Helsinki, Finland

CARIES-PREVENTIVE TREATMENT APPROACHES FOR CHILD AND YOUTH AT TWO EXTREMES OF DENTAL HEALTH IN HELSINKI, FINLAND

Sinikka Varsio

Academic dissertation

To be presented, with the permission of the Faculty of Medicine of the University of Helsinki, for public discussion in the main auditorium of the Institute of Dentistry, Mannerheimintie 172, Helsinki, on 24 September, 1999, at 12 noon.

Helsinki 1999

Supervised by

Docent Miira Vehkalahti, DDS, PhD
Department of Oral Public Health
Institute of Dentistry
University of Helsinki, Finland

Professor Heikki Murtomaa, DDS, PhD, MPH
Department of Oral Public Health
Institute of Dentistry
University of Helsinki, Finland

Reviewed by

Docent Eeva Widström, M.Sc, DDS, PhD
Karolinska Institute, Stockholm, Sweden and
Institute of Dentistry, University of Oulu, Finland

Docent Lars G. Petersson, DDS, PhD
Institute of Dentistry
University of Lund, Sweden

ISBN 951-45-8706-5 (PDF version)
Helsingin yliopiston verkkojulkaisut 1999

Electronic version available at http://ethesis.helsinki.fi

ABSTRACT

Varsio S. Caries-preventive treatment approaches for child and youth at two extremes of dental health in Helsinki, Finland. Department of Oral Public Health, University of Helsinki, Finland, 1999. 65 pp. ISBN 952-91-1150-9.

This study determined the prevalence and distribution of dental caries among young populations during the last two decades in Helsinki, Finland, and evaluated dentists' caries-preventive treatment approaches in real-life dental practice.

Data on numbers of dmf or DMF teeth and of teeth with current untreated caries (dt+DT) were collected from the annual official statistics of the Helsinki City Health Department for all 5- and 15-year-olds clinically examined from 1976 to 1993, amounting to about 4,000 patients in both age-groups in each year. Polarization of dental caries was described as the proportion of high-caries groups in each year, and as the proportion of dt+DT and dmf or DMF teeth in each high-caries group of the total number of all such teeth in the entire age-group.

The study on caries-preventive treatment practices was cross-sectional, with a two-point design, high-caries group vs. cavity-free group, covering data from 6-, 13-, and 15-year-old patients' oral health records of the year 1992. The high-caries patients (n=294) had the greatest number of dt+DT (5.5 to 8.7, on average, the range 3 to 18). The cavity-free patients (n=88; dmft or DMFT=0, dt+DT=0) were randomly selected from the same clinics as were the high-caries cases.

A strong polarization of caries was found, emphasizing the importance of using frequency distributions of subjects by caries indices in evaluation of caries occurrence in populations. Among the high-caries patients, the treatment strategy was filling-orientated with a slight tendency towards targeted preventive treatment. Dentists' judgement of patients' high risk for caries led a markedly improved caries prevention for these patients. However, dentists seemed to ignore instructions on individualized caries-preventive treatment and to place too much emphasis on clinical dental examinations and caries prevention for the cavity-free patients. Furthermore, uncompleted treatment courses were characteristic of the high-caries patients, offering evidence of the difficulties met in their treatment.

Recommendations are given for actions at the administrative and organizational level as well as for dental teams: individualization of dental treatment and its outcome should be monitored and rewarded; dentists should judge each patient's risk for caries, individualize check-up intervals, and integrate preventive measures into all dental visits of high-caries patients.

The author's address:
Sinikka Varsio, Institute of Dentistry, Department of Oral Public Health, University of Helsinki,
PO Box 41, FIN-00014 Helsinki, Finland. E-mail: sinikka.varsio@helsinki.fi.

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications referred to in the text by their Roman numerals.

I Vehkalahti M, Tarkkonen L, Varsio S, Heikkilä P. Decrease in and polarization of dental caries occurrence among child and youth populations, 1976-1993. Caries Res 1997;31:161-5.

II Varsio S, Vehkalahti M, Murtomaa H. Treatment practices in caries prevention for 6-year-olds in Finland. Community Dent Oral Epidemiol 1999;27 (in press).

III Varsio S, Vehkalahti M. Evaluation of preventive treatment by risk of caries among 13-year-olds. Community Dent Oral Epidemiol 1996;24:277-81.

IV Varsio S, Vehkalahti M. Dentists' decisions on caries risk and preventive treatment by dental state among 15-year-old adolescents. Community Dent Health 1997;14:166-70.

V Varsio S, Vehkalahti M, Murtomaa H. Dental care of six-year-old high-caries patients in relation to their cooperation. Community Dent Health 1999;16:171-5.

CONTENTS

INTRODUCTION

Finland was among the first countries to formulate national goals for improved dental health within the worldwide project 'Health for all by the year 2000' of the World Health Organization (Ministry of Social Welfare and Health 1986; 1993). By now, these goals have been reached and even exceeded for children and adolescents, Finnish 12-year-olds holding the world record for low numbers of DMF teeth. Furthermore, differences in dental health given as mean numbers of DMF teeth between different parts of the country have been diminishing among young populations due to the comprehensive public oral health care, which has gradually been developed to cover all child and youth populations in the entire country. Despite improved dental health, there still are children and adolescents demanding a huge amount of dental resources because of their serious caries problems.

There has been an ongoing tendency to decrease central government control and to delegate health-policy decision-making to the level of municipalities, the basic units responsible for providing public oral health services for the entire population in each of their areas. This change emphasizes the municipalities' responsibility for whether or not the resources available are used in the most efficient way. Allocation of public oral health resources should meet the needs of each community. Priorization of service provision can be made in several ways, both in administration and in clinical practice. To meet the current treatment needs of the population, proper knowledge of disease and risk levels is required, accompanied by evaluation and monitoring of oral health and oral health services.

Children and adolescents have had the main priority as regards provision and subsidy of public oral health services. However, following the improvement in their oral health over the last two decades, reallocation of public oral health services is needed to serve other patient groups requiring dental care. The present study aims to contribute to the ongoing discussion on appropriate and efficient use of resources in public oral health service by evaluating current caries-treatment practices alongside the changes in caries occurrence in child and youth populations.

LITERATURE REVIEW

Occurrence of dental caries in young populations

Occurrence of past caries and changes in it, both on the population and on the individual level, are described by such parameters as decayed, missing, and filled teeth (DMFT) or such tooth surfaces (DMFS) which, in cases of low caries occurrence, can be considered the same as DFT and DFS. Occurrence of present caries is described by decayed teeth (DT) or decayed tooth surfaces (DS). These parameters are recorded for primary teeth (dmft, dmfs, dt, ds) below the age of six years. Caries occurrence in different populations can be described by mean values of caries indices, by percentages of subjects attacked previously (DMFT>0) or currently (DT>0), and by frequency distributions of such subjects.

Social factors are related to occurrence of dental caries in children and adolescents (Milén et al., 1981; Demers et al., 1990; Schou, 1991; Vargas et al., 1998; Flinck et al., 1999). Parents' dental health status, knowledge and behaviour are related to caries occurrence of their children (Tala, 1984), those in the highest social class having the lowest caries experience in both high- and low-fluoride areas (Hausen et al., 1982). When 13- to 14-year-olds were categorized according to their socioeconomic status, DMFT indices in the highest and lowest categories were 2.9 and 6.0, on average (Bauch, 1990).

Occurrence of past caries in children and adolescents has declined substantially over the past decades in many industrialized countries (Brunelle, 1989; Riordan, 1995; Marthaler et al., 1996). Decline in caries indices at country level in four Nordic countries, in England and Wales, and in the USA, and at regional level in Sweden, Norway, and Denmark is described in Table 1. Recently, the opposite trend in caries occurrence has also been reported (Frencken et al., 1990; Pitts and Palmer, 1994; Riordan, 1995). In Norway, caries experience continued to decline at the national level among 5-, 12- and 15-year-olds from 1985 to 1991, but at district level, increases occurred in caries indices (Haugejorden, 1994).

Table 1. Statistics on mean values of caries indices in four Nordic countries, in England and Wales, and in the USA.

Country	Caries index and age	Mean values by year		
Finland[1]		**1975**	**1994**	**1997**
	dmft for 5-yr-olds	5.0	1.1	-
	DMFT for 6-yr-olds	1.2	0.2	-
	DMFT for 12-yr-olds	6.9	1.2	-
	DMFT for 15-yr-olds	12.4	2.8	-
Sweden		**1985**	**1990**	**1997**
National[2,3]	DFT for 12-yr-olds	3.1	2.0	1.0
		1973	**1993**	
In Jönköping[4]	dft for 5-yr-olds	6.5	2.5	
	DFT for 15-yr-olds	15.0	10.8	
Norway		**1985**	**1991**	**1997**
National[5,6]	DMFT for 12-yr-olds	3.4	2.3	1.7
		1959	**1984**	
In Lillehammer[7]	MFS for 14-yr-olds	34.1	7.5	
Denmark		**1988**	**1994**	**1997**
National[8,9]	DMFT for 12-yr-olds	1.6	1.3	-
	DMFS for 12-yr-olds	3.0	1.9	1.6
		1963	**1981**	
In Frederikssund[10]	dmfs for 7-yr-olds	20.9	6.1	
	DMFS for 13-yr-olds	24.3	7.0	
England and Wales[11,12]		**1973**	**1989-90**	**1993**
	dmft for 5-yr-olds	4.0	1.7	-
	DMFT for 12-yr-olds	4.8	1.5	1.4
	DMFT for 14-yr-olds	7.4	3.4	-
USA[13,14]		**1979-80**	**1986-87**	**1991**
	dfs for 6-yr-olds	4.8	3.7	-
	DMFS for 13-yr-olds	5.4	3.8	-
	DMFS for 15-yr-olds	8.1	5.7	-
	DMFT for 12-yr-olds	-	-	1.4

References:
1. National Board of Health, 1996. Data regarding the year 1997 not published yet.
2. Sundberg, 1996.
3. Socialstyrelsen, 1998.
4. Hugoson et al., 1995.
5. Haugejorden, 1994.
6. Statens helsetilsyn, in press.
7. Birkeland and Bragelien, 1987.
8. Marthaler et al., 1996.
9. Poulsen and Scheutz, 1999.
10. Bille et al., 1986.
11. Downer, 1992.
12. O'Brien, 1994.
13. Brunelle, 1989.
14. WHO, 1999.

The decline in mean DMFT and dmft values has been accompanied by increased numbers of caries-free (dmft=0, DMFT=0) children and adolescents. In the United States, the proportion of caries-free 6-year-olds increased from 90% in 1979-80 to 94% in 1986-87, the corresponding increase for 13-year-olds being from 21% to 34%, and for 15-year-olds from 15% to 22% (Brunelle, 1989). In Sweden, 64% of 6-year-olds were free of caries in their deciduous dentition in 1994, compared to 45% in 1985; during the same period, the proportion of caries-free 12-year-olds (DFT=0) increased from 18% to 49% (Sundberg, 1996).

The increase in numbers of caries-free subjects has been accompanied by a decline in numbers of subjects with high caries experience, leading to a skewed caries distribution in each age-group. In Friesland, the Netherlands, the proportion of 6-year-olds with dmfs≥10 declined from 64% to 13% during the period 1973-1988 (Frencken et al., 1990). Of the 12-year-old Swedish children, 21% had eight or more decayed or filled teeth (DFT≥8) in 1985, but in 1994, the proportion of such subjects was 7% (Sundberg, 1996). In the United States, 50% of 12-year-olds were free of caries (DMFT=0) in 1988-91, but 25% of subjects had 75% of all the DMFT teeth in that age-group (Kaste et al., 1996).

Occurrence of past and present caries in Finland

Caries experience has been declining in children and adolescents since the 1970's in Finland both at country level (see Table 1) and at province level. For 12-year-olds, the national value of the mean DMFT index was 2.0 in 1988, the range in the eleven provinces being 1.5 to 2.5; in 1994, the national DMFT was 1.2, range 0.9 to 1.4 (NBH, 1996).

In Helsinki, the mean DMFT index for 15-year-olds declined from 12.1 in 1976 to 5.1 in 1986, and their DT index from 3.0 to 1.4 (Vehkalahti et al., 1990). In Espoo, a city in the Greater Helsinki area, the mean DMFT index for 12-year-olds declined from 3.8 in 1980 to 1.8 in 1988, and their DT index from 1.0 to 0.5 (Luoma and Rönnberg, 1991). In their study, the corresponding declines in DMFT and DT values for 16-year-olds were reported: DMFT from 9.9 to 4.4 and DT from 2.1 to 0.9.

Frequency distributions by both DMFT and DT indices show decreasing trends in caries occurrence. At country level, the proportion of caries-free (DMFT=0) 0- to 17-year-olds has increased from 9% in 1975 to 46% in 1991 (NBH, 1993). In Helsinki, the proportion of 15-year-olds with DMFT=0 increased from 1% in 1976 to 9% in 1986, and the proportion of those with DT=0 from 19% to 48% (Vehkalahti et al., 1990). Concurrently, the proportion of 15-year-olds with DMFT≥17 decreased from 22% in 1976 to 2% in 1986, and proportion of those with DT≥7 from 11% to 4%.

In the city of Espoo, the proportion of 12-year-olds with DT=0 increased from 52% to 73%, and the proportion of 16-year-olds with DT=0 from 33% to 62% during the period 1980 to 1988 (Luoma and Rönnberg, 1991). Concurrently, the proportion of 12-year-olds with DT≥3 decreased from 13% to 5%. These high-caries subjects had 50% of all DT of the entire age-group in 1980, and 39% in 1988. For the 16-year-olds, the proportion of those with DT≥3 decreased from 31% in 1980 to 10% in 1988. These high-caries subjects had 74% of all DT of the entire age-group in 1980, and still had 56% in 1988.

Recent data on caries occurrence among 3- to 18-year-olds clinically examined through the public oral health services in 12 small towns, most of them in eastern Finland, showed a skewed caries distribution in 1996 (Torppa, 1998). Among the 6-year-olds, 75% were caries-free (DMFT=0), and half of all the decayed teeth belonged to 6% of all the 6-year-olds. Similarly, among the 12-year-olds, 76% were caries-free, and half of all DT belonged to 5% of the 12-year-olds. Among the 15-year-olds, 62% were cavity-free (DT=0), but 9% had more than 50% of all decayed teeth.

High-caries patients in the present decade have fewer caries than did high-caries subjects two decades ago. For instance, in Helsinki, the dental health of 15-year-old high-caries subjects was compared between the years 1976 and 1986 (Vehkalahti et al., 1991b). In both years, the high-caries group was defined as the highest quintile of subjects' distribution by number of DMF teeth. A considerable improvement in dental health was seen: in 1976, the highest quintile of 15-year-olds had 19.5 DMF teeth on average, compared to 10.8 in 1986. The corresponding figures as to their numbers of decayed teeth were 5.5 vs. 3.7.

Caries occurrence by type of tooth and tooth surface

In the permanent dentition of young populations, the occlusal surfaces are those most frequently attacked by caries (Bille et al., 1986; Brunelle, 1989; Virtanen and Larmas, 1995). In children and adolescents, permanent molars show the largest caries experience of all the teeth (Bille et al., 1986; Birkeland and Bragelien, 1987). Among the 15-year-olds in Helsinki, Finland, in 1986, 62% of the first permanent molars and 38% of the second molars had caries or fillings (DFT>0) (Vehkalahti et al., 1990). In 1990, occlusal surfaces in the first and second molars accounted for 66% of all DFS of the 15-year-olds with DMFT≥ 5 (An, 1993).

In general, risk for occlusal caries is highest soon after tooth eruption: for first permanent molars between 7 and 9 years of age, and for second permanent molars after the age of 13. However, the follow-up studies in the 1970's and 1980's have revealed the occurrence of new occlusal caries during adolescence (Nordblad, 1986; Ripa et al., 1988; Vehkalahti et al., 1991a; An, 1993; Larmas et al., 1995). Approximal surfaces of permanent molars tend to become carious from the age of 12 years after tightening of approximal contacts (Kolehmainen, 1983a; Nordblad, 1986; Virtanen and Larmas, 1995). For teenagers with past caries on approximal surfaces, the risk for developing new approximal lesions is higher than for those without past approximal caries (Bille and Carstens, 1989; Mejàre et al., 1999).

Explanations for caries decline in populations

Occurrence of caries has been declining in communities with and without organized preventive programmes or fluoridation (Renson, 1985; Hargreaves et al., 1987). Understanding the reasons behind the decline in caries is very important to further diminish caries occurrence. However, in a population, several explanations for caries decline may be relevant for different individuals, for different age-groups, for different teeth, and for different periods of time (Bratthall, 1996). The most probable reasons for caries decline can be assumed to be related to increased use of fluorides, improvements in oral hygiene, and dietary changes, as well as microbial, host, and salivary factors (Marthaler, 1984), accompanied by provision of preventive oral health services, increased dental awareness through organized oral health education programmes, and the ready availability of dental resources (Renson, 1985).

The number of cariogenic micro-organisms in 9- to 12-year-olds has been found to be significantly lower in 1984 than in 1973 (Klock and Krasse, 1987). The authors considered the reasons to have been decreased numbers of decayed and filled tooth surfaces, as well as improvement in oral hygiene accompanied by increased use of fluorides and sugar substitutes. Moreover, use of antibiotics to treat other infections has been seen to have influenced caries occurrence (Gibbons, 1996).

Dental caries progresses much more slowly than it did in the 1960's, even in the high-caries

patients (Kolehmainen and Rytömaa, 1977; Ekanayake and Sheiham, 1987; Bille and Carstens, 1989; Mejàre et al., 1999). This observation, accompanied with the introduction of new preventive measures, has led to changes in criteria for restorative treatment of caries (Dowell et al., 1983; Gröndahl, 1994). These criteria emphasize the arresting and repairing of initial lesions by removal of causal factors of caries or by preventive measures contributing to remineralization (Anderson et al., 1993; Anusavice, 1997). In addition, increased knowledge of the caries process, and improved techniques to diagnose its early stages allow the dentists to maximize the usefulness of these preventive measures (Winston and Bhaskar, 1998).

A recent review on the most probable explanations for the caries decline seen in many industrialized countries over the past three decades revealed a large variation in how the experts grade the impact of various possible factors; however, there is strong agreement on the positive effect of fluoride-containing dentifrice (Bratthall et al., 1996). A questionnaire sent to 55 experts from all continents and several research fields included 25 possible reasons to be given values on a scale from no importance to very important. Each expert was asked to consider a specific country or area, with or without water fluoridation. The question as to whether or not improved oral hygiene, excluding possible benefits from fluoride, had had any effect, the answers were clearly distributed across the whole scale. The importance of reduced use of sugar and increased use of its substitutes was, in fact, not highly valued by the experts. A great variation in these experts' opinions may demonstrate their differing interpretations of available data, or differing personal experiences and observations on local implemention of preventive programmes in which they may have been involved (Bratthall et al., 1996).

Opinions on factors related to improvement in dental health in children and adolescents was recently mapped in Finland (Luoma and Widström, 1997a). The experienced chief dental officers in the public oral health service stated their explanations for the caries decline. The most significant factors were as follows: improved socioeconomic level in the population accompanied by high valuation of overall and dental health, and improved knowledge of caries initiation and progress, as well as new caries-preventive methods such as fluoride toothpaste in the 1960's, fluoride varnish in the 1970's, and fissure sealants in the 1980's. Furthermore, the National Health Act, guaranteeing public oral health services for all children and adolescents in Finland, emphasized the importance of preventive dental care carried out by means of dental health education for groups and individuals, fluoride mouthrinses provided fortnightly, and provision of toothbrushes and fluoride tablets.

Risk for caries

In general, risk for caries in a population means the probability that new cases of caries will occur. In reality, caries risk varies between individuals according to each subject's balance between factors exposing for and protecting from caries attacks. For an individual, risk for caries means the probability that he or she will develop dental decay or experience a health-status change contributing to caries development over a specific period (Hausen et al., 1994). Decline in and skewed distribution of caries occurrence challenge dentists to accurately identify subjects particularly at risk for developing carious lesions, and thus to assess risk for caries at the individual level.

Individuals at high risk for developing caries can be described as high-risk, high-caries, or caries-active. Likewise, subjects at low risk for caries can be called low-risk, low-caries, caries-inactive, caries-free, or cavity-free. These alternatives show the lack of consensus on caries-risk terminology, suggesting the importance of clarifying the whole framework of caries risk in the dental profession. High-risk individuals can be defined according to clinical findings either on the basis of presence of the disease, or a selected cut-off point, or by selecting subjects with the greatest percentage of teeth or surfaces with evidence of disease (Beck, 1998). All these alternatives have been used in previous studies.

Caries-risk thinking fosters the treatment of the caries process instead of merely repair of cavities (Tinanoff, 1995a; Powell, 1998a), and integrates the tools of caries epidemiology, clinical cariology, and clinical decision-making (Moss and Zero, 1995). Caries-risk assessment is a clinical evaluation method with which dental professionals can target tailored caries-preventive treatment to the individuals at high risk for caries. The goals of caries-risk assessment and preventive treatment are elimination of caries or at least the reduction of high-caries subjects' occurrence of caries down to the level of the remaining part of the age-group (Hausen et al., 1994).

Caries is a behaviourally determined dynamic disease process and subject to continuous modification by diet, oral hygiene, and fluoride. Therefore, changes in subjects' dental health status challenge dentists to assess each patient's risk for developing caries on a continual basis (Blinkhorn and Geddes, 1987; Anusavice, 1997). Assessment of caries risk should thus include careful monitoring and documentation of changes in oral findings and risk factors (Brown, 1995). Need for continual assessment of caries risk is supported by a lack of consensus as to the age at which children at risk for developing caries should be identified (Demers et. al, 1990; Powell, 1998b). However, it has been verified that even children aged 1 to 3 years can be differentiated by their risk for caries in the near future (Wendt, 1995; Jokela, 1997).

Onset of a caries lesion requires interaction of all major determinants of caries development: susceptible host, cariogenic microbial flora, and carbohydrate-rich diet (Keyes, 1961; Bratthall, 1996). Of micro-organisms, *S. mutans* and *Lactobacilli* are recognized as important factors in caries development: *S. mutans* has been associated mainly with initial development of caries, and *Lactobacilli* with progression of carious lesions. Risk for caries is always modified by the individual's health behaviour, such as toothbrushing and dietary habits, as well as use of fluorides. In addition, risk for caries is influenced by factors related to tooth eruption and maturation, as well as tightening of approximal contacts, which increase risk for caries in all individuals (Carlos and Gittelsohn, 1965; Kolehmainen, 1983a; Nikiforuk, 1985; Carvalho et al., 1989; Kotsanos and Darling, 1991; Virtanen and Larmas, 1995).

Present knowledge of the most useful and valid predictors for identifying high-risk individuals emphasizes use of clinical examination together with proper dental history as the most important sources of information (Blinkhorn and Geddes, 1987; Bratthall and Ericsson, 1994; Hausen et al., 1994). Compared to a single risk indicator, a combination of several predictors produces more accurate prediction. However, such prediction models showing higher specificity than sensitivity are more accurate in identifying subjects who will not get caries (Demers et al., 1990), in particular in populations with low caries occurrence (Klock et al., 1989).

None of the most widely used predictors of caries risk is sufficiently accurate to be mechanically relied upon in detecting individuals at high risk for caries (Hausen et al., 1994). Furthermore, prediction methods satisfactory at one age may not necessarily be effective for another age-group (Sheiham and Joffe, 1991; Powell, 1998a; 1998b). Judgement of high risk must thus be made individually by a dental professional. A clinician's ability to predict whether a child aged 5 to 16 years will develop dentinal caries in his or her permanent teeth in the following 12 months was recently studied in Finland (Alanen et al., 1994). Only information routinely available at clinical dental examinations, i.e., the individual patient record, was used. On average, the clinicians were not quite able to identify those children who would develop caries, the sensitivity being 0.44, but they were good at identifying those who would not, the specificity being 0.90. However, accuracy in prediction varied greatly: some clinicians succeeded in reaching very high sensitivity and specificity figures, ranges being 0.57 to 0.79 for sensitivity and 0.79 to 0.98 for specificity. Accuracy of the prediction tended to be better in children whom the clinician had treated for several years. The authors concluded that each clinician should evaluate and improve his or her ability to identify high-risk children.

In general, among children and adolescents, the most reliable predictor of future caries has been their caries experience (Downer, 1978; Alaluusua et al., 1987; Demers et al., 1990; Gray et al., 1991; Holt, 1995; Vehkalahti et al., 1996). In a retrospective follow-up study in Helsinki, subjects' caries experience in their primary dentition at age 6 was documented to

predict (sensitivity 0.71, specificity 0.73) their low or high caries occurrence in their permanent dentition at age 15 (An, 1993). In a follow-up study, using precavity lesions as the sole caries predictor, four out of five 15- to 16-year-olds were correctly classified with regard to their future caries increment over three years (Bjarnason and Köhler, 1997). Seppä and Hausen (1988) also verified a strong relationship between presence of initial caries and increment of new lesions; they concluded further that data on initial caries did not increase the accuracy of risk assessment even if combined with data on decayed and filled surfaces.

The predictive power of microbiological tests developed for measuring counts of *S. mutans* and *Lactobacilli* in the saliva of children and adolescents with a low incidence of caries has decreased (Klock et al., 1989; Disney et al., 1992; Vehkalahti et al., 1996; Bjarnason and Köhler, 1997). Furthermore, a remarkable intra-individual variation found in teenagers' salivary findings makes a single-point measurements of salivary factors too unreliable for caries-diagnostic or predictive purposes (Tukia-Kulmala and Tenovuo, 1993; Tenovuo, 1997). Among young children, however, the strongest correlations for caries risk are occurrence of caries and level of *S. mutans* (Jokela, 1997).

Two caries prediction models were studied among 13- to 15-year-old adolescents in Helsinki in a longitudinal three-year study (Kolehmainen et al., 1985a). Identification of high-risk children was correct in 51% of cases, when the predictive model was based only on information which can be collected by a dental nurse, including data on patients' social class, frequency of toothbrushing, count of salivary aciduric bacteria, and visible dental plaque; however, when supplemented with data on patients' number of decayed and filled surfaces, correct identification increased to 60%.

An extensive study aiming to develop a caries prediction method of sufficient sensitivity, specificity, and simplicity for children was carried out at the University of North Carolina (Disney et al., 1992). In this four-year longitudinal study, caries risk assessment for each 7- and 11-year-old child was based on a combination of clinical, microbiological, and sociodemographic variables generally thought to be associated with high caries occurrence. In general, the three-year DMFS increments in the study subjects were low, the mean values for 7- and 11-year-olds being 1.9 and 3.1 at maximum; these figures were, however, considered to be sufficient for development of prediction models. As a result, information based on the clinical examinations provided the only statistically highly significant predictors, the most important of which were baseline primary dmfs and permanent DMFS scores, pit and fissure morphology, and caries increment scores predicted by the dentist on the basis of clinical dental examination.

Environmental and behavioural aspects in caries occurrence

Subjects' dietary and oral hygiene habits have been the most commonly studied behavioural factors related to caries occurrence. Both positive correlation and lack of correlation have been reported between the intake of sucrose-containing foods and caries (Hausen et al., 1994). Risk for caries among children has been shown to increase significantly with increasing sugar consumption only when oral hygiene is simultaneously poor (Kleemola-Kujala and Räsänen, 1982), indicating synergistic interaction between sugar intake and oral hygiene in caries development. However, Marthaler (1990) concluded that in today's modern societies which make use of prevention, the relationship between sugar consumption and current caries still exists. A high increment of approximal caries has been reported for teenagers consuming a high proportion of their total energy intake as sugars, between meals in particular (Burt et al., 1988). However, individuals with a frequent and long-term use of sugars could be detected by means of an interview regarding dietary habits (Hölund et al., 1985).

Subpopulations with high caries occurrence have been reported to differ from those with low caries occurrence mainly because individuals in a high-caries population were

irregular toothbrushers (König, 1994). This finding on the important role of oral hygiene for risk for caries, is supported by Mathiesen et al. (1996), who found that among teenagers exposed to fluoride, those with good oral hygiene had significantly fewer carious lesions and filled approximal surfaces than did those with poor oral hygiene. However, the opposite results have also been documented. In the study carried out in an area of Finland with fluoridated water, those children who brushed their teeth daily developed more caries than did the occasional brushers, the proportion of children with new caries lesions within one year being 51% vs. 45% among those with occasional sugar consumption, and 53% vs. 42% among those with frequent sugar consumption (Hausen et al., 1981). The authors explained these unexpected findings by increased oral fluoride concentration in the presence of plaque. Similar findings on reduced acidogenicity of fluoride-rich plaque have been reported by Ekstrand et al. (1985) and Oliveby et al. (1990).

Toothbrushing is more frequent among children of a high social class and is related to oral health behaviour of their parents (Tala, 1984; Schou, 1991; Åstrøm and Jacobsen, 1996; Åstrøm, 1998; Flink et al., 1999). Oral health care habits are an integral part of children's lifestyle, interacting with their other health-related behaviours (Rajala et al., 1980; Schou et al., 1990; Kuusela et al., 1997). The observation that individuals' health outcome may be determined by interaction between several of their health-related behaviours, as well as between environmental and social factors, has led to what is known as the lifestyle approach in health promotion. Information on patients' social and behavioural factors should, therefore, be utilized in comprehensive assessment of patients' caries risk (Blinkhorn and Geddes, 1987). Individuals' values concerning dental health influence their oral health behaviour, regularity of attendance at the oral health service, and compliance in carrying out the instructions and advice of health professionals. Therefore, high-risk patients should be given the earliest opportunity for preventive treatment, either engaging the patient in managing the caries process or if not succeeding in this, providing intensified professional preventive measures (Winston and Bhaskar, 1998). Unfortunately, in most cases, dental professionals' aid in preventing further caries progression may remain a lifelong need among high-caries patients (Fejerskov, 1995).

Avoidance of dental care and behaviour management problems can result from negative treatment experiences and dental anxiety, having been developed in connection with restorative treatment (Klingberg et al., 1995). High numbers of decayed untreated teeth and many missed appointments have been found in children with unco-operative behaviour during dental treatment (Mejàre et al., 1989; Klingberg et al., 1994). Traumatic dental experiences in childhood may lead to low rates of utilization of oral health services even in youth and adulthood (Milgrom et al., 1988). However, this link can be broken by multiple, positive, prevention-orientated dental visits (Milgrom and Weinstein, 1993; Edelstein, 1995). Melamed et al. (1975) tested the effect of modelling, i.e., learning by observing the consequences of others' behaviour, for 5- to 9-year-old children, most of whom had no earlier experience of dental care. Dental anxiety of the children was measured by amount and frequency of disruptive behaviour during three dental visits, which were carried out in the following order: radiography, clinical dental examination, and restorative procedure. Just before the restorative visit, half the children were prepared for the restoration by showing them a film on such treatment provided for a child of the same age. During the first two visits, the amount of dental anxiety remained low for all children, but significantly increased during the treatment among those not having seen the film, emphasizing the importance of thorough preparation before any demanding treatment procedures.

Caries-treatment strategies

Dentists have a role both in treatment of cavities and in prevention, i.e., treatment of caries activity (Edelstein, 1995). Dentists' choice of treatment and prevention methods for individual patients are strongly determined by their beliefs as to how determinants of caries interrelate and influence the outcome, dental health (Fejerskov and Thylstrup, 1994).

The filling-orientated treatment strategy called by Edelstein (1995) the "historical approach", is based on the idea that early recognition and repair of new cavities, during fixed and frequent recalls, guarantees dental health. This treatment strategy has been prevailing in many countries (Elderton and Nuttall, 1983; Telivuo and Murtomaa, 1988; Chen, 1990; Vehkalahti et al., 1992; Kärkkäinen, 1997). As an extreme example of this approach, some high-risk children might be treated very aggressively, even put under general anaesthesia, in order to minimize continued restorative need over time (O'Sullivan and Curzon, 1991; Edelstein, 1995).

The prevention-orientated treatment strategy called by Edelstein (1995) the "developing approach", is based on the belief that the benefits of restorative treatment are transitory if the caries process remains ongoing. Patients are diagnosed both for caries activity and for cavity status, which are treated independently and sequentially, caries activity first. Treating caries as a disease process rather than merely repairing the damage it causes is gaining increasing emphasis because of new knowledge of caries-preventive therapies (Edelstein, 1994; Douglas and Fox, 1994; Winston and Bhaskar, 1998). Prevention of future disease is guaranteed by engaging the patient in managing the caries process and by recall intervals tailored to the patient's individual needs. According to Edelstein (1995), the better the patient controls the disease, the less restorative treatment is necessary, selective restorative care being limited to situations in which arrest of caries cannot be otherwise maintained or in which function is compromised.

In general, a population strategy seeks to control causes of caries incidence, whereas a high-risk strategy seeks to protect susceptible individuals (Sheiham and Joffe, 1991; Fejerskov, 1995). The population strategy, targeting preventive treatment to all subjects, is useful in populations with high caries occurrence because of its goal: to change the distribution of disease by controlling the determinants of caries in the entire population. Today, such strategy becomes questionable in most of the industrialized countries, with their skewed caries distribution.

According to the high-risk strategy, individuals at high risk for caries are identified and individualized caries-preventive measures are directed to these high-risk subjects to diminish their caries risk. For a successful application of the high-risk strategy, there are three basic prerequisites, attainment on which in real-life dental practice there is no agreement among dental professionals (Hausen et al., 1994). First, occurrence of caries in the target population must be low enough to justify the effort and expense of identifying high-risk individuals. Second, accurate, acceptable, and feasible measures for identifying high-risk subjects must be available. Third, the preventive interventions must be effective and feasible.

Well-organized implementation of scientific innovations in caries prevention, individually tailored to each patient, holds great promise for promoting long-term dental health in a population (Axelsson et al., 1993; Edelstein, 1995; Wei, 1995; Krasse, 1996b, Winston and Bhaskar, 1998). Therefore, both population and high-risk strategies are considered still to be needed, flexibly used in different communities (Fejerskov, 1995; Burt, 1998). Accordingly, the population-strategy approach can be directed to a selected part of the total population, i.e., in areas with high caries occurrence, with no need to use expensive screening methods for identifying high-risk individuals (Fejerskov, 1995; Burt, 1998).

Caries-preventive measures in oral health service

Caries-preventive measures aim to prevent onset of caries, to arrest progression of caries lesions manifesting both subclinically and clinically, and even to repair them. Contemporary dental education emphasizes the slow progression of caries when subjected to preventive measures, leaving ample time for attempts to arrest and repair initial lesions before restorative treatment is the only remaining alternative. Prevention can be successfully carried out both by eliminating causal factors of caries and by improving the resistance of teeth against caries attacks, even under conditions of heavy demineralization (ten Cate and Duijsters, 1982, Winston and Bhaskar, 1998). Dentistry has several caries preventive measures to offer, some of which emphasize the patient's own responsibility in managing the disease, and the others the dental professional's role in disease management.

Caries-preventive measures aiming to change a patient's harmful dental health behaviour favorable to disease include oral hygiene instructions, dietary counselling, and advice on home use of fluorides. Individual oral hygiene instructions and dietary counselling for teenagers have been shown to increase subjects' knowledge of the role of dental plaque and sucrose in the caries process and its prevention; this leads, however, only to short-lasting changes in dental health behaviour (Kolehmainen, 1983b, 1985b; Wikner, 1986). Long-lasting improvements in a patient's dental health habits can be obtained if patients have internalized their own responsibility for their dental health outcome and have been instructed and frequently reinforced in carrying out proper home self-care (Chiodo et al., 1986; Eldestein, 1995).

Professional plaque removal results in significant reduction in caries (Axelsson and Lindhe, 1981, Bellini et al., 1981; Demers et al., 1990). Similarly, provision of fluoride varnish, chlorhexidine, and fissure sealants are verified as effective (Ripa, 1980; 1993; Twetman and Petersson, 1998). For the high-caries patients with poor compliance with instructions and advice on home care, intensified prevention should be provided by dental professionals to reduce high risk for caries (Tinanoff, 1995b). Recommendations regarding the appropriate frequency of fluoride varnish applications for the high-caries children and adolescents have been varied from one application every third or sixth months per patient per year (Modéer et al., 1984, Axelsson, et al., 1987; Seppä and Tolonen, 1990; Petersson et al., 1991) to three applications during one week per patient per year (Petersson and Westerberg, 1994).

Type and extent of preventive measures must be adjusted according to each subject's individual needs. For the high-caries patients with a heavy cariogenic challenge, topical application of fluorides as a sole preventive action is insufficient, and thus must be supplemented with other preventive measures (Lindquist et al. 1989; Anusavice 1995; Krasse, 1996a; Burt, 1998). During eruption of the first permanent molars which increases risk for caries also for cavity-free subjects, several combinations of preventive measures can effectively keep occlusal tooth surfaces caries-free (Ripa, 1980; Carvalho et al., 1992; Karjalainen et al., 1994; Arrow, 1997). Moreover, teeth having the opportunity to erupt and mature in an oral environment protecting them against caries show long-lasting resistance against caries attacks (Alanen et al., 1985; Isokangas et al., 1993; Virtanen et al., 1996).

Decision-making in dental treatment

Treatment-planning decisions include the dentist's assessment of probabilities for poor versus good outcomes of different treatment options and determination of their value for the patient's oral health state. The resultant course of action is most likely to lead to the outcome to which the dentist has attached the highest value both in treatment and patient terms (Kay and Nuttall, 1995a; 1995b).

Large variation has been reported among dentists in planning preventive and restorative treatment for the same patients (Rytömaa et al., 1979; Elderton and Nuttall, 1983, Espelid et al., 1985; Kay et al., 1992). When a group of dentists planned treatment for the same young adults (Elderton and Nuttall, 1983), all the dentists planned to give restorative treatment, with a wide range of suggested fillings, but only a few of the dentists considered the patients to be in need of preventive care. Those who did suggested one to four different types of preventive measures.

Treatment decisions in dental care will always differ because dentists notice different levels of disease (perceptual variation), meaning, for example, that the same tooth surface can be categorized by different dentists either to be healthy, to have initial caries, or to have a cavity. The other explanation for variation in dentists' treatment decisions is that they evaluate the same oral condition differently and thus decide on different treatment options (judgemental variation), suggesting that each dentist should be able to defend his or her own treatment decisions (Kay and Nuttall, 1995c). Variation occurring in any one dentist's treatment is a sign of individual assessment of each patient's characteristics and treatment needs (Kay and Nuttall, 1995a). Accordingly, treatment protocols should match level of disease severity. Variation between dentists' treatment practices for the same patients or patients at similar disease levels can be acceptable treatment planning, if there exists a rational basis for the decisions made (Kay and Nuttall, 1995a). However, if this variation is due to judgemental variation, affected by dentists' individual treatment criteria and the thresholds at which they feel treatment is needed, or is due to no consensus about effectiveness of different treatment protocols, then guidelines or specific criteria for optimal treatment should be set (Kay and Nuttall, 1995c).

Individualizing check-up intervals

In general, decrease in caries occurrence and slow progression of caries lesions at an early stage both suggest that intervals between clinical dental examinations could be extended. However, because of skewed caries distribution, individualized check-up intervals are necessary, based on the philosophy of high-risk strategy, aiming to target dental resources to those who would benefit from them the most. This requires the dentist's assessment of each subject's risk for developing caries. Accordingly, decisions on check-up intervals should be influenced by eruption of permanent molars (Carvalho et al., 1992; Arrow, 1997), and by data regarding a patient's interest and competency in controlling the caries process, and by the degree of success to be achieved with professional preventive measures (Blinkhorn and Geddes, 1987; Edelstein, 1995; Anusavice, 1997; Winston and Bhaskar, 1998).

In Nordic countries, annual clinical dental examinations for children have been the rule (Milén et al., 1981; 1988; Vehkalahti et al., 1992; Kärkkäinen, 1997; Wang, 1998; Widström et al., 1998), although since the 1980's, dentists have been encouraged to adjust check-up intervals according to each patient's individual needs (NBH, 1985). Extended check-up intervals for low-risk patients have resulted in savings because of a decrease in examination time, whereas treatment time has remained unchanged, suggesting that patients' dental health has not been compromised (Wang et al., 1992; Wang, 1994; Wang and Holst, 1995). Among the high-caries patients, individualized check-up intervals contribute to accurate timing of preventive intervention (Ketomäki and Luoma, 1993). However, extended check-up intervals for all subjects are justified only when combined with individual-based preventive care (Crossner and Unell, 1986).

So far, accomplishments in individualizing check-up intervals have turned out to be only moderate, revealing dentists' possible fear of changing the established routine (Wang and Holst, 1995; Wang and Riordan, 1995; Wang et al., 1998a). Irrespective of the large variation in restorative treatment decisions for children and adolescents, only a slight variation has been seen in their check-up intervals (Espelid et al., 1985). Not even recommendations to indi-

vidualize intervals between clinical dental examinations have lengthened check-up intervals for caries-free children and adolescents (Wang and Holst, 1995). However, some patients judged to be at high risk for caries by their dentists have had shorter check-up intervals than other patients, although most children have been recalled at intervals of 11-13 months regardless of dentist's judgement of high risk or the number of decayed teeth (Wang and Holst, 1995).

Targeting of preventive treatment

A population strategy for children, by means of group-based preventive measures such as fluoride rinses and tooth-brushings at schools, has been carried out in Finland, as well as in other Nordic countries (Wang, 1998). In recent years, with child populations of varying caries risk, there has been a trend to re-target caries-preventive resources to the high-caries subjects. Selection of subjects for targeted prevention is made on the basis of each patient's caries risk, judged at a clinical dental examination (Axelsson et al., 1993; Blinkhorn and Geddes, 1987; Bratthall and Ericsson, 1994; Hausen et al., 1994; Fejerskov, 1995). In the Nordic countries, dental professionals have reported to follow this high-risk strategy, but in reality, preventive care has tended to be similar for all children, suggesting that a population strategy is not supplemented with a high-risk strategy (Sundberg et al., 1996; Kärkkäinen, 1997; Wang et al., 1998b).

In Finland, provision and targeting of preventive treatment has been evaluated both in private dental practice (Telivuo and Murtomaa, 1988) and in public oral health services (Milén et al., 1988; Vehkalahti et al., 1991b; 1992; An, 1993; Kärkkäinen, 1997). All of these have confirmed poor targeting of preventive treatment to high-caries patients and serious undertreatment of patients in urgent need of intensified caries prevention. Similar findings have been reported in Sweden (Crossner and Unell, 1986; Källestål et al., 1994). However, some signs of improvement, in terms of increased coverage (An, 1993) and more accurate targeting (Kärkkäinen 1997) of preventive measures, have been seen in recent years.

In 1981, Milén et al. (1988) evaluated distribution and content of public oral health services in Finland among 4- to 16-year-old children and adolescents. According to their results, public oral health services were very unevenly used: half the children were given only one-fifth of the services, whereas one-fifth of the children had been given as much as half of all oral health services, mainly restorative treatment. The heavy-consumers tended to have had more preventive treatment than the rest, but at least half of the 4- to 16-year-old children did not receive adequate prevention.

The adequacy and appropriateness of the oral health services in Helsinki were evaluated from patient records of 15-year-olds, comparing the highest and lowest quintiles of subjects' distribution by number of DMF teeth in 1976 to 1986 (Vehkalahti et al., 1991b; 1992). In 1986, slightly fewer preventive measures were carried out than 10 years earlier, but no targeting of prevention was seen in either year. In general, the authors considered preventive treatment to be insufficient and overly uniform, including similar check-up intervals for all patients.

In the early 1990's in Finland, no differences were found in caries-preventive policies between different parts of Finland or between public or private dentists (Kärkkäinen, 1997). His evaluation of targeting of caries preventive treatment for children and adolescents was based on three approaches: 1) a questionnaire on administrative instructions for caries prevention and preventive policies reported by chief dental officers in the public oral health service of Finland, 2) a questionnaire on preventive policies for a random sample of public and private dentists all over the country, and 3) data on preventive treatment in patients' oral health records in public clinics in two cities.

The chief dental officers reported to base their administrative instructions on current know-

ledge of caries prevention, emphasizing individualized caries-preventive practices for each patient group. In general, they reported more preventive treatment to have been provided than did the dentists in the public oral health service. Modern methods of caries prevention were reported to be in common use, but according to the patient records, fewer measures were carried out than reported in the questionnaires. Patients with a low risk for caries had received a lot of preventive treatment, suggesting inaccurate targeting of prevention. However, the occurrence of approximal caries recorded at clinical dental examination, and dentist's judgement of high risk resulted in more accurate targeting than did other signs of past or present caries. Even in the latter case, however, many high-caries patients had been left without any preventive treatment, which was in line with findings by Vehkalahti et al. (1991b; 1992).

AIM OF THE PRESENT STUDY

The aim was to study the prevalence of dental caries and its distribution among young populations (I), and dentists' caries-preventive treatment practices among high-caries and cavity-free patients (II-V).

In particular, the aim was to evaluate changes in population distributions by caries indicators during the last two decades, and dentists' judgement of high-caries patients' individual risk for caries, as well as treatments provided to high-caries and cavity-free patients, and to evaluate caries-preventive treatment in relation to patients' dental state, to dentists' judgement of high risk, and to patient's level of co-operation.

HYPOTHESIS

Dentists judge each patient's risk for caries and individualize caries-preventive treatment and check-up intervals according to each patient's current needs.

PERMISSION FOR THE STUDY

The present study has been carried out in co-operation with the Helsinki City Health Department. Permission to use information from patients' individual oral health records was given by the Helsinki City Health Department and the Ministry of Social Welfare and Health.

MATERIAL AND METHODS

Background

In Finland, oral health manpower includes 4,600 dentists, giving a ratio of one dentist to 1,100 inhabitants, on average (Eaton et al., 1998). The number of dental hygienists is 900 and that of dental assistants about 5,000. Oral health services are provided both in the private and public sector, almost equal in size. The private sector provides dental services mainly for the adult population.

Public oral health services have been gradually developed to cover all child and youth populations in the entire country (Nordling, 1988). In the early 1900's, dental care was provided, free of charge, to poor school-children on a charity basis by private dentists in a few biggest cities. The first such clinic was founded in 1907 in Helsinki; the financial support for it from the city of Helsinki began 15 years later. Since 1926, the Finnish government has shared the expense of school dental care, but first only those expenses concerning health promotion, but since 1937 all treatment costs. Since 1957, each community was obligated to organize, free of charge, dental health care for all children attending public schools in its area.

Nowadays, public oral health services are provided according to the regulations of the Primary Health Act, which came into force in 1972. Communities are the basic units responsible for providing public oral health services for the entire population in their area, children and adolescents having, however, the main priority. Public oral health services are free of charge for all subjects under the age of 19, and highly subsidized for other patient groups. Among schoolchildren, participation in oral health services has nationwide been very high, 90 to 98%. National statistics on patients' dental state by age-cohort are collected every third year in public oral health service.

In Helsinki, public oral health services are administered by seven independent districts, each of which has the responsibility and resources for providing public health care in its area. Public dental services were provided by 344 full-time salaried dental professionals in public oral health service in 1992, comprising 154 dentists, 20 dental hygienists, and 170 dental assistants (Helsinki City Health Department, 1993a). Dentists are paid some extra fee for the treatment procedures provided, the amount of which varies according to the item of service in question and degree of difficulty of the procedure. Clinical dental examinations are done by dentists; patients in need of preventive care may be referred to dental hygienists or to assistants, if available. According to the law, however, dentists are responsible for diagnosis, treatment decisions, and treatment planning, as well as for the entire treatment provided. Regular meetings discussing treatment decisions and treatment practices are organized for the personnel during working hours.

As a rule, clinical dental examinations have been carried out on a once-a-year-basis. Official statistics including information on patients' clinical findings as well as on treatment provided are annually collected for each age-group.

Study design and selection of subjects

For the study on prevalence and distribution of dental caries (I), data from 1976 to 1993 were collected from the annual official statistics of the Helsinki City Health Department. These statistics are based on data on individual dental findings recorded at clinical dental examinations of about 4,000 patients per age-group each year, in total about 95,000 subjects annually. The age-groups of 5-year-olds and 15-year-olds were selected: 5-year-olds because this is the last year for collecting statistics on caries experience in the primary dentition (dmf teeth), and 15-year-olds because it is the last year the entire age-group must attend school, which guarantees high participation in dental check-ups.

The study on treatment practices (II-V) was cross-sectional with a two-point design, high-caries group vs. cavity-free group, covering data drawn from 6-, 13- and 15-year-old patients' oral health records of the year 1992. In Helsinki, a total of 3,849 children who were 6 years, 4,017 who were 13, and 3,421 who were 15 participated in clinical dental examinations in the public oral health service in 1992 (Helsinki City Health Department, 1993a). The distribution of these subjects by their total number of decayed primary and permanent teeth (dt+DT) shows that the majority in each age-group had sound teeth, but 3% to 7% had four or more decayed teeth (Figures 1a, 1b, 1c). These minorities had, however, as many as 29% to 59% of all decayed teeth in their age-group.

Among the age-groups of 6-, 13-, and 15-year-olds, the study groups, called high-caries and cavity-free groups, were selected from the two tails of the distribution of subjects by number of dt+DT. Data on dt+DT were available from official municipal automatic data processing (ADP) recordings. The sample included subjects from all the seven administrative districts, the numbers of the study subjects proportional to the numbers of all 6-, 13- and 15-year-olds clinically examined in 1992 in the district in question. This was done by listing all 6-, 13- and 15-year-olds, each age-group at a time, district by district, in descending order by subject's number of dt+DT. Those with the greatest number of dt+DT in each district were included in the high-caries group. The cavity-free patients, having neither past nor present caries in their primary and permanent dentitions (dmf=0, DMF=0, dt+DT=0), were randomly selected from the same clinics as were the high-caries cases.

In total, 400 subjects were selected, 303 being high-caries and 97 cavity-free patients. The high-caries patients represented 35% of all 6-year-olds with dt+DT≥4, 35% of all 13-year-olds with dt+DT≥3, and 39% of all 15-year-olds with dt+DT≥4 clinically examined in 1992; the corresponding figures for the cavity-free patients were 1.0%, 1.0% and 1.5%. These numbers of subjects in the high-caries and in the cavity-free group were considered high enough to reveal dentists' real-life caries-preventive treatment practices in relation to each patient's dental findings. Smaller numbers of cavity-free subjects were required, due to their homogenous caries state (Miettinen, 1985).

The original samples and the final study groups by age and gender are shown in Table 2. Of the 400 oral health records, 18 (5.9%) were excluded because of incomplete or missing recordings. Excluded cases occurred in all three age-groups. Information on number of DMF teeth and decayed teeth (dt+DT) in the basic populations, and in the final high-caries and cavity-free groups by age are given in Table 3.

Table 2. Sampling of subjects, original and final, by age and gender (II-V). Number of subjects with missing information in parentheses.

Study groups		Age-groups				By gender	
		6-yr-olds	13-yr-olds	15-yr-olds	Total	Boys	Girls
		n	n	n	n	n	n
High-caries:	original	99	100	104	303	181	122
	final	97 (2)	97 (3)	100 (4)	294 (9)	175 (6)	119 (3)
Cavity-free:	original	32	32	33	97	50	47
	final	29 (3)	27 (5)	32 (1)	88 (9)	45 (5)	43 (4)

Table 3. Description of basic populations and final study groups by age.

Basic populations[1] and study groups	n	DMFT Mean	dt+DT Mean	dt+DT Range
6-year-old basic population	3,849	0.3	0.8	0-18
Final study groups				
High-caries group	97	0.3	8.7	4-18
Cavity-free group	29	0.0	0.0	0-0
13-year-old basic population	4,017	1.9	0.6	0-15
Final study groups				
High-caries group	97	8.3	5.5	3-15
Cavity-free group	27	0.0	0.0	0-0
15-year-old basic population	3,421	3.2	0.8	0-16
Final study groups				
High-caries group	100	10.5	6.5	4-16
Cavity-free group	32	0.0	0.0	0-0

[1]All 6-, 13-, and 15-year-old subjects clinically examined in Helsinki public oral health service in 1992.

Fig. 1a

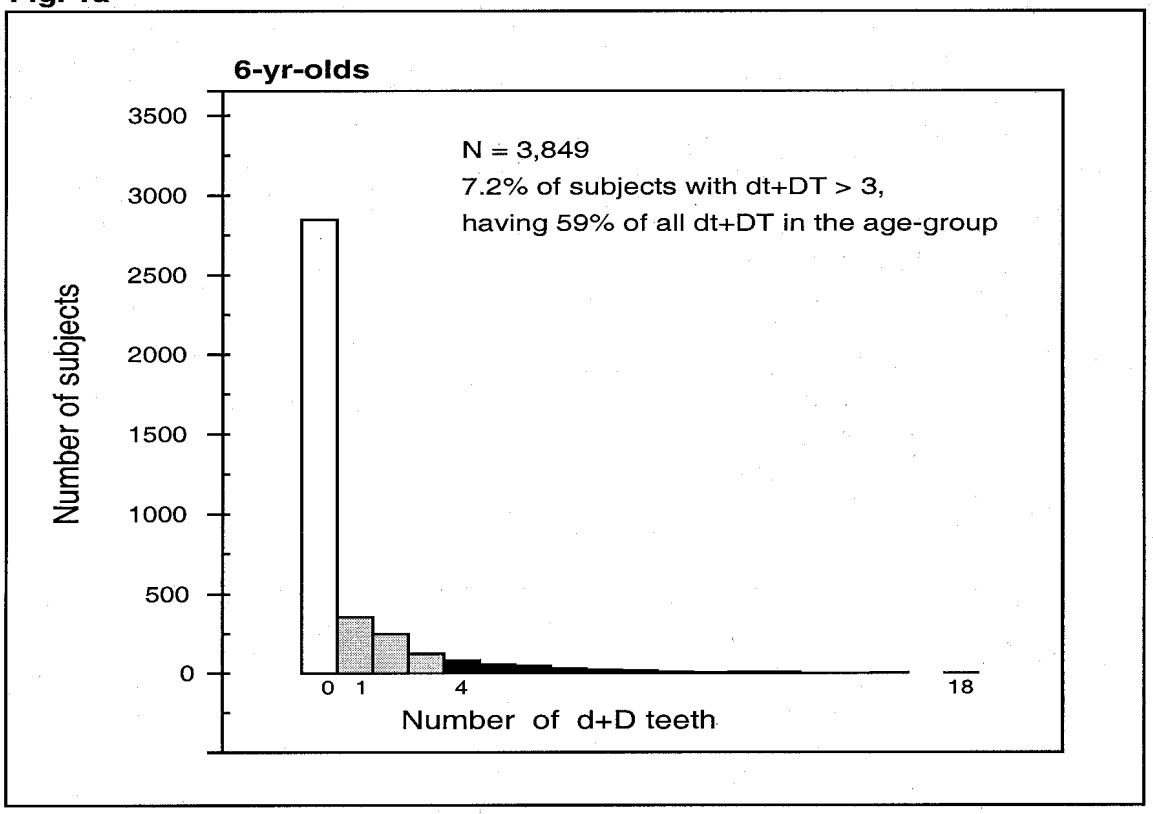

6-yr-olds
N = 3,849
7.2% of subjects with dt+DT > 3,
having 59% of all dt+DT in the age-group
Number of subjects
3500
3000
2500
2000
1500
1000
500
0
0 1 4 18
Number of d+D teeth

Fig. 1b

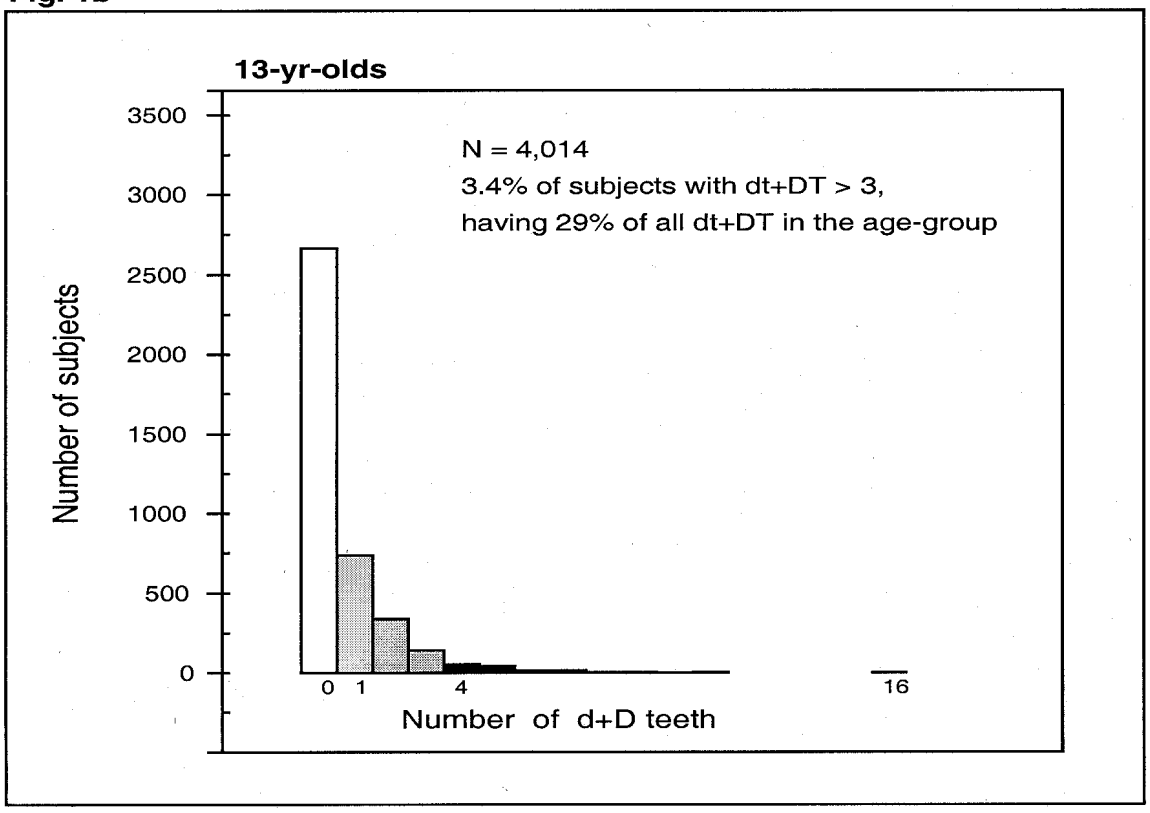
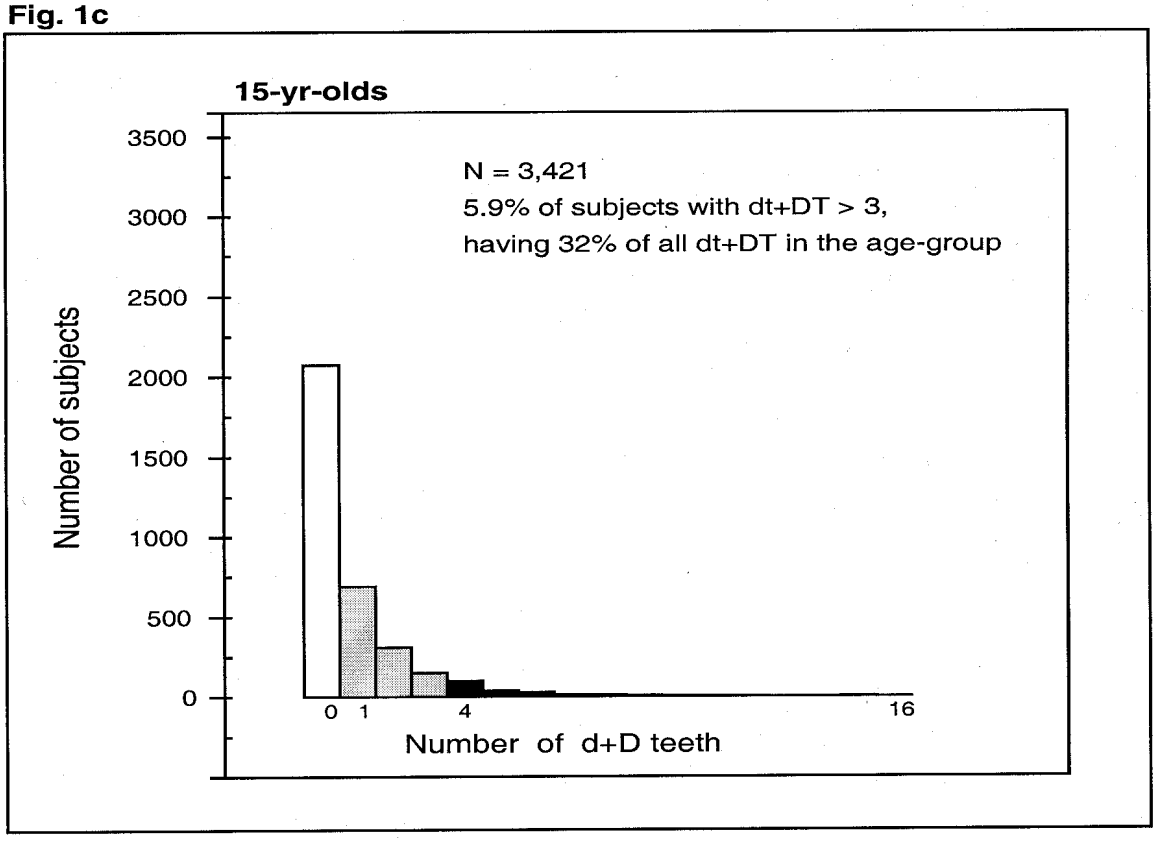

13-yr-olds
N = 4,014
3.4% of subjects with dt+DT > 3,
having 29% of all dt+DT in the age-group
Number of subjects
3500
3000
2500
2000
1500
1000
500
0
0 1 4 16
Number of d+D teeth

Fig. 1c



Figures 1a, 1b, 1c. Distribution of subjects by number of decayed teeth (dt+DT) in Helsinki public oral health service. Data based on official statistics on all 6-, 13- and 15-year-olds clinically examined in 1992.

Data collection, definitions and descriptions

For the study on prevalence and distribution of caries (I), information on numbers of teeth with caries experience among all 5-year-olds (dmft) or all 15-year-olds (DMFT) and on primary and permanent teeth with current untreated caries (dt+DT), diagnosed at subject's clinical dental examination, was collected from the official statistics, 1976 to 1993, year by year. The following definitions were used in evaluation of changes in frequency distributions by subject:

Polarization of dental caries was described:
1) as the proportion of high-caries groups and of cavity-free groups, both in terms of caries experience and current untreated caries
2) as the proportion of teeth with caries experience and teeth with current untreated caries in each high-caries group of the total number of all such teeth in the entire age-group.

The high-caries group in terms of caries experience among the 5-year-olds included all 5-year-old subjects with three or more primary teeth with past caries (dmft≥3). For the 15-year-olds, limits were set higher because of the high mean number of DMF teeth at age 15: six or more permanent teeth with caries experience (DMFT≥6), or, as an alternative, 15 or more DMFT teeth (DMFT≥15).

The high-caries group in terms of current untreated caries was similar for both the age-groups: three or more decayed teeth (dt+DT≥3).

For the study on treatment practices (II-V), data were drawn from patients' individual oral health records. The Helsinki City Health Department (1985) has given detailed, written instructions on its record-keeping practice. Patient records should include information on the state of each subject's primary and permanent dentition, recorded at a clinical dental examination, and a detailed description of the following treatment course, visit by visit (Appendix 1). For the present study, data were collected for the year 1992; furthermore, for 6-year-olds, retrospective information on their previous clinical dental examinations and treatment courses were gathered for ages 3 to 5. Data, first collected onto data-collection forms (Appendix 2), were organized as follows:

Dental state was described by caries state and eruption stage as found in patient records. ***Caries state*** was indicated by number of decayed teeth (dt+DT) and DMF teeth, as well as numbers of decayed and filled surfaces (DFS), decayed surfaces (DS), and initial caries lesions (CI). ***Eruption stage*** of permanent teeth was recorded tooth by tooth, and categorized as erupted, erupting, or not erupted.

Dentists' judgement of high-caries patients' risk for caries was based on dentists' own original statements. Patient charts include a place to annotate the judgement of patient's risk for caries, either on a dichotomous scale or as a free-format comment. Dentists' judgement of high risk was categorized as having or not having recorded the high-caries patient in question as being at high risk for caries.

Dentists' judgement of patients' level of co-operation, collected for 6-year-olds, was based on dentists' own original statements. Patient charts include a place to annotate the judgement on patient's level of co-operation, either on a dichotomous scale or as a free-format comment. Dentists' judgement of patient's co-operation was categorized as good or poor.

Utilization of dental services was recorded by number of dental visits, excluding visits made for orthodontic reasons, the interval between the clinical dental examination in 1992 and the following check-up, and data on whether or not the treatment course had been completed. The treatment course was regarded as completed in cases of such annotation's being recorded and in cases of the filling treatment's being completed.

Operative treatment was recorded by number of fillings, pulpotomies, and extractions. Use of local anaesthesia in connection with filling treatment was recorded for 6-year-olds.

Caries-preventive treatment included preventive measures provided by the dentists, dental hygienists, and dental assistants. Preventive measures were categorized as 'patient-active' and 'patient-passive' prevention, emphasizing the patient's role in caries management, being either active or passive (Vehkalahti, 1997). 'Patient-active' prevention, including instructions and advice on home care, was used as follows: number of oral hygiene instructions, any provision of dietary counselling including advice on use of sugar substitutes, and advice on home use of fluorides, either by means of mouthrinses or tablets. 'Patient-passive' caries prevention included the number of topical applications of fluorides and fissure sealants, as well as professional tooth cleaning.

Evaluation of treatment provided

Treatment provided was evaluated by comparing preventive treatment given to the high-caries group and cavity-free group, as well as within each study group in relation to patients' dental state, to dentists' judgement of high-caries patients' high risk for caries and to patients' level of co-operation. Caries-preventive treatment was described by proportion of patients having received preventive measures, by intensity of prevention, i.e., number of times preventive measures had been provided per patient (per treatment course) and per visit, and by number of different types of preventive measures provided, indicating the diversity of caries prevention.

Criteria for evaluation of treatment provided were based on guidelines and instructions given by the National Board of Health (1985) and the Helsinki City Health Department (1985) which have instructed dentists to individualize caries-preventive treatment and check-up intervals based on each patient's risk for developing caries. Accordingly, in the present study, a prevention-orientated high-risk strategy was expected to have been used by the dentists: intensive preventive treatment was expected to have been targeted to the high-caries patients. In addition, all patients, including cavity-free subjects, with erupting permanent molars or premolars were considered to have been at increased risk for caries and consequently in need of intensified caries-preventive treatment (Carlos and Gittelsohn, 1965; Nikiforuk, 1985; Carvalho et al., 1989, Virtanen and Larmas, 1995). The interval for each patient to the following check-up was expected to have been adjusted according to the patients' caries state and eruption stage of permanent molars.

The Helsinki City Health Department (1985) has instructed dentists to judge and record each patient's risk for caries and level of co-operation on a dichotomous scale on the patient's oral health record. In more detail, dentists are instructed to judge at least all those patients with three or more decayed teeth (dt+DT) to be at high risk for caries; this criterion was met by all high-caries patients in the present study. According to the same instructions, high-caries patients' caries-preventive treatment should be based on the causal factors of caries, and provided at each dental visit until the disease is considered to be under control. In the present study, therefore, a variety of preventive measures was expected to have been provided to the high-caries patients, combined and intensified according to each patient's individual needs. In particular, preventive treatment was assumed to have been even more pronounced in cases of erupting molars and premolars.

Statistical evaluation

In the study on prevalence and distribution of caries (I), differences in trends between 5- and 15-year-olds over the years were evaluated by comparing slopes of the trend lines estimated by a regression model.

In the study on treatment practices (II-V), statistical methods included the chi-square test, t-test, and analysis of variance for evaluation of differences between groups, and the correlation coefficient for evaluation of associations between variables, two at a time, and furthermore, a linear regression model to analyse the intensity of preventive treatment provided to the high-caries and cavity-free patients. Finally, for the data on the high-caries patients, a logistic regression model (Kleinbaum et al., 1998) was applied to evaluate dentists' judgements of high risk and the caries-preventive treatment provided. Estimates in each logistic regression model were used to calculate the corresponding odds ratios and their 95% confidence intervals.

RESULTS

Prevalence and distribution of dental caries in young populations (I)

Evaluation of dental caries occurrence among all 5- and 15-year-old patients in Helsinki revealed a decline in caries occurrence and a strong polarization of caries, past and present, in both of these age-cohorts (Table 4). There has been a fourfold decline in DMFT- and dt+DT-indices of 15-year-olds during the 17 years, 1976-1993, accompanied by a threefold increase in the proportion of 15-year-old subjects with no current caries. This trend of polarization was weaker among 5- than 15-year-olds. High-caries subjects still existed in 1993 in both age-groups: 10% of the subjects, on average, had the majority of all untreated decayed teeth (dt+DT) in the entire age-group.

Table 4. Changes in caries prevalence and its distribution among 5- and 15-year-olds in Helsinki, 1976-1993.

Age (years)	Year	Mean dmft or DMFT	% with dmft or DMFT=0	Mean dt+DT	% with dt+DT=0	High-caries subjects with dt+DT≥3	
						% of all subjects in age-group	these subjects had this % of all dt+DT
5	1981	1.4	62	0.9	70	13	80
	1986	1.3	67	0.9	71	12	73
	1990	0.9	75	0.6	79	9	73
	1993	0.8	78	0.6	80	8	76
15	1976	12.1	<1	3.1	19	49	87
	1986	5.1	12	1.2	50	15	61
	1990	3.6	20	0.9	60	10	55
	1993	3.0	26	0.8	62	10	55

dmft for 5-yr-olds; DMFT for 15-yr-olds; dt+DT for both ages.

Dentists' judgement of high-caries patients' risk for caries (II-IV)

In the high-caries study groups, similarly for 6-, 13-, and 15-year-olds, one patient out of five had been judged by the dentist as being at high risk for caries (Table 5). According to a logistic regression model, this dentist's judgement of high risk was not explained by the patient's number of decayed teeth (p=0.88) or DMF teeth (p=0.06), or by patient's gender (p=0.23) or age (p=0.09). Furthermore, dentists' judgements of high risk correlated neither with eruption stage of permanent teeth (χ^2= 0.084, NS) nor patient's level of co-operation (χ^2= 0.932, NS).

Table 5. Dentists' judgement of high risk among high-caries patients (n=294) by age in 1992, and high-caries patients' caries state by such judgement.

Age-group	Number of high-caries patients	High risk[1] judged by the dentist, %	Number of dt+DT by judgement of high risk			
			Judged		Not judged	
			Mean	(SD)	Mean	(SD)
6-yr-olds	97	22	9.0	(2.6)	8.7	(3.0)
13-yr-olds	97	23	6.1	(2.6)	5.3	(2.0)
15-yr-olds	100	17	7.2	(3.5)	6.4	(2.4)
Total	294	20	7.4	(3.1)	6.7	(2.8)

[1]Based on original statements by dentists in patient records.
Statistical evaluation between mean values of dt+DT within each age-group by t-test: all NS.

Treatment provided to high-caries and cavity-free patients (II-IV)

Treatment courses had been completed among all the cavity-free patients (Table 6). Among the high-caries patients, 39% of the treatment courses had remained uncompleted. The high-caries patients' treatment courses differed from those of the cavity-free patients in number of dental visits, five times more numerous for the former. Preventive measures per patient seemed to have been provided for the high-caries patients slightly more often than for the cavity-free patients.

Table 6. Description of treatment courses in 1992 among study subjects by age (n=382).

Age (years)	Patients	No. of visits, excluding orthodontics		No. of preventive measures		No. of fillings made		Treatment course completed
		Mean	(SD)	Mean	(SD)	Mean	(SD)	%
6	Cavity-free	1.4	(0.9)	2.1	(2.2)	0.0	0.0	100
	High-caries	6.4***	(4.0)	2.7NS	(2.5)	4.8***	(3.3)	55***
13	Cavity-free	1.8	(1.0)	2.6	(2.0)	0.0	0.0	100
	High-caries	6.7***	(3.8)	3.2NS	(2.5)	5.8***	(3.6)	67***
15	Cavity-free	1.1	(0.3)	1.2	(0.8)	0.0	0.0	100
	High-caries	6.4***	(4.2)	2.2***	(1.7)	6.3***	(4.3)	61***
Total	Cavity-free	1.4	(0.8)	1.9	(1.8)	0.0	0.0	100
	High-caries	6.5***	(4.0)	2.7**	(2.3)	5.6***	(3.8)	61***

Statistical evaluation within each age-group by t-test and chi-square test: *** $p<0.001$, ** $p<0.01$, NS not significant

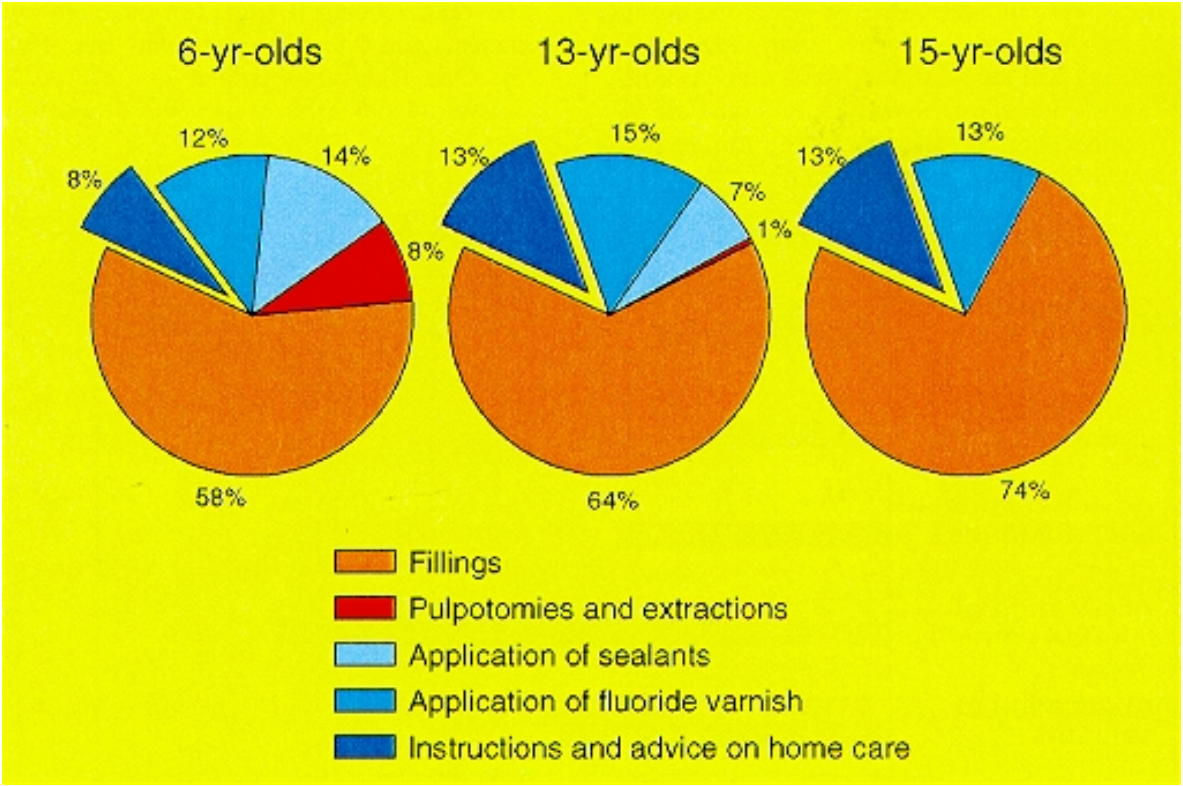


Figure 2. Treatment provided to high-caries patients (n=294) by age. Percentages describe proportion of each treatment of all measures provided, excluding orthodontics.

Treatment provided to the high-caries patients had been very similar in all three age-groups, the majority (58% to 74%) of treatment items having been restorative treatment (Figure 2). Tooth extractions and pulpotomies had predominantly been done in primary teeth. Fillings had been made under local anaesthesia to 24% of 6-year-olds.

Caries-preventive treatment in relation to patients' caries state (II-IV)

The majority of the preventive measures provided both for the high-caries patients (Figure 2) and for the cavity-free patients were topical applications of fluoride varnish or fissure sealants. Of the 2.7 preventive measures per high-caries patient, 0.9 were 'patient-active', and 1.7 'patient-passive'. The corresponding figure for the cavity-free patients was 1.9, of which 0.3 were 'patient-active' and 1.6 'patient-passive'.

Similar numbers of high-caries and cavity-free patients had received one or more caries-preventive measures during their treatment course (87% vs. 85%, NS). Application of fluoride varnish had been the most frequently provided preventive action, given similarly to high-caries and cavity-free patients (Figure 3). More high-caries patients than cavity-free patients had received oral hygiene instruction, dietary counselling, and advice on home use of fluorides, but the majority of the former had remained without such measures.

The high-caries patients had received 2.7 preventive measures per patient compared to 1.9 for the cavity-free (Table 6). Figures 4a and 4b show the number of preventive measures provided per visit in relation to each patient's number of decayed teeth (dt+DT). Among the high-caries patients, number of dt+DT had no influence (r=-0.097) on intensity of caries-preventive treatment: they had received 0 to 2 preventive measures per visit, 0.5 on average. The corresponding figures for the cavity-free were 0 to 4 preventive measures per visit, 1.3 on average.

The high-caries patients had been given a greater variety of different types of preventive measures than had the cavity-free, 2.0 vs. 1.4, the ranges being 0 to 5 for the high-caries patients and 0 to 4 for the cavity-free (Figure 5). One high-caries patient out of ten had received 4 to 5 different preventive measures.

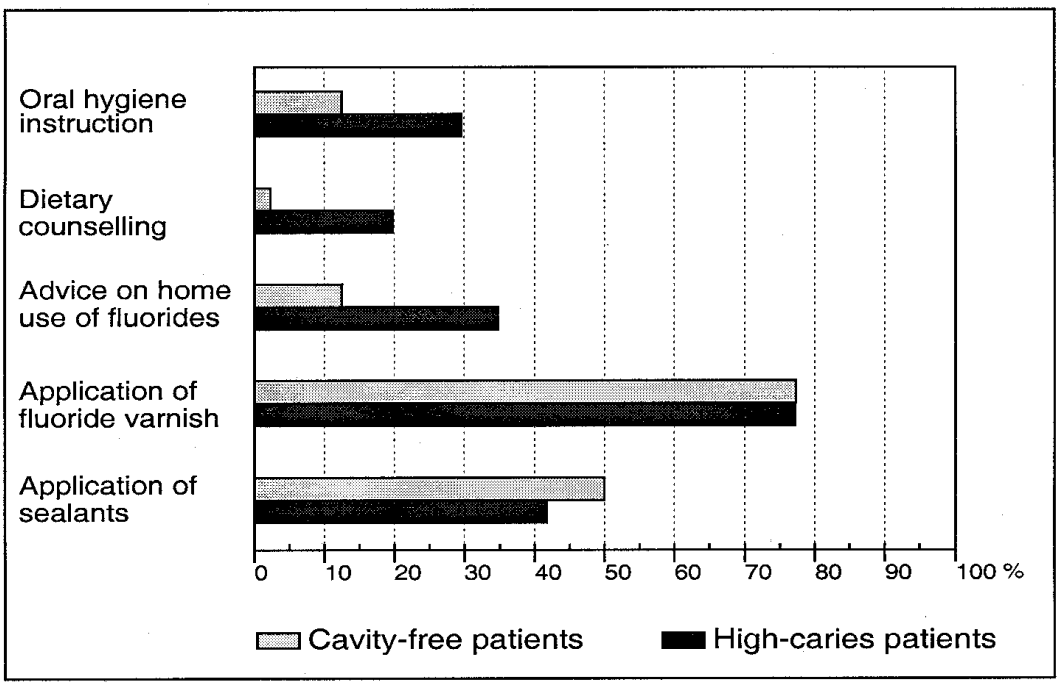


Figure 3. Proportion of high-caries (n=294) and cavity-free (n=88) patients receiving each item of preventive treatment.

Fig. 4a

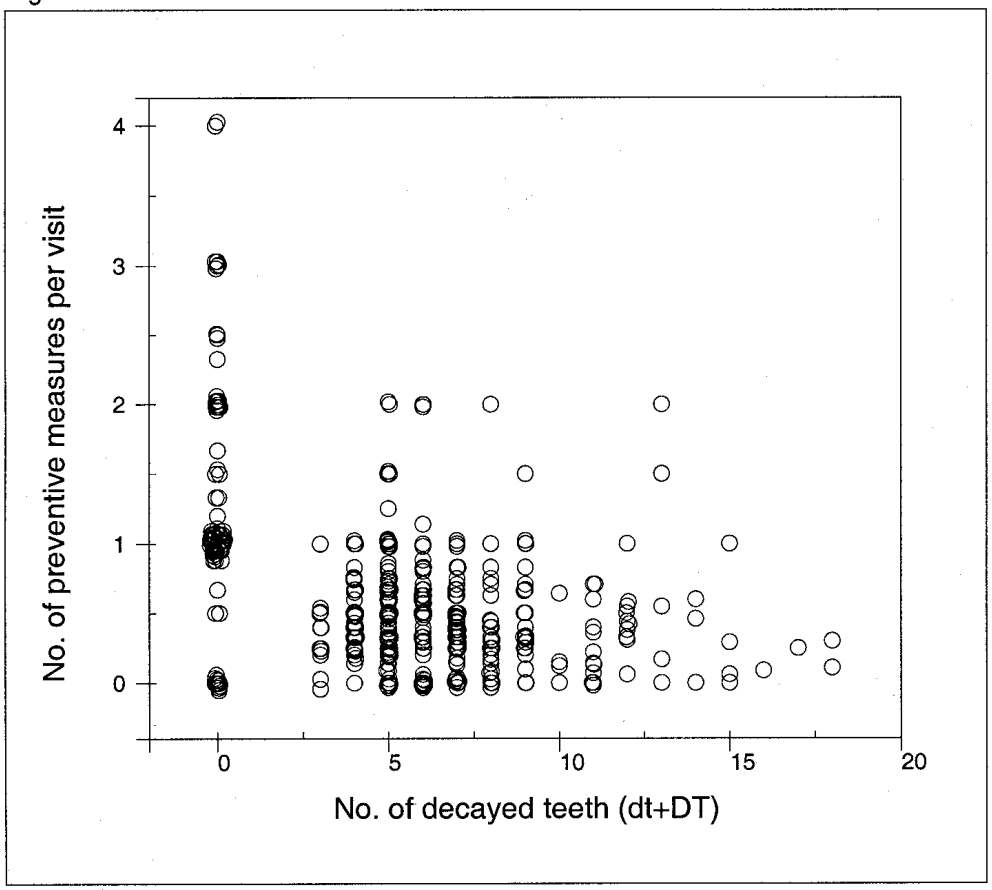
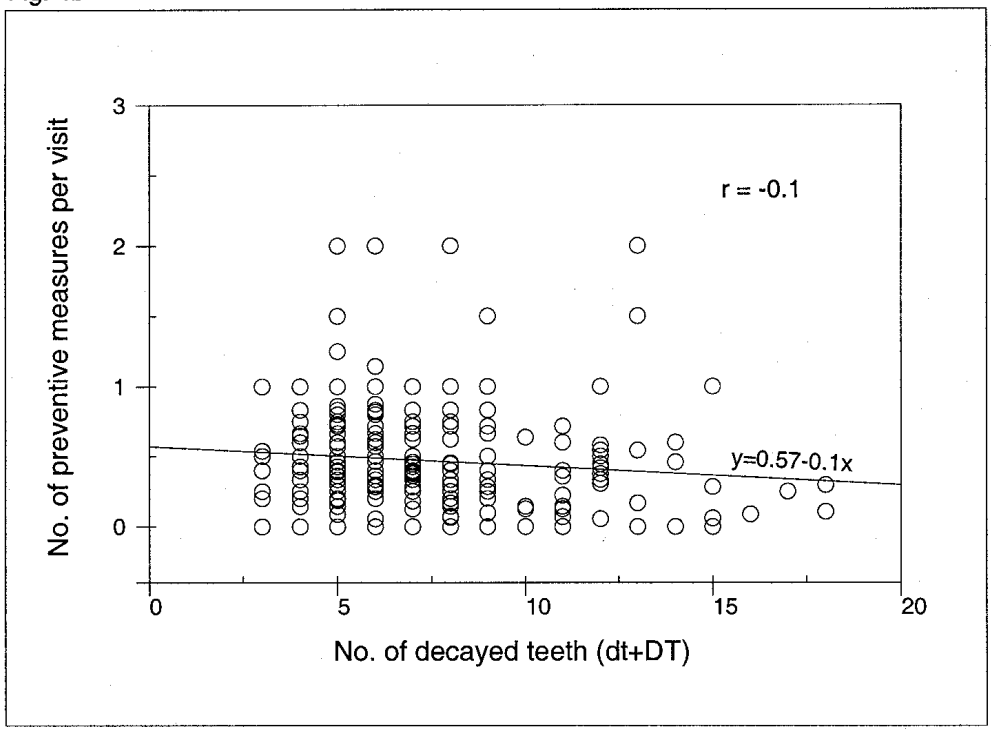


Fig. 4b



Figures 4a,4b. Caries-preventive measures per visit by number of decayed teeth; one circle per patient. Figure 4a includes cavity-free (n=88) and high-caries (n=294) patients, Figure 4b high-caries patients only.

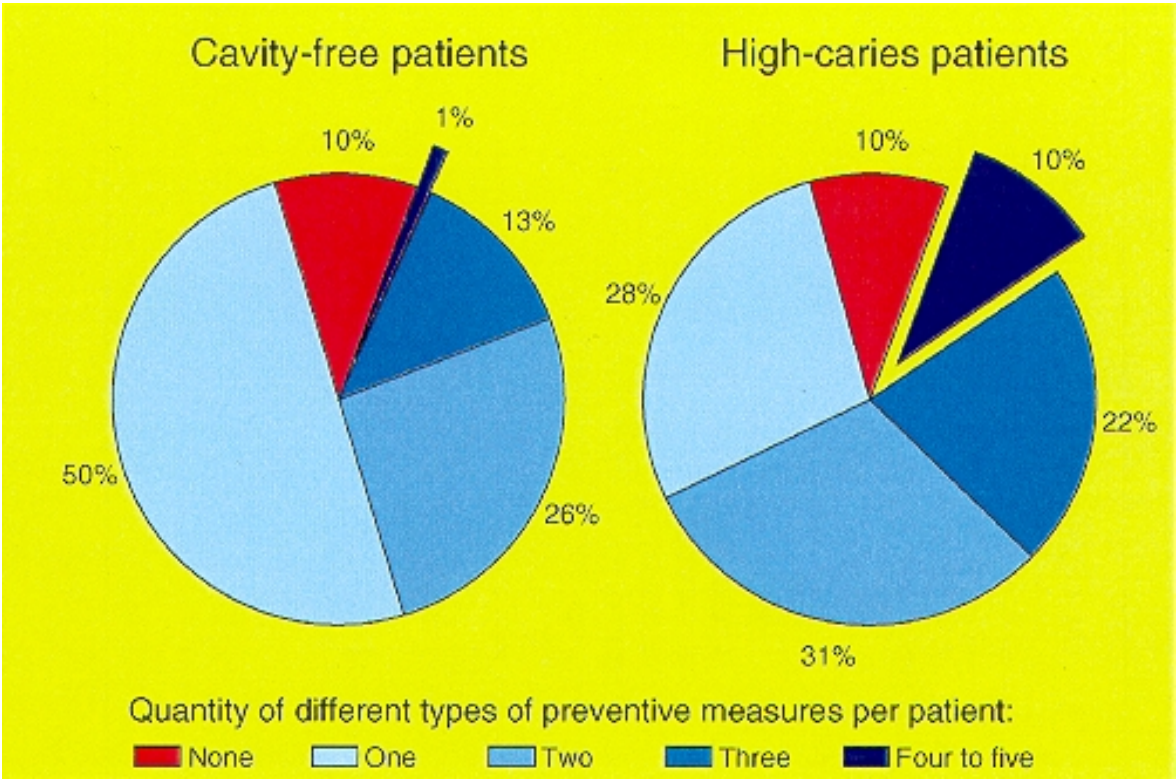


Figure 5. Proportion of cavity-free (n=88) and high-caries (n=294) patients receiving different types of preventive measures, including oral hygiene instruction, dietary counselling, advice on home use of fluorides, application of fluoride varnish, and of fissure sealants.

Caries-preventive treatment in relation to erupting permanent teeth (II, III)

According to individual oral health records, erupting first permanent molars were recorded as present in 42% of 6-year-old high-caries patients, and erupting premolars or second permanent molars in 27% of 13-year-old high-caries patients. For the cavity-free patients, the corresponding figures were 35% for 6-year-olds and 59% for 13-year-olds.

More patients with erupting first permanent molars than those without had been given oral hygiene instructions (15% vs. 4%, $p<0.05$). This targeting was not seen in evaluation of preventive measures given both to 6- and to 13-year-old high-caries and cavity-free patients with and without erupting first or second permanent molars or premolars (Table 7). High-caries patients with erupting permanent teeth had received dietary counselling less frequently than had those without.

Table 7. Caries-preventive measures given (%), in relation to eruption stage of permanent molars (Ms) or premolars (PMs) among 6- and 13-year-old patients.

Preventive measure	High-caries patients		Cavity-free patients	
	With erupting Ms or PMs (n=64) %	Without erupting Ms or PMs (n=130) %	With erupting Ms or PMs (n=26) %	Without erupting Ms or PMs (n=30) %
Oral hygiene instruction	25	26	12	7
Dietary counselling	9	23*	4	0
Advice on home use of fluorides	31	35	15	20
Application of fluoride varnish	75	76	81	63
No prevention	9	14	8	23

Eruption stage originally discovered and recorded at clinical dental examination.
Statistical evaluation within high-caries and cavity-free groups by the presence of erupting teeth; chi-square test: *$p<0.05$, all others NS.

Caries-preventive treatment in relation to dentists' judgement of high risk (II, III)

Dentist's judgement of high risk led to an increase in coverage of caries-preventive treatment, and in intensified caries prevention provided per patient, especially 'patient-active' prevention. As many as 97% of the high-caries patients whom their dentists had judged as high-risk patients had received preventive treatment, compared to 84% of those high-caries patients without such a high-risk judgement ($p=0.01$). Preventive treatment had been more intensive ($p<0.01$) for those judged as high-risk patients by the dentist than for the rest (Table 8).

Table 8. Regression model on number of preventive measures per patient among high-caries (n=294) and cavity-free patients (n=88).

Independent variable	Regression coefficient	Standard deviation	β^*	p
Dentist's judgement of high risk	0.744	0.275	0.129	<0.01
Number of visits	0.207	0.024	0.402	<0.001
Patient's age	-0.030	0.025	0.056	NS

Constant=1.628, $R^2=0.211$
β^*=standardized regression coefficient.

According to logistic regression, models fitted on high-caries patients' data (subjects' age and gender, and numbers of dt+DT and DMF teeth) showed no association with the provision of preventive treatment, the dentist's judgement of high risk being the only variable of significance. Each model revealed a strong association with dentist's judgement of high risk and the provision of caries-preventive treatment, the odds ratios being from 2.7 to 13.5 in favour of cases in which high risk had been the judgement (Table 9).

Table 9. Association with dentists' judgement of high risk and caries-preventive treatment provided for high-caries patients (n=294), by logistic regression modelling[1].

Variable and category	Odds ratio[2]	95% confidence interval	p-value
'Patient-active'[3] prevention provided	13.5	5.2 - 35.6	0.000
'Patient-passive'[3] prevention provided	2.7	1.2 - 6.4	0.022
Any caries prevention provided	7.4	1.7 - 31.4	0.007

[1]In addition, each model included patients' age and gender, and numbers of dt+DT and DMF teeth, all of which remained statistically non-significant.

[2]Compared to cases not been judged as high-risk patients by their dentist.

[3]'Patient-active' prevention: oral hygiene instruction, dietary counselling, and advice on home use of fluorides. 'Patient-passive' prevention: applications of fluoride varnish and fissure sealants.

As shown in Figure 6, dentist's judgement of high risk increased 'patient-active' prevention in particular, which was twofold (1.7 vs. 0.8, $p<0.001$) for the high-caries patients receiving a high-risk judgement compared to other high-caries patients. Of all patients studied, the fewest preventive measures had been provided to the high-caries patients who had not been judged by their dentists as high-risk patients and who failed to complete the treatment course.

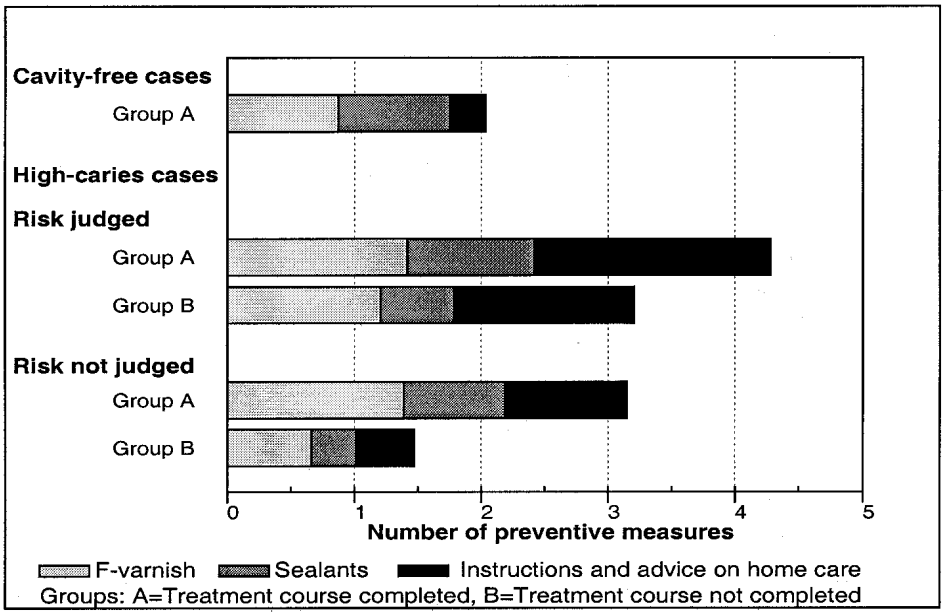


Figure 6. Mean number of preventive measures per cavity-free patient (n=88) and per high-caries patient (n=294) by dentist's judgement of high risk, and by completion of treatment course.

Caries-preventive treatment in relation to 6-year-old patients' level of co-operation (V)

According to the oral health records of 6-year-old patients, dentists had judged none of the cavity-free, but 34% of the high-caries patients as being nonco-operative. Among these nonco-operative, coverage of preventive treatment had been the lowest for all 6-year-olds (Table 10). Furthermore, they had been provided with the fewest preventive measures per visit, and their treatment courses were completed less frequently ($p<0.05$) than for the co-operative high-caries patients.

Table 10. Comparison of treatment courses among 6-year-olds in relation to their co-operation, based on original statements by dentists in patient records.

Description of treatment courses	Cavity-free patients	High-caries patients	
	Co-operative (n=29)	Co-operative (n=64)	Nonco-operative (n=33)
Number of visits; mean (SD)	1.4 (0.9)	5.6 (3.4)	7.8 (4.7)**
Number of preventive measures per visit; mean (SD)	1.4 (1.1)	0.6 (0.6)	0.4 (0.4)*
Preventive treatment provided, %	79%	89%	76%^{NS}
Treatment course completed, %	100%	63%	39%*

Statistical evaluation among high-caries patients by co-operation; t-test and chi-square test: $^{**}p<0.01$, $^{*}p<0.05$, ^{NS}not significant.

Individualizing check-up intervals (II-IV)

The check-up intervals between the clinical dental examination in 1992 and the following check-up were not influenced by patients' number of decayed teeth ($r=0.04$): the high-caries patients had a similar check-up interval as did the cavity-free patients in all three age-groups, 12 months on average (Table 11). Furthermore, among the high-caries and cavity-free patients, half the subjects had check-up intervals of 11 to 13 months, 4% had intervals of 6 months or less, and 16% had check-up intervals longer than 15 months. Dentists' decisions on check-up interval had been influenced neither by their judgement of high risk ($r=0.06$) nor by eruption of permanent teeth ($r=0.07$). Among the 6-year-olds, the unco-operative tended to have longer check-up intervals than the co-operative ($r=0.16$).

Table 11. Interval between clinical dental examination in 1992 and the following check-up among cavity-free and high-caries patients (n=284).

Patient group	Interval to the following check-up (in months)							
	6-year-olds		13-year-olds		15-year-olds		Total	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Cavity-free	11.6	(2.7)	13.0	(4.1)	12.1	(1.6)	12.2	(3.0)
High-caries	12.2	(4.2)	12.4	(3.2)	12.5	(3.4)	12.4	(3.6)

Statistical evaluation within each age-group by t-test: all NS.

DISCUSSION

The present study evaluated public oral health services provided in Helsinki, which account for approximately one-tenth of all public oral health services provided in Finland. A previous report in Finland in the early 1990's showed no differences in caries prevention policies between different parts of Finland or between public and private dentists, but revealed the discrepancy between number of caries-preventive measures reported to be provided and actually carried out (Kärkkäinen, 1997). In addition, statistics by the Social Insurance Institution (1999) verify the provision of caries-preventive treatment for young adults in different parts of Finland by private dentists as being similar. The present findings may, therefore, give a good estimate as to future trends in caries occurrence and as to overall caries-preventive approach for children and youth in Finland.

The study on prevalence and distribution of caries during the two past decades revealed downward trends in past and current caries, confirming similar findings in many industrialized countries (Bille et al., 1986; Brunelle, 1989; Marthaler et al., 1996; Sundberg, 1996). During the last few years, caries decline seemed to have levelled off, suggesting that caries is not disappearing. Moreover, many countries have seen a slight increase in caries occurrence (Frencken et al., 1990; Haugejorden, 1994; Pitts and Palmer, 1994; Riordan, 1995), which is, however, in contrast to the present Finnish findings.

Decline in caries occurrence was characterized by a strong polarization. Alongside the decrease in mean dt+DT figures, current high-caries patients have fewer dt+DT than had the corresponding high-caries groups 15 to 20 years ago. Despite the decline in the proportion of children with dt+DT≥3, they had over half of all decayed teeth in their age-group. This fact emphasizes the importance of using frequency distributions of subjects attacked, rather than mean values, in evaluation of oral health at population level, and in strategies for organizing oral health care services.

Contrary to the hypothesis of the present study, and despite the decline in and polarization of caries occurrence among child and youth populations, dentists routinely had ignored each patient's risk for caries and thus failed to individualize caries-preventive treatment according to patient needs. The present results reflect treatment practices adopted as real-life working routines for the child and youth populations in Helsinki, because nearly all children in each age-group participate in the public oral health service, and because at the time treatment was provided, the dentists in the public oral health service were unaware they were to be evaluated later. Furthermore, the subjects were selected from all the seven administrative districts in Helsinki, numbers of study subjects in proportion to the numbers of all 6-, 13- and 15-year-olds clinically examined and treated in each district in 1992. These age-groups were selected because biological factors, i.e., eruption and maturation of permanent molars, and tightening of approximal contacts, increase risk for caries at these ages, even in cavity-free subjects.

The cavity-free group was intentionally given that name, because the data were based on patient records, and from these, it was impossible to judge whether or not the subjects were actually totally free of any stages of caries. The term 'caries-free' requires absence of initial lesions as well, recording of which varies between dentists (Moberg Sköld et al., 1995). Contrary to this, recordings on caries reaching down to the dentine, i.e., cavities, can be considered to be more reliable

and more uniformly diagnosed and recorded by the dentists (Fejerskov, 1995). The other study group was given the name 'high-caries' group to emphasize that the patients in this group had the highest numbers of decayed teeth in their age-group. Simultaneous use of several indicators for caries risk, a method shown to be more accurate than use of a single variable in selecting high-risk individuals (Demers et al., 1990), was inappropriate here, because the automatic data processing data-base of 4,000 subjects in each age-group allowed selection of subjects on the basis of number of decayed teeth; the data-base ignored data on initial caries lesions or erupting permanent molars, which are also shown to be related to increased risk for caries. Selection of subjects on the basis of dt+DT produced the high-caries group, which happened to include more boys than girls. However, no statistically significant differences were found in caries state by gender. Furthermore, boys and girls were assumed to have been treated similarly, irrespective of their gender, related only to their individual dental needs.

Oral health care can be considered as a process including clinical dental examination, diagnosis, treatment planning, and the treatment provided. Evaluation of this process can be accurately carried out by use of structured patient records (Jerge and Orlowski, 1985). Such records are used throughout public oral health service. In addition, detailed written instructions on record-keeping are available in each dental clinic in Helsinki. In general, recording items of treatment can be considered as reliably done if dentists are financially rewarded based on recordings (Källestål et al., 1997). In evaluation of validity and reliability of the present data, the key question was which treatment procedures dentists had eventually performed in relation to patients' dental findings discovered by the dentists themselves. To reveal the individualization in caries-preventive treatment, the cavity-free patients were selected from the same clinics as the high-caries cases.

For those that this study calls high-caries patients, the dentists had diagnosed 3 to 18 decayed teeth, dt+DT. The dentists should thus have had no doubt whether or not these patients were at high risk for caries. Furthermore, according to the limit (dt+DT≥3) set by the Helsinki City Health Department (1985), all these high-caries patients should have been judged as high-risk patients by their dentists. However, this happened in only one high-caries patient out of five, showing that assessing patients' risk for caries was not a routine practice in the public oral health service in Helsinki. A similar lack of clarity in caries-risk thinking was recently reported throughout Finland (Kärkkäinen, 1997).

In the present study, it remained unclear on what the dentists based their judgement of high risk, because no correlation was found between dentists' judgement of high risk and their recordings in the patient records. Data on patients' social background and oral health behaviour, known to be related to caries risk (Milén et al., 1981; Tala, 1984; Bauch, 1990; Schou, 1991; Flinck et al., 1999) and recommended to be utilized in assessing patients' future risk for caries (Blinkhorn and Geddes, 1987; Edelstein, 1995), had, in patient records, been ignored. Unfortunately, there is no tradition in Finland of utilizing such information to gain comprehensive understanding on high-caries patients' risk for caries (Vehkalahti et al., 1992; Helminen et al., 1998).

In order to assess quality of dental care, the actual care provided to patients must be compared to the criteria for optimal or adequate care (Bailit, 1985). In the present study, instructions guiding dentists' treatment practices in every-day dental practice (Helsinki City Health Department, 1985; National Board of Health, 1985) served as such criteria. Similar instructions on individually tailored caries-preventive treatment are available in many textbooks of cariology (Blinkhorn and Geddes, 1987; Bratthall and Ericsson, 1994) and in scientific papers (Newbrun, 1992a; 1992b; Anderson et al., 1993; Anusavice, 1995; Edelstein, 1995; Moss and Zero, 1995; Powell, 1998a). The present study's two-point study design, comparing two extreme groups of patients as to risk for caries, should have revealed dentists' individualized caries-preventive treatment practices, if such individualization had existed. In addition, caries prevention was evaluated from various aspects, but all evaluations resulted in similar findings: a filling-orientated treatment strategy for the high-caries patients with insufficient and inaccurately targeted preventive treatment. Moreover, too much emphasis was laid on

clinical dental examinations of and caries prevention for the cavity-free patients.

In every-day dental practice, the dentists ignored, for one reason or another, the instructions of the Helsinki City Health Department and the Finnish health authorities. This finding is in line with that of Kärkkäinen (1997): dentists in the public oral health service stated that they carried out caries-preventive treatment more frequently than was verified on the basis of recordings in patient records; and in addition, the Finnish chief dental officers reported that only one out of three dentists properly followed instructions on individualized caries-preventive treatment. In such a situation, one could criticize the appropriateness of the instructions given and the need to update them (Crall, 1989).

Insufficient caries-preventive treatment for the high-caries patients might be explained by the statement that dentists may fail to record every single piece of preventive advice they give to their patients (Lennon et al., 1990), especially during demanding visits, or when caries prevention is provided at the same visit as restorative treatment. Even if the possible underecording of preventive measures is, however, taken into account in the present results, preventive treatment for the high-caries patients would still remain inadequate, considering their high numbers of dt+DT (mean dt+DT 5.5 to 8.7). Moreover, nonrecording of some treatment procedures can be a sign that they are less valued, not considered worth recording (Torppa, 1993). Similarly, dentists' differing values and beliefs as to the outcomes of their caries-preventive treatment can be seen by their treatment approaches: either filling-orientated or prevention-orientated (Holloway and Clarkson, 1994).

A filling-orientated treatment strategy can spring from dental education or be related to patients' greater desire for restorative treatment than for prevention (Chen, 1990). Furthermore, provision of restorative treatment may be more financially rewarding for dentists than is provision of preventive measures (Chen, 1990; Fejerskov, 1995). Under the remunerative system of the public oral health service in Finland, dentists are paid monthly additional fees for the number of clinical check-ups and some items of treatment. In general, extra fees for the most common fillings are greater than those for preventive measures, suggesting that preventive treatment has been underemphasized by their employers in the public oral health service.

In the United Kingdom, treatment for children under two different payment systems has been evaluated by Lennon et al. (1990), by Mellor and Lennon (1993), and by Holloway and Clarkson (1994). Under the fee-for-service system, in effect until 1990, dentists were paid a fee for each item of treatment. Under the capitation system currently in use, dentists are paid a standard annual sum for undertaking the dental care of each child registered in their practice. Compared to the fee-for-service, the capitation system of remuneration has been shown to encourage dentists to favour prevention-orientated treatment practices (Lennon et al., 1990; Holloway and Clarkson, 1994), but has had little influence on check-up intervals (Mellor and Lennon, 1993).

In dental clinics employing dental hygienists, caries-preventive treatment is provided more frequently than in those without such personnel (Chen, 1990; Holloway and Clarkson, 1994). Unfortunately, the number of dental hygienists in the public oral health service in Helsinki is low, which does not support delegating preventive treatment. However, dentists have responsibility for all treatment, including prevention, regardless of availability of auxiliary personnel.

A very positive finding in the present study was that a dentist's judgement of high risk improved individual-based treatment decisions, putting more emphasis on prevention, especially on provision of preventive measures that activate patients to carry out proper home care. A tendency towards more accurate targeting in cases of dentist's judgement of high risk have also been reported by Wang and Holst (1995) and Kärkkäinen (1997). Caries-risk assessment for each patient should, therefore, be adopted as routine in dental practice to individualize caries-preventive treatment and check-up intervals. Unfortunately, in the present study, dentists' judgement of high risk was not reflected in their decisions on patients' check-up intervals, which were similar for the cavity-free and high-caries groups. However, considerable savings could have resulted from extending check-up intervals for the cavity-free patients up to two years. In the Helsinki public

oral health service, a conservative estimate on savings in the three age-groups studied would have been 2,500 visits in one year, corresponding to one dentist's annual work, on average.

After 1992, the Helsinki City Health Department (1993b) has encouraged its dentists to individualize their treatment practices. Detailed instructions require judgement of each patient's risk for caries on a three-level scale at every clinical dental examination, and require individualizing check-up intervals, the following of which instructions is monitored and rewarded. A national report on present and recommended practice regarding check-up intervals for children and adolescents in Finland has recently been published (Eerola et al., 1998). This report recommends check-up intervals of 1.5 to 2.0 years for subjects at low risk for caries, but emphasizes that individualization of check-up intervals should be modified at the local level to fit each community and the disease level of each local population. However, no rapid changes in dentists' caries-preventive treatment practices can be expected, according to experience in Norway, where large-scale use of new preventive treatment methods required 10 to 30 years (Haugejorden, 1988).

Comparison of the present results with those produced in the last two decades in Finland shows the slow improvement in treatment routines (Table 12). The main changes in caries prevention seem to have been an increase in application of fluoride varnish, with no targeting, and a slight tendency to target oral hygiene instructions to high-caries patients. It can be argued that a population-based and filling-orientated treatment approach (Elderton and Nuttall, 1983; Telivuo and Murtomaa, 1988; Chen, 1990) has remained popular since the 1960's and 1970's, despite today's completely different occurrence and severity of caries. During one dentist-generation's working life, tremendous improvement in the young population's dental health has occurred, accompanied by a huge change in dental procedures. In the 1960's, everyday dental treatment mainly included extractions and large fillings, whereas at the present time, increasing numbers of children are cavity-free, and the majority of fillings are one-surfaced (Vehkalahti et al., 1991b; Axelsson et al., 1993; Ketomäki and Luoma, 1993).

Despite improvement in dental health in industrialized countries, even today some high-caries children resemble high-caries subjects seen 20 years ago, forming a subpopulation in need of special attention by dental professionals. However, dentists of the present study had difficulties in treating the most diseased high-caries patients, the nonco-operative in particular, with 40% to 60% of their treatment courses remaining uncompleted. Public oral health service officials should be concerned about the high-caries patients who fail to complete their treatment courses. If such disadvantaged children's and adolescents' preventive care is ignored very serious problems may appear; however, if they adopt positive social norms for appreciation of good dental health and health behaviour they may become regular attendants (Blinkhorn, 1993; Eerola et al., 1998).

Present findings on the great number of uncompleted treatment courses may indicate that dentists' caries-treatment approaches for the most diseased patients are inappropriate and not conducive to patient co-operation. It is well known that local anaesthesia can alleviate dental anxiety (Klingberg et al., 1994; Kent and Croucher, 1998). Unfortunately, in the present study, only one 6-year-old high-caries patient out of four had, during his or her restorative treatment, received local anaesthesia, confirming the results by Murtomaa et al. (1996) on minor use of local anaesthetics among Finnish dentists. Regarding timing of preventive measures in treatment of nonco-operative high-caries children, opinions have previously been contradictory. According to the filling-orientated approach, preventive treatment is not provided until all cavities are restored, possibly at one visit under general anaesthesia (O'Sullivan and Curzon, 1991; Edelstein, 1995). On the population level, a huge amount of resources would be required for the use of general anaesthesia for all high-caries patients in each age-group, year after year. In addition, although life-threatening risks are always involved the results for dental health would not even be long-lasting.

Table 12. Comparison of Finnish studies on preventive treatment for adolescents having either high (HC) or low (LC) numbers of teeth with past and present caries.

Subpopulations by age, year, and city	Mean no. of decayed teeth	Mean no. of visits made		Mean no. of preventive measures				Proportion of subjects having received prevention, %			
				Fluoride varnish		Oral hygiene instructions		Fluoride varnish		Oral hygiene instructions	
	HC	HC	LC	HC	LC	HC	LC	HC	LC	HC	LC
15-yr-olds in 1976, Helsinki (n=396)[1]	5.5	6.4	2.4	0.6	0.7	0.8	0.4	53	63	46	30
15-yr-olds in 1986, Helsinki (n=367)[1]	3.7	3.9	1.4	0.7	0.6	0.6	0.5	57	61	51	34
15-yr-olds in 1992, Helsinki (n= 132)[2]	6.5	6.4	1.1	1.1	0.9	0.5	0.2	80	88	37	19
10 to 15-yr-olds in 1990-92, Jyväskylä (n= 57)[3]	-	3.5	2.5	1.0	0.8	0.8	0.8	65	64	44	42

Sources of information and definition of HC and LC groups:

[1]Vehkalahti et al., 1991b. Definitions for HC and LC groups: the highest and lowest quintiles of distribution of subjects by number of DMF teeth.

[2]Present study. HC had the highest number of dt+DT, LC had dmft=0, DMFT=0, dt+DT=0.

[3]Kärkkäinen, 1997. HC patients had DT≥1.

The high-caries children who have been conventionally treated show more lasting co-operation than do those treated under general anaesthesia, probably because conventional treatment enables the patients to feel they are coping with a difficult dental situation on their own (Varpio and Wellfelt, 1991). High-caries patients' co-operation can be supported by enabling them to experience such success (Edelstein, 1995; Milgrom and Weinstein, 1993); this might be achieved by providing prevention at a separate visit or at the same visit as for restorative treatment. Prevention also requires regular reassessment of the efforts of the patient and of the dentist (Edelstein, 1995). In the present study, however, the high-caries patients' preventive measures had not been integrated into their treatment course, although these patients made a greater number of dental visits than did their contemporaries: 6.5 vs. 3.1, on average (Helsinki City Health Department, 1993a). The need for prevention-orientated treatment approach is supported by the finding that high-caries children's behavioural problems increase concurrently with increasing number of restorative visits (Holst and Crossner, 1987). However, dentists can be trained to help their patients cope with even demanding dental visits by providing proper instruction, training, positive reinforcement, and minimization of pain (Melamed, 1975; Holst and Ek, 1988; Milgrom and Weinstein, 1993).

For evaluation of preventive treatment in relation to patients' co-operation, age of six years was chosen because at this age children appear to be most vulnerable regarding dental fear (Milgrom and Weinstein, 1993). To postpone the age at which a child will face filling treatment, pulpotomies, and extractions, if any is needed, is of great importance in preventing the vicious cycle of operative procedures and dental fear, possibly continuing into adulthood (Milgrom et al., 1988; Milgrom and Weinstein, 1993; Kent and Croucher, 1998). Caries prevention against the first signs of increased risk for caries, before development of any cavities, preferably already in the primary dentition, could prevent this vicious cycle (Anusavice, 1995; Tinanoff, 1995b). Eruption of permanent teeth, however, offers a new opportunity to achieve cavity-free dentition, even for subjects with a severely decayed primary dentition. Therefore, proper timing of prevention is required, demanding individualized preventive treatment during eruption of the first permanent molars (Carvalho et al., 1992; Axelsson et al., 1993). Dentists in the present study did not take advantage of this opportunity; however, targeting of preventive measures was more accurate in cases of erupting first permanent molars rather than of second permanent molars.

These dentists' caries-preventive treatment practices ignored current scientific knowledge. Such a gap between knowledge of caries prevention and what happens in real-life dental practice has been generally reported (Tala, 1984; Blinkhorn and Geddes, 1987; Telivuo and Murtomaa, 1988; Nakata, 1990; Vehkalahti et al., 1992; Källestål and Holm, 1994; Horowitz, 1995; Kärkkäinen, 1997). Furthermore, inflexibility of established treatment routines also concerns individualization of check-up intervals (Wang and Holst, 1995; Wang and Riordan, 1995; Wang et al., 1998a), which suggests dentists' lack of confidence in accurate identification of high-risk individuals or disbelief in patients' own contribution in controlling caries process (Alanen, 1993). In general, worded by Tinanoff (1995a), dental practice "has been slow to adapt to changes in caries occurrence since caries-risk assessment and prevention-based practice conflict with the traditions of fee-for-service and procedure-oriented dental education". The problem is to find ways to stimulate both dentists and patients to take advantage of new caries-preventive knowledge (Krasse, 1996b), not ignoring basic knowledge of caries initiation (Luoma and Widström, 1997b).

From the organizational point of view, employees' values and values supported by the organization fundamentally determine the actions of the employees, influencing whether or not the desired outcome or goal set by the organization is achieved (Senge, 1990). Put into the setting of the public oral health service, the goal of improved dental health for high-caries patients and the most efficient use of dental resources should be regarded as the main priority by all dentists, chief dental officers, the entire public oral health organization, and the Finnish health authorities. In many dental care programmes, one of the shortcomings has merely been the lack of defined goals (Sheiham

and Joffe, 1991). Moreover, the structure of the public oral health organization, accompanied by good leadership and management, must support the desired course of actions and the goal set (Bejerot et al., 1998).

In the ongoing discussion of dental health costs (Petersson et al., 1987; Utriainen and Widström, 1990; Arinen et al., 1994; Jokela, 1997; Källestål et al., 1997; Schwarz, 1998), there appears the need to encourage the providers of public oral health services to monitor and evaluate the impact of their treatment on dental health. Such a line of thinking has earlier been quite unfamiliar in dentistry, and requires proper follow-up systems and cost-benefit analysis to initiate the optimal course of action. In the Swedish public oral health service, it has been calculated that costs of prevention, with dental staff salaries forming its major portion, account for a third to half of the costs of all dental services for teenagers (Källestål et al., 1997). In public oral health services in Helsinki, the share of prevention, both in terms of amount of services and their market price, ranged from 20% to 33% in the seven districts (Vehkalahti and Helminen, 1994). These figures show the importance of appropriate and efficient use of preventive services.

Individualizing treatment requires substantial participation by the dentists; it is much easier to provide treatment similarly to all patients. However, both overtreatment and undertreatment increase treatment costs. The remunerative system in the public oral health service may not sufficiently support the dentists in continuos assessing and improving their treatment practices: dentists are rewarded by treatment output only, not by the outcome of their treatment practices.

Dentists report basing their choice of preventive methods mainly on continuing education courses, meetings, and instructions from chief dental officers (Chen, 1990; Kärkkäinen, 1997; Wang 1998). In addition, leaders in the dental community and those with a wide network of professional colleagues tend to be the first to adopt new caries-preventive practices (Fiset and Grembowski, 1997). In everyday dental practice, therefore, discussion of treatment practices and exchange of knowledge and experiences by dental professionals could speed up the evolution from established routines towards new dental practices. However, dialogue and communication are still less common than top-down management in the public oral health servive (Bejerot et al., 1998).

Nowadays, dental resources, being scarce, should be used the least for those least in need; for the high-caries patients, it could be necessary to use "the full blast of all that modern preventive dentistry has to offer" (Burt, 1998). However, caries seems to progress steadily with age in all populations, also among those earlier cavity-free and those receiving extensive oral health care (Fejerskov, 1995; Mejàre et al., 1998; Utriainen et al., 1998). Therefore, the dental profession should find a balance between these two objectives: to significantly reduce caries among high-caries patients, but also to keep the cavity-free subjects free of caries. An adequate level of caries-preventive treatment is required for each individual, including assessment of caries risk by the dentist. Tailoring and timing of prevention and check-up intervals, as well as emphasis on patients' responsibility in promoting their own oral health would result in savings in the treatment of cavity-free patients, and in improvement in dental health for high-caries patients.

CONCLUSIONS

During the last two decades, dental caries in young populations, even for high-caries subjects, has been declining in terms of mean values. Concurrently, dental caries has continued to polarize: the majority of children and adolescents are cavity-free, with the minority being high-caries subjects. Despite the fact that high-caries patients in the 1990's have better dental health than did high-caries patients in the 1970's, they still make a huge challenge for dental professionals, demanding a vast amount of resources.

Based on patient records, too much effort has been expended in clinical dental examinations of and preventive treatment for cavity-free patients. Check-up intervals and preventive treatment were similar for the high-caries and for the cavity-free patients. In addition, it seemed that dentists had difficulties in treating the most diseased high-caries patients, especially the nonco-operative, as half the treatment courses of these patients remained uncompleted. Caries-preventive treatment and use of local anaesthesia for these high-caries patients seemed to have been insufficient or inappropriate in relation to their needs, rather than serving as a means to improve patients' co-operation.

The present study revealed that caries prevention was tailored more accurately for those high-caries patients whom the dentists had judged to be at high risk for caries than for those without such a judgement. Unfortunately, dentists' judgements of high risk were rare. In real-life dental practice, it seemed that dentists ignored the instructions by their employer and the Finnish health authorities on individualized caries-preventive treatment.

RECOMMENDATIONS

Recommendations for administrative and organizational level:

Because of the strong polarization of caries, evaluation of caries occurrence in populations should be based on frequency distributions of subjects by caries findings rather than on their mean values. The Finnish health authorities and the public oral health employer should focus on monitoring implementation of dental treatment and whether or not treatment strategies meet patients' needs.

Individualized use of caries-preventive treatment practices as an integral part of everyday dental practice should be encouraged and rewarded. Outcome of treatment provided by the entire dental team − dentists, dental hygienists, and assistants − should be monitored and rewarded.

Clinics with an appropriate level of competence and resources for demanding conventional treatment of high-caries patients should be established. In particular, dentists' treatment of nonco-operative high-caries patients should be acknowledged and rewarded.

Recommendations for dental teams:

Dentists should judge each patient's risk for caries and individualize check-up intervals of all patients. The entire dental team should integrate preventive measures into all visits of high-caries patients, and use prevention as a means to improve their co-operation. Instructions concerning individualized caries-treatment practices should regularly be discussed within each team.

SUMMARY

Efficient use of oral health care resources includes allocation of caries-preventive treatment to match changes in caries occurrence at both population and individual level. Healthy dentition, being the same goal for all subjects, can be attained at population level by targeting caries-preventive treatment to high-caries subjects, and at individual level, by timing and tailoring prevention according to each patient's current needs. The aim of the present study was to determine the prevalence and distribution of dental caries among young populations during the last two decades in Helsinki, Finland, and dentists' caries-preventive treatment approaches in real-life dental practice among patients either high-caries or cavity-free. The hypothesis was set as follows: dentists judge each patients's risk for caries and individualize caries-preventive treatment and check-up intervals according to each patient's current needs.

For the study on prevalence and distribution of caries, data on numbers of teeth with caries experience (dmft or DMFT) and of teeth with current untreated caries (dt+DT) were collected from the annual official statistics of the Helsinki City Health Department for all 5- and 15-year-olds clinically examined from 1976 to 1993, amounting to about 4,000 patients in both age-groups in each year. Polarization of dental caries was described as the proportion of high-caries groups in each year, both in terms of caries experience (dmft≥3 for 5-year-olds, and DMFT≥6 or DMFT≥15 for 15-year-olds) and current untreated caries (dt+DT≥3 for both age-groups), and as the proportion of dt+DT and dmf or DMF teeth in each high-caries group of the total number of all such teeth in the entire age-group.

The study on caries-preventive treatment practices was cross-sectional, with a two-point design, high-caries group vs. cavity-free group, covering data from 6-, 13-, and 15-year-old patients' oral health records of the year 1992. Based on official municipal automatic data-processing recordings, the two study groups from the two tails of the distribution of subjects by dt+DT index were selected to represent treatment practices in all the seven administrative districts in Helsinki. Patients with the greatest number of dt+DT in each district were included in the high-caries group (n=294; mean dt+DT being 5.5 to 8.7 in the three age-groups). The cavity-free patients (n=88; dmft or DMFT=0, dt+DT=0) were randomly selected from the same clinics as were the high-caries cases.

Data from patients' individual oral health records were gathered: dental state, dentists' judgement of patients' risk for caries and level of co-operation, and treatment provided, described by utilization of dental services, and by operative and caries-preventive treatment, described as 'patient-active' and 'patient-passive' prevention. 'Patient-active' prevention, emphasizing patient's active role in caries management, included oral hygiene instructions, dietary counselling, and advice on home use of fluorides. 'Patient-passive' prevention, emphasizing dental professionals' role in caries prevention, included topical applications of fluorides and fissure sealants, as well as professional tooth cleaning. Targeting of caries-preventive treatment was evaluated between the high-caries group and the cavity-free group.

A strong polarization of caries was found, emphasizing the importance of using frequency distributions of subjects by caries indices in evaluation of caries occurrence in populations rather than their mean values. Contrary to the hypothesis, too much emphasis was placed on clinical dental examinations of and caries prevention for the cavity-free patients. Treatment courses for the high-caries patients differed most prominently

from those of the cavity-free subjects in number of dental visits and fillings, but less in number of preventive measures and intervals to the following check-up. A slight tendency towards targeted preventive treatment to the high-caries patients was evident in provision of instructions and advice on home care and in provision of different types of preventive measures. Among the high-caries patients, the treatment strategy was similar at all ages studied, being filling-orientated and in favour of application of fluoride varnish and fissure sealants. High-caries patients' age, gender, and number of dt+DT and DMF teeth showed no association with the provision of preventive treatment. However, dentists' judgement, unfortunately rare, of patients' high risk for caries strongly increased coverage of caries-preventive treatment, especially instructions and advice on home care. Uncompleted treatment courses were characteristic of the high-caries patients, especially of the nonco-operative ones. Check-up intervals had not been influenced by patients' number of decayed teeth, by dentists' judgement of high risk, nor by eruption of permanent teeth.

It was concluded that high-caries patients still make a huge challenge for dental professionals, demanding a vast amount of resources. It seems that dentists ignore the instructions on individualized caries-preventive treatment and have difficulties in treating the high-caries patients.

Recommendations for actions at the administrative and organizational level were given as follows: individualization of dental treatment and its outcome should be monitored, encouraged, and rewarded. Recommendations for dental teams were as follows: dentists should judge each patient's risk for caries, individualize check-up intervals, and integrate preventive measures into all dental visits of high-caries patients, as well as regularly discuss these caries-preventive practices within each team.

REFERENCES

Alaluusua S, Kleemola-Kujala E, Nyström M, Evälahti M, Grönroos L. Caries in primary teeth and salivary *Streptococcus mutans* and lactobacillus levels as indicators of caries in permanent teeth. Pediatr Dent 1987;9:126-30.

Alanen P, Tiekso J, Paunio I. Effect of war-time dietary changes on dental health of Finns 40 years later. Community Dent Oral Epidemiol 1985;13:281-4.

Alanen P. Hammassairauksien prevention kannattavuuden arviointiongelmista. In: Widström E, Murtomaa H, eds. Profylaksian kannattavuus lasten ja nuorten hammashoidossa. Teoria ja käytäntö. Stakes raportteja 97/1993. pp. 7-23.

Alanen P, Hurskainen K, Isokangas P, Pietilä I, Levänen J, Saarni U-M, Tiekso J. Clinician's ability to identify caries risk subjects. Community Dent Oral Epidemiol 1994;22:86-9.

An N. Caries development and prediction in children and adolescents. PhD thesis, University of Helsinki; 1993.

Anderson MH, Bales DJ, Omnell K-A. Modern management of dental caries: the cutting edge is not the dental bur. JADA 1993;124 (June):37-44.

Anusavice KJ. Treatment regimens in preventive and restorative dentistry. JADA 1995;126(June):727-43.

Anusavice KJ. Efficacy of nonsurgical management of the initial caries lesions. J Dent Educ 1997;61:895-905.

Arinen S, Widström E, Pietilä I. Suun terveydenhuollon voimavarat ja tuotokset terveyskeskuksissa vuonna 1991 (Summary in Swedish). Stakes 2/1994. p.24.

Arrow P. Control of occlusal caries in the first permanent molars by oral hygiene. Community Dent Oral Epidemiol 1997;25:278-83.

Axelsson P, Lindhe J. Effect of oral hygiene instruction and professional toothcleaning on caries and gingivitis in schoolchildren. Community Dent Oral Epidemiol 1981;9:251-5.

Axelsson P, Paulander J, Nordkvist K, Karlsson R. Effect of fluoride containing dentifrice, mounthrinsing, and varnish on approximal dental caries in a 3-year clinical trial. Community Dent Oral Epidemiol 1987;15:177-80.

Axelsson P, Paulander J, Svärdström G, Tollskog G, Nordensten S. Integrated caries prevention: effect of a needs-related preventive program on dental caries in children. County of Värmland, Sweden: results after 12 years. Caries Res 1993;27(suppl 1):83-94.

Bailit HL. Quality assurance and development of criteria and standards. Dent Clin of North Am 1985;29:457-63.

Bauch J. Sozial- und verhaltenswissenschaftliche Ergebnisse. In: Mundgesundheit in der Bundesrepublik Deutschland. Institut der Deutschen Zahnärzte IDZ. Köln: Deutscher Ärzte-Verlag; 1990. p.38.

Beck JD. Risk revisited. Community Dent Oral Epidemiol 1998;26:220-5.

Bejerot E, Söderfeldt B, Aronsson G, Härenstam A, Söderfeldt M. Changes in control systems assessed by publicly employed dentists in comparison with other professionals. Acta Odontol Scand 1998;56:30-5.

Bellini HT, Arneberg P, von der Fehr FR. Oral hygiene and caries. A review. Acta Odont Scand 1981;39:257-65.

Bille J, Hesselgren K, Thylstrup A. Dental caries in Danish 7-, 11- and 13-year-old children in 1963, 1972 and 1981. Caries Res 1986;20:534-42.

Bille J, Carstens K. Approximal caries progression in 13- to 15-year-old Danish children. Acta Odontol Scand 1989;47:347-54.

Birkeland JM, Bragelien J. Continual highly significant decrease in caries prevalence among 14-year-old Norwegians. Acta Odontol Scand 1987;45:135-40.

Bjarnason S, Köhler B. Caries risk assessment in adolescents. Swed Dent J 1997;21:41-8.

Blinkhorn AS, Geddes DAM. Assessment of caries risk and the potential for preventive management. In: Elderton RJ, ed. Positive dental prevention. London: William Heinemann Medical Books; 1987. pp.20-8.

Blinkhorn AS. Factors affecting the compliance of patients with preventive dental regimens. Int Dent J 1993;43:294-8.

Bratthall D, Ericsson D. Tests for assessment of caries risk. In: Thylstrup A, Fejerskov O, eds. Textbook of Clinical Cariology. Copenhagen: Munksgaard; 1994. pp.333-53.

Bratthall D. Dental caries: intervened-interrupted-interpreted. Concluding remarks and Cariography. Eur J Oral Sci 1996;104:486-91.

Bratthall D, Hänsel-Petersson G, Sundberg H: Reasons for the caries decline: what do the experts believe? Eur J Oral Sci 1996;104:416-22.

Brown JP. Developing clinical teaching methods for caries risk assessment: introduction to the topic and its history. J Dent Educ 1995;59:928-31.

Brunelle JA. National Institute of Dental Research, Epidemiology and Oral Disease Prevention Program. Oral health of United States children: the national survey of dental caries in U.S. school children: 1986-1987. NIH Publication No. 89-2247, 1989.

Burt BA, Eklund SA, Morgan KJ, Larkin FE, Guire KE, Brown LO, Weintraub JA. The effects of sugars intake and frequency of ingestion on dental caries increment in a three-year longitudinal study. J Dent Res 1988;67:1422-9.

Burt BA. Prevention policies in the light of the changed distribution of dental caries. Acta Odontol Scand 1998;56:179-86.

Carlos JP, Gittelsohn AM. Longitudinal studies of the natural history of caries. II. A life-table study of caries incidence in the permanent teeth. Arch Oral Biol 1965;10:739-51.

Carvalho JC, Ekstrand KR, Thylstrup A. Dental plaque and caries on occlusal surfaces of first permanent molars in relation to stage of eruption. J Dent Res 1989;68:773-9.

Carvalho JC, Thylstrup A, Ekstrand KR. Results after 3 years of non-operative occlusal caries treatment of erupting permanent first molars. Community Dent Oral Epidemiol 1992;20:187-92.

Chen M-S. Preventive dentistry in Texas, USA. Community Dent Oral Epidemiol 1990;18:239-43.

Chiodo GT, Rosenstein DI, Clarke JH. Counseling principles for more effective patient education. Community Dent Oral Epidemiol 1986;14:190-2.

Crall JJ. Evaluations of effectiveness and quality of care. J Dent Educ 1989;53:673-6.

Crossner C-G, Unell L. A longitudinal study of dental health and treatment need in Swedish teenagers. Community Dent Oral Epidemiol 1986;14:10-4.

Demers M, Brodeur J-M, Simard PL, Mouton C, Veilleux G, Fréchette S. Caries predictors suitable for mass-screenings in children: a literature review. Community Dent Health 1990;7:11-21.

Disney JA, Graves RC, Stamm JW, Bohannan HM, Abernathy JR, Zack DD. The University of North Carolina Caries Risk Assessment study: further developments in caries risk prediction. Community Dent Oral Epidemiol 1992;20:64-75.

Douglas CW, Fox CH. The emerging field of oral pharmaceuticals. JADA 1994;125(January, spec suppl):2-4.

Dowell TB, Holloway PJ, Keshani D, Clerehugh V. Do dentists fill teeth unnecessarily? Br Dent J 1983;155:247-9.

Downer MC. Caries prediction from epidemiologic data. In: Bibby BG, Shern RJ, eds. Proceedings 'Methods of caries prediction'. Microbiol Abstracts, spec suppl; 1978. pp.37-42.

Downer MC. Time trends in caries experience of children in England and Wales. Caries Res 1992;26:466-72.

Eaton KA, Widström EA, Renson CE. Changes in the numbers of dentists and dental caries levels in 12-year-olds in the countries of the European Union and economic area. J Roy Soc Health 1998;118:40-8.

Edelstein BL. The medical management of dental caries. JADA 1994:125(January, spec suppl):31-9.

Edelstein BL. Case planning and management according to caries risk assessment. Dent Clin of North Am 1995;39:721-36.

Eerola A, Hausen H. Lahti S, Widström E. Tutkimus- ja tarkastusvälit lasten ja nuorten suun terveydenhuollossa. Asiantuntijatyöryhmän raportti (Oral health examination intervals among Finnish children and adolescents. Report of an expert group. Summary in English). Stakes raportteja 225/1998. pp.87-8.

Ekanayake LS, Sheiham A. Reducing rates of progression of dental caries in British schoolchildren. A study using bitewing radiographs. Br Dent J 1987;163:265-9.

Ekstrand J, Birkhed D, Lindgren L-E, Oliveby A, Edwardsson S, Frostell G. Effect of repeated intake of a sugar free fluoride-containing chewing gum on acidogenicity and microbial composition of dental plaque. Scand J Dent Res 1985;93:309-14.

Elderton RJ, Nuttall NM. Variation among dentists in planning treatment. Br Dent J 1983;154:201-6.

Espelid I, Tveit AB, Haugejorden O, Riordan PJ. Variation in radiographic interpretation and restorative treatment decisions on approximal caries among dentists in Norway. Community Dent Oral Epidemiol 1985;13:26-9.

Fejerskov O, Thylstrup A. Different concepts of dental caries and their implications. In: Thylstrup A, Fejerskov O, eds. Textbook of Clinical Cariology. Copenhagen: Munksgaard; 1994. pp.209-17.

Fejerskov O. Strategies in the design of preventive programs. Adv Dent Res 1995;9:82-8.

Fiset L, Grembowski D. Adoption of innovative caries-control services in dental practice: a survey of Washington state dentists. JADA 1997;128 (March):337-45.

Flinck A, Källestål C, Holm A-K, Allebeck P, Wall S. Distribution of caries in 12-year-old children in Sweden. Social and oral health related behavioural patterns. Community Dent Health 1999;16:160-5.

Frencken JE, Kalsbeek H, Verrips GH. Has the decline in dental caries been halted? Changes in caries prevalence amongst 6- and 12-year-old children in Friesland, 1973-1988. Int Dent J 1990;40:225-30.

Gibbons R. The caries decline. A comment. Eur J Oral Sci 1996;104:424-5.

Gray MM, Marchment MD, Anderson RJ. The relationship between caries experience in the deciduous molars at 5 years and in first permanent molars of the same child at 7 years. Community Dent Health 1991;8:3-7.

Gröndahl H-G. Radiologic diagnosis in caries management. In: Thylstrup A, Fejerskov O, eds. Textbook of Clinical Cariology. Copenhagen: Munksgaard; 1994. pp.367-82.

Hargreaves JA, Wagg BJ, Thompson GW. Changes in caries prevalence of Isle of Lewis children, a historical comparison from 1937 to 1984. Caries Res 1987;21:277-84.

Haugejorden O. Adoption of fluoride-based caries preventive innovations in a public dental service. Community Dent Oral Epidemiol 1988;16:5-10.

Haugejorden O. Changing time trend in caries prevalence in Norwegian children and adolescents. Community Dent Oral Epidemiol 1994;22:220-5.

Hausen H, Heinonen OP, Paunio I. Modification of occurrence of caries in children by toothbrushing and sugar exposure in fluoridated and nonfluoridated areas. Community Dent Oral Epidemiol 1981;9:103-7.

Hausen H, Milén A, Heinonen OP, Paunio I. Caries in primary dentition and social class in high and low fluoride areas. Community Dent Oral Epidemiol 1982;10:33-6.

Hausen H, Seppä L, Fejerskov O. Can caries be predicted? In: Thylstrup A, Fejerskov O, eds. Textbook of Clinical Cariology. Copenhagen: Munksgaard; 1994. pp.393-411.

Helminen SE, Vehkalahti M, Murtomaa H, Kekki P, Ketomäki T-M. Quality evaluation of oral health record-keeping for Finnish young adults. Acta Odontol Scand 1998;56:288-92.

Helsinki City Health Department (1985). Instructions for preventive treatment in municipal dental clinics (Circular).

Helsinki City Health Department (1993a). Official statistics in 1992.

Helsinki City Health Department (1993b). Uudelleen-arviointiprojekti.

Holloway PJ, Clarkson JE. Cost:benefit of prevention in practice. Int Dent J 1994;44:317-22.

Holst A, Crossner C-G. Direct ratings of acceptance of dental treatment in Swedish children. Community Dent Oral Epidemiol 1987;15:258-63.

Holst A, Ek L. Effect of systematized "behavior shaping" on acceptance of dental treatment in children. Community Dent Oral Epidemiol 1988;16:349-55.

Holt RD. The pattern of caries in a group of 5-year-old children and in the same cohort at 9 years of age. Community Dent Health 1995;12:93-9.

Horowitz AM. The public's oral health: the gaps between what we know and what we practice. Adv Dent Res 1995;9:91-5.

Hugoson A, Koch G, Bergendal T, Hallonsten A-L, Slotte C, Thorstensson B, Thorstensson H. Oral health of individuals aged 3-80 years in Jönköping, Sweden, in 1973, 1983, and 1993. II. Review of clinical and radiographic findings. Swed Dent J 1995;19:243-60.

Hölund U, Theilade E, Poulsen S. Validity of a dietary interviewing method for use in caries prevention. Community Dent Oral Epidemiol 1985;13:219-21.

Isokangas P, Mäkinen KK, Tiekso J, Alanen P. Long-term effect of xylitol chewing gum in the prevention of dental caries: a follow-up 5 years after termination of a prevention program. Caries Res 1993;27:495-8.

Jerge CR, Orlowski RM. Quality assurance and the dental record. Dent Clin of North Am 1985;29:483-96.

Jokela J. Kariesriskin arviointi ja prevention kohdentaminen alle kuoluikäisillä (Summary in English). PhD thesis. University of Turku; 1997.

Karjalainen S, Eriksson A-L, Ruokola M, Toivonen A. Caries development after substitution of supervised fluoride rinses and toothbrushings by unsupervised use of fluoride toothpaste. Community Dent Oral Epidemiol 1994;22:421-4.

Kaste LM, Selwitz RH, Oldakowski RJ, Brunelle JA, Winn DM, Brown LJ. Coronal caries in the primary and permanent dentition of children and adolescents 1-17 years of age: United States, 1988-1991. J Dent Res 1996;75 (Spec Iss):631-41.

Kay EJ, Nuttall NM, Knill-Jones R. Restorative treatment thresholds and agreement in treatment decision-making. Community Dent Oral Epidemiol 1992;20:265-8.

Kay E, Nuttall N. Treatment planning. Clinical decision making- an art or a science? Part III: To treat or not to treat. Br Dent J 1995a;153-5.

Kay E, Nuttall N. Treatment planning. Clinical decision making- an art or a science? Part VI: Decision making in dental practice: a case study. Br Dent J 1995b;269-73.

Kay E, Nuttall N. Treatment planning. Clinical decision making- an art or a science? Part II: Making sense of treatment decisions. Br Dent J 1995c;178:113-6.

Kent G, Croucher R. Alleviating anxiety. In: Achieving Oral Health. The social context of dental care. Great Britain: Biddles Ltd, Guildford and King's Lynn; 1998. pp.110-34.

Ketomäki T-M, Luoma A-R. Järjestelmällisen hammas-huollon yksilöllisen tutkimusvälin yhteys kariekseen ja voimavarojen käyttöön. Stakes aiheita; 1993. pp.1-49.

Keyes PH. Recent advances in dental caries research. Bacteriology. Bacteriological findings and biological implications. Int Dent J 1961;12:443.

Kleemola-Kujala E, Räsänen L. Relationship of oral hygiene and sugar consumption to risk of caries in children. Community Dent Oral Epidemiol 1982;10:224-33.

Kleinbaum DG, Kupper LL, Muller KE, Nizam A. Applied regression analysis and other multivariate methods (3rd ed.). Duxpury Press; 1998.

Klingberg G, Vannas Löfqvist L, Bjarnason S, Norén JG. Dental behavior management problems in Swedish children. Community Dent Oral Epidemiol 1994;22:201-5.

Klingberg G, Berggren U, Carlsson SG, Norén JG. Child dental fear: cause-related factors and clinical effects. Eur J Oral Sci 1995;103:405-12.

Klock B, Krasse B. Caries status and microbial conditions in children in 1973 and 1984. J Dent Res 1987;95:13-7.

Klock B, Emilson CG, Lind S-O, Gustavsdotter M, Olhede-Westerlund AM. Prediction of caries activity in children with today's low caries incidence. Community Dent Oral Epidemiol 1989;17:285-8.

Kolehmainen L, Rytömaa I. Increment of dental caries among Finnish dental students during a period of 2 years. Community Dent Oral Epidemiol 1977;5:140-4.

Kolehmainen L. Dental caries on different tooth surfaces among 13-15-year-old Helsinki schoolchildren. Proc Finn Dent Soc 1983a;79:107-14.

Kolehmainen L. Effect of systematic oral hygiene instruction on oral health among 13-year-old schoolchildren. Proc Finn Dent Soc 1983b;79:211-7.

Kolehmainen L, Heinonen OP, Haapakoski J. Caries prediction and its evaluation in 13 to 15 year-old schoolchildren. Community Dent Health 1985a;2:15-21.

Kolehmainen L. Effect of individual instructions on sugar consumption among 13-15-year-olds. Proc Finn Dent Soc 1985b;81:142-50.

Kotsanos N, Darling AI. Influence of posteruptive age of enamel on its susceptibility to artificial caries. Caries Res 1991;25:241-50.

Krasse B. The caries decline: is the effect of fluoride toothpaste overrated? Eur J Oral Sci 1996a;104:426-9.

Krasse B. From the art of filling teeth to the science of dental caries prevention: a personal review. J Public Health Dent 1996b;56:271-7.

Kuusela S, Honkala E, Rimpelä A, Karvonen S, Rimpelä M. Trends in toothbrushing frequency among Finnish adolescents between 1977 and 1995. Community Dent Health 1997;14:84-8.

Källestål C, Holm A-K. Allocation of dental caries prevention in Swedish teenagers. Community Dent Oral Epidemiol 1994;22:100-5.

Källestål C, Oscarson N, Holm A-K. Costs for prevention of dental caries in a group of Swedish teenagers. Swed Dent J 1997;21:193-7.

Kärkkäinen S. Karieksen ehkäisykäytäntö Suomessa 1990-luvun alussa (Summary in English). PhD thesis. Acta Universitatis Ouluensis D434; 1997.

König KG. Implications of changes in caries prevalence on research. Int Dent J 1994;44:451-6.

Larmas MA, Virtanen JI, Bloigu RS. Timing of first restorations in permanent teeth: a new system for oral health determination. J Dent 1995;23:347-52.

Lennon MA, Worthington HV, Coventry P, Mellor AC, Holloway PJ. The capitation study. 2. Does capitation encourage more prevention? Br Dent J 1990;168:213-5.

Lindquist B, Edward S, Torell P, Krasse B. Effect of different caries preventive measures in children highly infected with mutans streptococci. Scand J Dent Res 1989;97:330-7.

Luoma A-R, Rönnberg K. Caries experience and distribution in relation to treatment needs among teenagers in Espoo, Finland. Community Dent Oral Epidemiol 1991;19:101-3.

Luoma A-R, Widström E. Syyt lasten ja nuorten suun terveydentilan nopeaan kohentumiseen. In: Widström E, Luoma A-R, Isokangas P et al., eds. Hammaskaries on vähentynyt Suomessa – syyt ja seurausvaikutukset (Summary in English). Stakes raportteja 209/1997a. pp.27-44.

Luoma A-R, Widström E. Vaatimuksena näyttöön perustuva hammashoito- hammassairauksien ehkäisy yhä avainasemassa. Dialogi 1997b, nr.7/1997. pp.28-9.

Marthaler TM. Explanations for changing patterns of disease in Western World. In: Guggenheim B, ed. Cariology Today. Int. Congr., Zürich 1983. Basel: Karger; 1984. pp.13-23.

Marthaler TM. Changes in the prevalence of dental caries: how much can be attributed to changes in diet? Caries Res 1990;24(suppl 1):3-15.

Marthaler TM, O'Mullane DM, Vrbic V. The prevalence of dental caries in Europe 1990-1995. ORCA Saturday Afternoon Symposium 1995. Caries Res 1996;30:237-55.

Mathiesen AT, Øgaard B, Rølla G. Oral hygiene as a variable in dental caries experience in 14-year-olds exposed to fluoride. Caries Res 1996;30:29-33.

Mejàre I, Ljungkvist B, Quensel E. Pre-school children with uncooperative behavior in the dental situation. Some characteristics and background factors. Acta Odontol Scand 1989;47:337-45.

Mejàre I, Källestål C, Stenlund H, Johansson H. Caries development from 11 to 22 years of age: a prospective radiographic study. Caries Res 1998;32:10-6.

Mejàre I, Källestål C, Stenlund H. Incidence and progression of approximal caries from 11 to 22 years of age in Sweden: a prospective radiographic study. Caries Res 1999;33:93-100.

Melamed B, Weinstein D, Hawes R. Reduction of fear-related dental management problems with use of filmed modelling. JADA 1975;90:822-6.

Mellor AC, Lennon MA. Frequency of examination of children by dentists working under different payment systems in the United Kingdom. Int J Paed Dent 1993;3:83-8.

Miettinen O. Theoretical epidemiology. New York: John Wiley & Sons; 1985. pp. 46-83.

Milén A, Hausen H, Heinonen OP, Paunio I. Caries in primary dentition related to age, sex, social status, and county of residence in Finland. Community Dent Oral Epidemiol 1981;9:83-6.

Milén A, Laaksonen T, Tala H. Use of children's oral health services in Finland with special reference to heavy consumption. Community Dent Oral Epidemiol 1988;16:22-6.

Milgrom P, Fiset L, Melnick S, Weinstein P. The prevalence and practice management consequences of dental fear in a major US city. JADA 1988;116:641-7.

Milgrom P, Weinstein P. Dental fears in general practice: New guidelines for assessment and treatment. Int Dent J 1993;43:288-93.

Ministry of Social Welfare and Health (1986). Terveyttä kaikille vuoteen 2000: Suomen terveyspolitiikan pitkän aikavälin tavoite- ja toimintaohjelma. STM.

Ministry of Social Welfare and Health (1993). Terveyttä kaikille vuoteen 2000: uudistettu yhteistyöohjelma. STM.

Moberg Sköld U, Klock B, Rasmusson C-G, Torstensson T. Is caries prevalence underestimated in today's caries examination? Swed Dent J 1995;19:213-7.

Modéer T, Twetman S, Bergstrand F. Three-year study of the effect of fluoride varnish (Duraphat) on proximal caries progression in teenagers. Scand J Dent Res 1984;92:400-7.

Moss ME, Zero DT. An overview of caries risk assessment, and its potential utility. J Dent Educ 1995;59:932-40.

Murtomaa H, Milgrom P, Weinstein P, Vuopio T. Dentists' perceptions and management of pain experienced by children during treatment: a survey of groups of dentists in the USA and Finland. Int J Paed Dent 1996;6:25-30.

Nakata M. Transfer of innovations for advancement in dentistry (guest editorial). J Dent Res 1990;69:1543.

National Board of Health (1985). Instructions on public oral health services for patients born after the year 1960. NBH regulation n:o 6/85.

National Board of Health (1993). Official statistics in 1991.

National Board of Health (1996). Official statistics in 1994.

Newbrun E. Preventing dental caries: current and prospective strategies. JADA 1992a;123 (May):68-73.

Newbrun E. Preventing dental caries: breaking the chain of transmission. JADA 1992b;123 (June):55-9.

Nikiforuk G. Understanding dental caries I Etiology and mechanisms. Basic and clinical aspects. Basel: Karger; 1985. pp.24-59.

Nordblad A. Patterns and indicators of dental decay in the permanent dentition of children and adolescents. PhD thesis, University of Oulu; 1986.

Nordling H. Suomen kunnallisella hammashuollolla pitkä historia. Juhlaesitelmä Espoon kunnalisen hammas-huollon 50-vuotisjuhlassa 14.12.1987. Suomen Hammas-lääkärilehti 1988, nr. 4/88. pp.176-80.

O'Brien M. Children's dental health in the United Kingdom 1993. Office of population censuses and surveys. London: HMSO; 1994.

Oliveby A, Weetman DA, Geddes DAM, Lagerlöf F. The effect of salivary clearance of sucrose and fluoride on human dental plaque acidogenicity. Archs Oral Biol 1990;35:907-11.

O'Sullivan EA, Curzon MEJ. The efficacy of comprehensive dental care for children under general anaesthesia. Br Dent J 1991;171:56-8.

Petersson LG, Ripa U, Lind SO. Rational dentistry, a Swedish model for efficiency in the public dental service for children and young adults. Community Dent Health 1987;4:447-54.

Petersson LG, Arthursson L, Östberg C, Jönsson G, Gleerup A. Caries-inhibiting effects of different modes of Duraphat varnish reapplication: a 3-year radiographic study. Caries Res 1991;25:70-3.

Petersson LG, Westerberg I. Intensive fluoride varnish program in Swedish adolescents: economic assessment of a 7-year follow-up study on proximal caries incidence. Caries Res 1994;28:59-63.

Pitts NB, Palmer JD. The dental caries experience of 5-, 12- and 14-year-old children in Great Britain. Surveys coordinated by the British Association for the Study of Community Dentistry in 1991/92, 1992/3 and 1990-91. Community Dent Health 1994;11:42-52.

Poulsen S, Scheutz F. Dental caries in Danish children and adolescents 1988-1997. Community Dent Health 1999;16:166-70.

Powell LV. Caries risk assessment: relevance to the practitioner. JADA 1998a;129(March):349-53.

Powell LV. Caries prediction: a review of the literature. Community Dent Oral Epidemiol 1998b;26:361-71.

Rajala M, Honkala E, Rimpelä M, Lammi S. Toothbrushing in relation to other health habits in Finland. Community Dent Oral Epidemiol 1980;8:391-5.

Renson CE, Crielaers PJA, Ibikunle SAJ, Pinto VG, Ross CB, Sardo Infirri J, Takazoe I, Tala H. Changing patterns of oral health and implications for oral health manpower: Part I. Report of a working group convened jointly by the Fédération Dentaire International and the World Health Oraganisation. Int Dent J 1985;35:235-51.

Riordan PJ. Secular changes in treatment in a school dental service. Community Dent Health 1995;12:221-5.

Ripa LW. Occlusal sealants: rationale and review of clinical trials. Int Dent J 1980;30:127-39.

Ripa LW, Leske GS, Varma AO. Longitudinal study of the caries susceptibility of occlusal and proximal surfaces of first permanent molars. J Public Health Dent 1988;48:8-13.

Ripa LW. Sealants revisted: an update of the effectiveness of pit-and-fissure sealants. Caries Res 1993;27(suppl 1):77-82.

Rytömaa I, Järvinen V, Järvinen J. Variation in caries recording and restorative treatment plan among university teachers. Community Dent Oral Epidemiol 1979;7:335-9.

Schou L, Currie C, McQueen D. Using a "lifestyle" perspective to understand toothbrushing behaviour in Scottish schoolchildren. Community Dent Oral Epidemiol 1990;18:230-4.

Schou L. Social and behavioural aspects of caries prevention. In: Johnson NW, ed. Risk markers for oral diseases. Volume 1. Dental caries. Markers of high and low risk groups and individuals. Cambridge: Cambridge University Press; 1991. pp.172-97.

Schwarz E. Is caries prevention cost-effective? Does anybody care? Acta Odontol Scand 1998;56:187-92.

Senge P. The fifth discipline: the art and practice of the learning organization. Doubleday: New York;1990.

Seppä L, Hausen H. Frequency of initial caries lesions as predictor of future caries increment in children. Scand J Dent Res 1988;96:9-13.

Seppä L, Tolonen T. Caries preventive effect of fluoride varnish applications performed two or four times a year. Scand J Dent Res 1990;98:102-5.

Sheiham A, Joffe M. Public dental health strategies for identifying and controlling dental caries in high and low risk populations. In: Johnson NW, ed. Risk markers for oral diseases. Volume 1. Dental caries. Markers of high and low risk groups and individuals. Cambridge: Cambridge University Press; 1991. pp. 445-81.

Social Insurance Institution (1999). Sairaanhoito-korvaustilastoja 1998. Kansaneläkelaitos.

Socialstyrelsen (1998). Tandhälsan hos barn och ungdomar 1995-1997. Meddelandeblad Nr 11/98. Sweden.

Statens helsetilsyn (in press). Tannhelsetjenesten i Norge. Årsmelding 1997.

Sundberg H. Changes in the prevalence of caries in children and adolescents in Sweden 1985-1994. Eur J Oral Sci 1996;104:470-6.

Sundberg H, Bjerner B, Sjögren K. Estimation of prophylactic measures in Swedish public dental health care. Results from a questionnaire. Eur J Oral Sci 1996;104:477-9.

Tala H. Dental caries of children, their parents' social status and knowledge of the prevention of the disease. Proc Finn Dent Soc 1984;80:204-8.

Telivuo M, Murtomaa H. Preventive dentistry in private practice in Finland. Proc Finn Dent Soc 1988;84:183-90.

ten Cate JM, Duijsters PPE. Alternating demineralization and remineralization of artificial enamel lesions. Caries Res 1982;16:201-10.

Tenovuo J. Salivary parameters of relevance for assessing caries activity in individuals and populations. Community Dent Oral Epidemiol 1997;25:82-6.

Tinanoff N. Critique of evolving methods for caries risk assessment. J Dent Educ 1995a;59:980-5.

Tinanoff N. Dental caries risk assessment and prevention. Dental Clinics of North America 1995b;39:709-19.

Torppa H. Profylaktiset hoitotoimet terveyskeskuksissa. In: Widström E, Murtomaa H, eds. Profylaksian kannattavuus lasten ja nuorten hammashoidossa. Teoria ja käytäntö. Stakes raportteja 97/1993. pp. 25-34.

Torppa H. Karieksen esiintyminen lapsilla ja nuorilla Finstar-tietojärjestelmää käyttävissä terveyskeskuksissa. In: Eerola A, Hausen H. Lahti S, Widström E, eds. Tutkimus- ja tarkastusvälit lasten ja nuorten suun terveydenhuollossa. Asiantuntijatyöryhmän raportti (Oral health examination intervals among Finnish children and adolescents. Report of an expert group. Summary in English). Stakes raportteja 225/1998. pp.27-32.

Tukia-Kulmala H, Tenovuo J. Intra- and inter-individual variation in salivary flow rate, buffer effect, lactobacilli, and mutans streptococci among 11- to 12-year-old schoolchildren. Acta Odontol Scand 1993;51:31-7.

Twetman S, Petersson LG. Comparison of the efficacy of three different chlorhexidine preparations in decreasing the levels of mutans streptococci in saliva and interdental plaque. Caries Res 1998;32:113-8.

Utriainen P, Widström E. Economic aspects of dental care in Finnish health centers. Community Dent Oral Epidemiol 1990;18:235-8.

Utriainen P, Pahkala K, Kentala J, Laippala P, Mattila K. Changes in the oral health of adolescents treated by the Finnish public dental services between the ages 13 and 15 years. Community Dent Oral Epidemiol 1998;26:149-54.

Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III, 1988-1994. JADA 1998; 129 (September):1229-38.

Varpio M, Wellfelt B. Some characteristics of children with dental behaviour problems. Five-year follow-up of pedodontic treatment. Swed Dent J 1991;15:85-93.

Vehkalahti M, Helminen S, Rytömaa I. Caries decline from 1976 to 1986 among 15-year-olds in Helsinki. Caries Res 1990;24:279-85.

Vehkalahti M, Solavaara L, Rytömaa I. An eight-year follow-up of the occlusal surfaces of first permanent molars. J Dent Res 1991a;70:1064-7.

Vehkalahti M, Rytömaa I, Helminen S. Decline in dental caries and public oral health care of adolescents. Acta Odontol Scand 1991b;49:323-8.

Vehkalahti M, Rytömaa I, Helminen S. Assessment of quality of public oral health care on the basis of patient records. Community Dent Oral Epidemiol 1992;20:102-5.

Vehkalahti M, Helminen S. Outcome of public oral health services in relation to treatment mix. Acta Odontol Scand 1994;52:1-6.

Vehkalahti M, Nikula-Sarakorpi E, Paunio I. Evaluation of salivary tests and dental status in the prediction of caries increment in caries-susceptible teenagers. Caries Res 1996;30:22-8.

Vehkalahti M. Active or passive prevention – treatment decisions in public dental clinics. Abstract 170. 6th World Congress on Preventive Dentistry (WCPD'97), Cape Town, South Africa.

Virtanen JI, Larmas MA. Timing of first fillings on different permanent tooth surfaces in Finnish schoolchildren. Acta Odontol Scand 1995;53:287-92.

Virtanen JI, Bloigu RS, Larmas MA. Timing of first restorations before, during, and after a preventive xylitol trial. Acta Odontol Scand 1996;54:211-6.

Wang N, Marstrander P, Holst D, Øvrum L, Dahle T. Extending recall intervals - effect on resource consumption and dental health. Community Dent Oral Epidemiol 1992;20:122-4.

Wang NJ. Productivity in dental care for children. Factors influencing the time spent delivering dental care. Community Dent Health 1994;11:227-32.

Wang NJ, Holst D. Individualizing recall intervals in child dental care. Community Dent Oral Epidemiol 1995;23:1-7.

Wang NJ, Riordan PJ. Recall intervals, dental hygienists and quality in child dental care. Community Dent Oral Epidemiol 1995;23:8-14.

Wang NJ. Preventive dental care of children and adolescents in the 1990s: Denmark, Iceland, Norway, and Sweden. Acta Odotol Scand 1998;56:169-72.

Wang NJ, Berger B, Ellingsen BH. Clinical judgement as a basis for choice of recall interval in child dental care? Community Dent Health 1998a;15:252-5.

Wang NJ, Källestål C, Petersen PE, Arnadottir IB. Caries preventive services for children and adolescents in Denmark, Iceland, Norway and Sweden: strategies and resource allocation. Community Dent Oral Epidemiol 1998b;26:263-71.

Wei SHY. Strategies for application of scientific findings in prevention. Adv Dent Res 1995;9:96-9.

Wendt L-K. On oral health in infants and toddlers. PhD thesis. Swed Dent J Supplement 106;1995.

WHO Oral Health Country/ Area Profile Programme 1999. Data supplied by PAHO, March 1996. (www-pages).

Widström E, Utriainen P, Pietilä I. Suun terveydenhuollon palvelutarjonta terveyskeskuksissa vuonna 1997 (Summary in Swedish). Stakes aiheita 31/1998. p. 8.

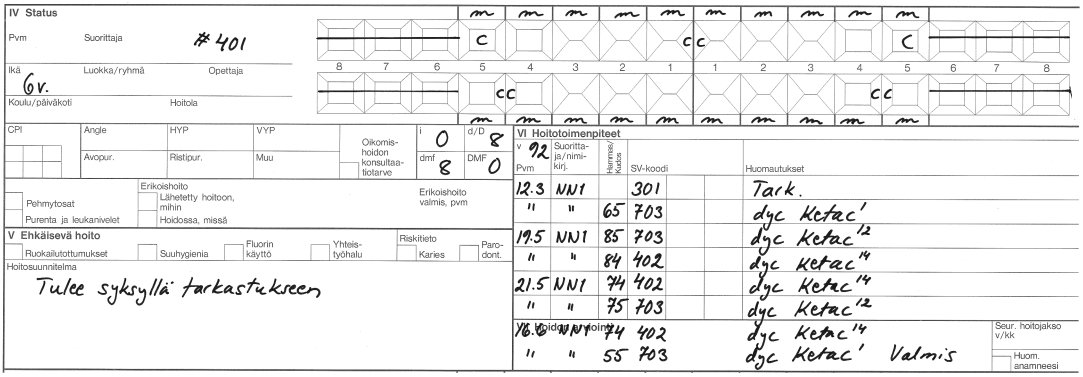
Wikner S. An attempt to motivate improved sugar discipline in a 12-year-old high caries-risk group. Community Dent Oral Epidemiol 1986;14:5-7.

Winston AE, Bhaskar SN. Caries Prevention in the 21st century. JADA 1998;129(November):1579-87.

Åstrøm AN, Jakobsen R. The effect of parental dental health behavior on that of their adolescent offspring. Acta Odontol Scand 1996;54:235-41.

Åstrøm AN. Parental influences on adolescents' oral health behavior: two-year follow-up of the Norwegian Longitudinal Health Behavior Study participants. Eur J Oral Sci 1998;106:922-30.

Appendix 1. Examples of patient records (cases #401, 430, and 137).



IV Status

Pvm | Suorittaja: #401

Ikä: 6v. | Luokka/ryhmä | Opettaja

Koulu/päiväkoti | Hoitola

CPI | Angle | Avopur. | HYP | Ristipur. | VYP | Muu | Oikomishoidon konsultaatiotarve | i: 0 | d/D: 8 | dmf: 8 | DMF: 0

Erikoishoito: Pehmytosat; Purenta ja leukanivelet; Lähetetty hoitoon, mihin; Hoidossa, missä; Erikoishoito valmis, pvm

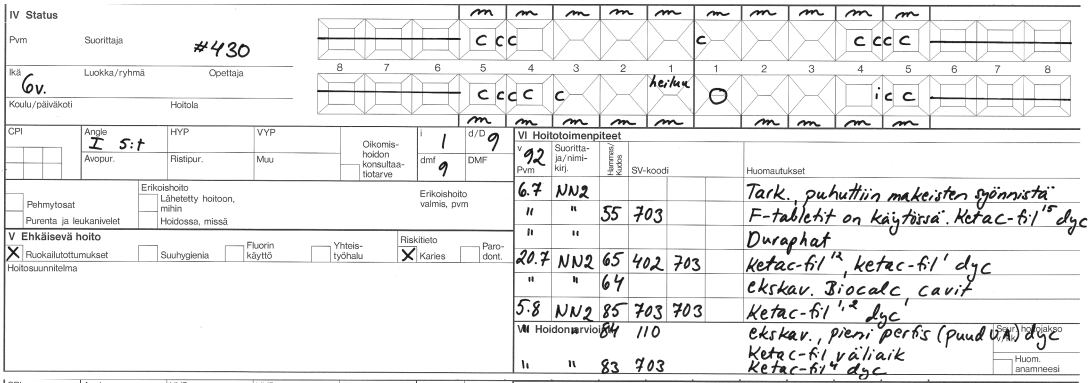
V Ehkäisevä hoito: Ruokailutottumukset; Suuhygienia; Fluorin käyttö; Yhteistyöhalu; Riskitieto: Karies; Paradont.

Hoitosuunnitelma: Tulee syksyllä tarkastukseen

VI Hoitotoimenpiteet

v Pvm	Suorittaja/nimikirj.	Hammas/kudos	SV-koodi			Huomautukset
12.3	NN1		301			Tark.
"	"	65	703			dyc Ketac'
19.5	NN1	85	703			dyc Ketac'12
"	"	84	402			dyc Ketac'14
21.5	NN1	74	402			dyc Ketac'14
"	"	75	703			dyc Ketac'12
16.6	NN1	74	402			dyc Ketac'14
"	"	55	703			dyc Ketac' Valmis

VII Hoidon arviointi | Seur. hoitojakso v/kk | Huom. anamneesi



IV Status

Pvm | Suorittaja: #430

Ikä: 6v. | Luokka/ryhmä | Opettaja

Koulu/päiväkoti | Hoitola

CPI | Angle: I 5:t | Avopur. | HYP | Ristipur. | VYP | Muu | Oikomishoidon konsultaatiotarve | i: 1 | d/D: 9 | dmf: 9 | DMF

Erikoishoito: Pehmytosat; Purenta ja leukanivelet; Lähetetty hoitoon, mihin; Hoidossa, missä; Erikoishoito valmis, pvm

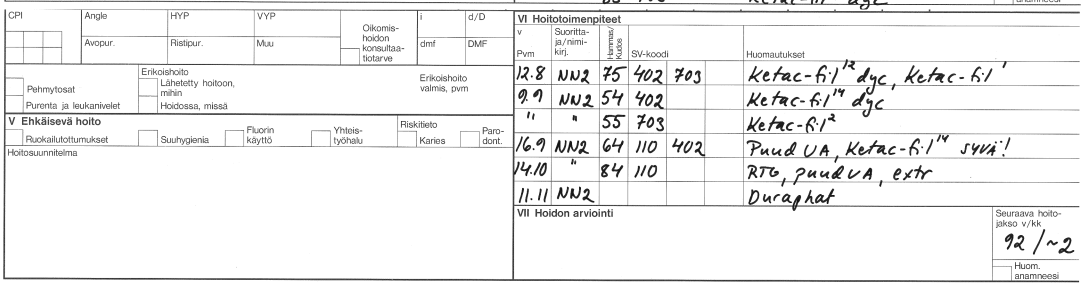
V Ehkäisevä hoito: X Ruokailutottumukset; Suuhygienia; Fluorin käyttö; Yhteistyöhalu; Riskitieto: X Karies; Paradont.

Hoitosuunnitelma

VI Hoitotoimenpiteet

v Pvm	Suorittaja/nimikirj.	Hammas/kudos	SV-koodi			Huomautukset
6.7	NN2					Tark. puhuttiin makeisten syönnistä
"	"	55	703			F-tabletit on käytössä. Ketac-fil'15 dyc
"	"					Duraphat
20.7	NN2	65	402	703		Ketac-fil'12, ketac-fil' dyc
"	"	64				ekskav. Biocalc' cavit
5.8	NN2	85	703	703		Ketac-fil'1,2 dyc'
"	"	84	110			ekskav., pieni perbs (puudVA) dyc
"	"	83	703			Ketac-fil väliaik
						Ketac-fil'4 dyc

VII Hoidon arviointi | Seur. hoitojakso | Huom. anamneesi



CPI | Angle | Avopur. | HYP | Ristipur. | VYP | Muu | Oikomishoidon konsultaatiotarve | i | d/D | dmf | DMF

Erikoishoito: Pehmytosat; Purenta ja leukanivelet; Lähetetty hoitoon, mihin; Hoidossa, missä; Erikoishoito valmis, pvm

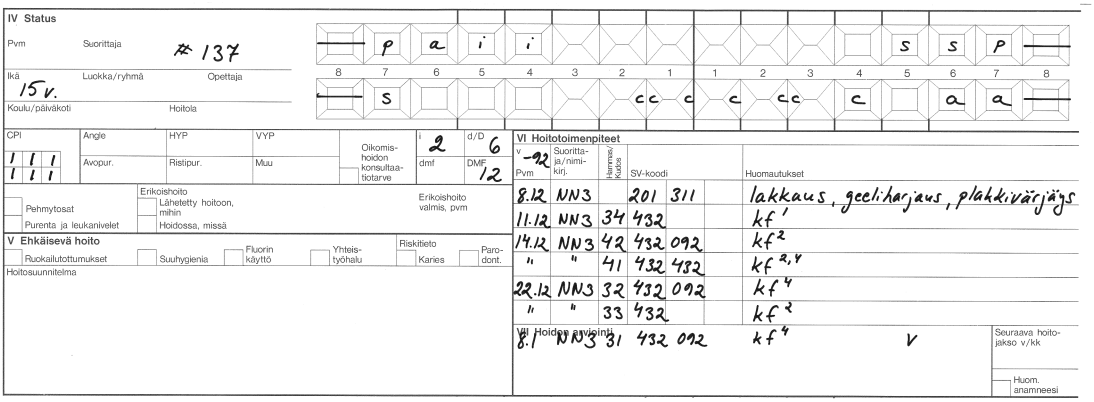
V Ehkäisevä hoito: Ruokailutottumukset; Suuhygienia; Fluorin käyttö; Yhteistyöhalu; Riskitieto: Karies; Paradont.

Hoitosuunnitelma

VI Hoitotoimenpiteet

v Pvm	Suorittaja/nimikirj.	Hammas/kudos	SV-koodi			Huomautukset
12.8	NN2	75	402	703		Ketac-fil'12 dyc, Ketac-fil'
9.9	NN2	54	402			Ketac-fil'14 dyc
"	"	55	703			Ketac-fil'2
16.9	NN2	64	110	402		Puud UA, Ketac-fil'14 syvä!
14.10	"	84	110			RTG, puudVA, extr
11.11	NN2					Duraphat

VII Hoidon arviointi | Seuraava hoitojakso v/kk: 92/~2 | Huom. anamneesi



IV Status

Pvm | Suorittaja: #137

Ikä: 15v. | Luokka/ryhmä | Opettaja

Koulu/päiväkoti | Hoitola

CPI: 1 1 1 / 1 1 1 | Angle | Avopur. | HYP | Ristipur. | VYP | Muu | Oikomishoidon konsultaatiotarve | i: 2 | d/D: 6 | dmf | DMF: 12

Erikoishoito: Pehmytosat; Purenta ja leukanivelet; Lähetetty hoitoon, mihin; Hoidossa, missä; Erikoishoito valmis, pvm

V Ehkäisevä hoito: Ruokailutottumukset; Suuhygienia; Fluorin käyttö; Yhteistyöhalu; Riskitieto: Karies; Paradont.

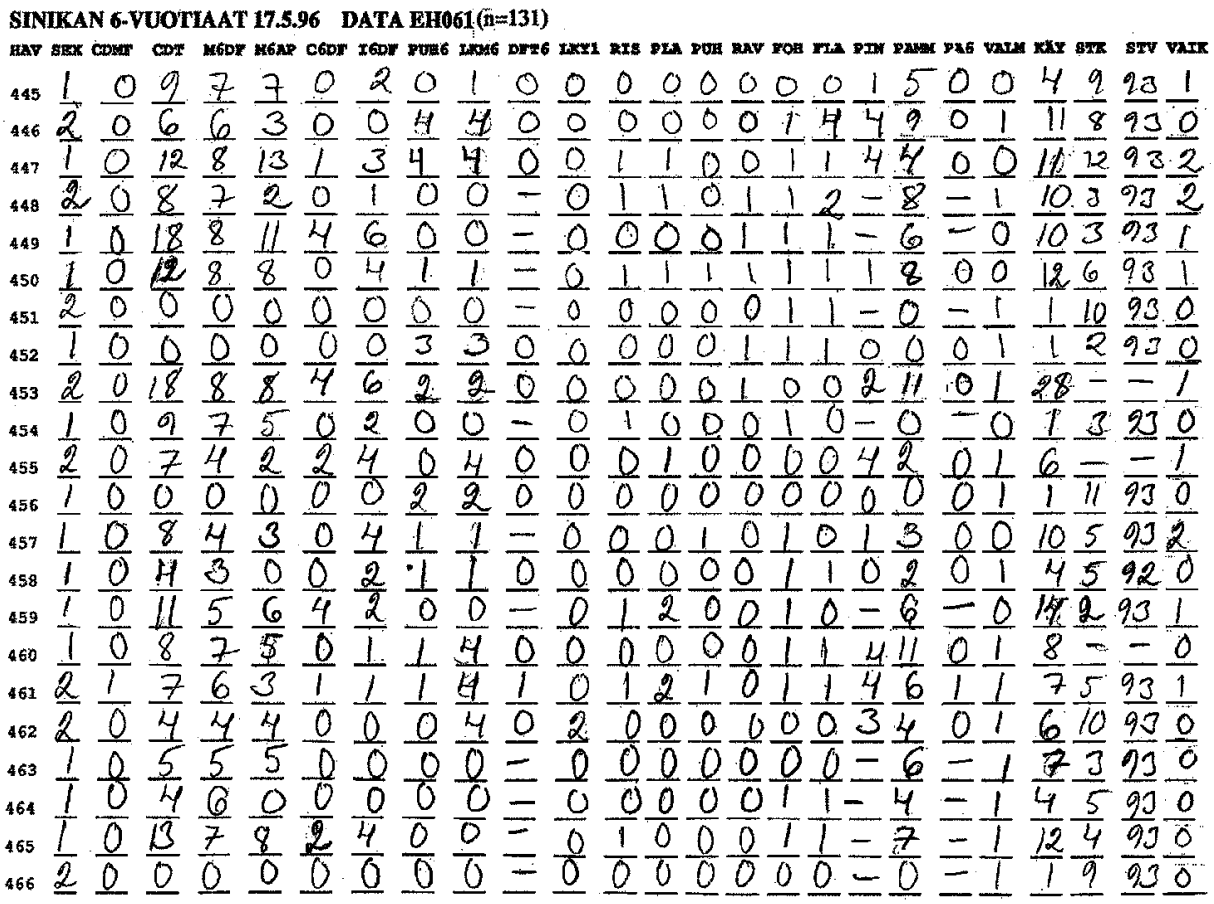
Hoitosuunnitelma

VI Hoitotoimenpiteet

v Pvm	Suorittaja/nimikirj.	Hammas/kudos	SV-koodi			Huomautukset
-92 8.12	NN3		201	311		lakkaus, geeliharjaus, plakkivärjäys
11.12	NN3	34	432			kf'
14.12	NN3	42	432	092		kf2
"	"	41	432	432		kf2,4
22.12	NN3	32	432	092		kf4
"	"	33	432			kf2
8.1	NN3	31	432	092		kf4 V

VII Hoidon arviointi | Seuraava hoitojakso v/kk | Huom. anamneesi

Appendix 2. Example of data collection form.



SINIKAN 6-VUOTIAAT 17.5.96 DATA EH061(n=131)

	HAV	SEX	CDMF	CDT	M6DF	M6AP	C6DF	I6DF	PUB6	LKM6	DFT6	LKY1	RIS	PLA	PUH	RAV	FOH	FLA	PIN	PANM	PA6	VALM	KÄY	STK	STV	VAIK
445	1	0	9	7	7	0	2	0	1	0	0	0	0	0	0	0	0	0	1	5	0	0	4	9	93	1
446	2	0	6	6	3	0	0	4	4	0	0	0	0	0	0	1	4	4	9	0	1	11	8	93	0
447	1	0	12	8	13	1	3	4	4	0	0	1	1	0	0	1	1	4	4	0	0	11	12	93	2
448	2	0	8	7	2	0	1	0	0	–	0	1	1	0	1	1	2	–	8	–	1	10	3	93	2
449	1	0	18	8	11	4	6	0	0	–	0	0	0	0	1	1	1	–	6	–	0	10	3	93	1
450	1	0	12	8	8	0	4	1	1	–	0	1	1	1	1	1	1	1	8	0	0	12	6	93	1
451	2	0	0	0	0	0	0	0	0	–	0	0	0	0	0	1	1	–	0	–	1	1	10	93	0
452	1	0	0	0	0	0	0	3	3	0	0	0	0	0	1	1	1	0	0	0	1	1	2	93	0
453	2	0	18	8	8	4	6	2	2	0	0	0	0	0	1	0	0	2	11	0	1	28	–	–	1
454	1	0	9	7	5	0	2	0	0	–	0	1	0	0	0	1	0	–	0	–	0	1	8	93	0
455	2	0	7	4	2	2	4	0	4	0	0	0	1	0	0	0	0	4	2	0	1	6	–	–	1
456	1	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	1	1	11	93	0
457	1	0	8	4	3	0	4	1	1	–	0	0	0	1	0	1	0	1	3	0	0	10	5	93	2
458	1	0	11	3	0	0	2	1	1	0	0	0	0	0	0	1	1	0	2	0	1	4	5	92	0
459	1	0	11	5	6	4	2	0	0	–	0	1	2	0	0	1	0	–	6	–	0	14	2	93	1
460	1	0	8	7	5	0	1	1	4	0	0	0	0	0	0	1	1	4	11	0	1	8	–	–	0
461	2	1	7	6	3	1	1	1	4	1	0	1	2	1	0	1	1	4	6	1	1	7	5	93	1
462	2	0	4	4	4	0	0	0	4	0	2	0	0	0	0	0	0	3	4	0	1	6	10	93	0
463	1	0	5	5	5	0	0	0	0	–	0	0	0	0	0	0	0	–	6	–	1	7	3	93	0
464	1	0	4	6	0	0	0	0	0	–	0	0	0	0	0	1	1	–	4	–	1	4	5	93	0
465	1	0	13	7	8	2	4	0	0	–	0	1	0	0	0	1	1	–	7	–	1	12	4	93	0
466	2	0	0	0	0	0	0	0	0	–	0	0	0	0	0	0	0	–	0	–	1	1	9	93	0

ACKNOWLEDGEMENTS

This study was carried out at the Institute of Dentistry, University of Helsinki, in 1994-1999, mostly alongside my full-time work in the public oral health service of the City of Helsinki.

I wish to express my deepest respect and gratitude to my supervisor, Docent Miira Vehkalahti, DDS, PhD, for steadily guiding me throughout all the phases of this work from introducing the fundamentals of scientific thinkng and research to defending this thesis. Without her deep knowledge, expert advice, and continuous encomagement and support over these years I would never have had the courage and ability to complete this work She has devoted innumerable evenings and weekends to reading and commenting on my drafts and to processing statistical evakations and figurs for my manuscripts, as well as to discussing them with me in great detail.

I am deeply indebted to my second supervisor, Professor Heikki Murtomaa, DDS, PhD, MPH, for his interest in my work and for his critical and valuable suggestions for the thesis, as well as for providiug me with the excellent facilities to complete this work on leave from my post in the oral health service.

I am profoundly grateful to the official referees of this thesis, Docent Eeva Widström, M.Sc, DDS, PhD, and Docent Lars G. Petersson, DDS, PhD, for their going into this subject so thoroughly and for their efficient mutual co-operation, which minimixed my efforts in revising the manuscript. Their valuable suggestions considerably improved mythesis and strengthened my belief in the importante of my work

I wish to express my warm thanks to Carol Norris, PhD, for her excellent revision of my manuscript as to the English language and for stimulating liuguistic discussions with her. I owe my sincere thanks to Ari Vaskin, M.Sc, for his valuable help in solving several computer problems encountered while I was finishing my work

I highly appreciate the financial support from the Finnish Dental Society and from the University of Helsinki. I wish to express my warm thanks to the Helsinki City Health Department, especially Chief Dental Officer Seppo Helminen, DDS, and the public dental clinics for the excellent co-operation in demandiug data collection.

I can never thank enough all the members of my family for their love, patience, and support.

Helsinki, August 1999

Sinikka Varsio