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Caries in the primary teeth and salivary *Streptococcus mutans* and lactobacillus levels as indicators of caries in permanent teeth

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Abstract

The relation between dental caries in the primary and permanent dentitions of the same individuals was studied during the period of general decline of caries in the child population. The caries activity of the study group in their teens, measured by caries-related microbial tests and clinical parameters, was low. However, the results suggest that caries experience of the primary dentition was associated with caries experience of the subsequent permanent dentition. The association was strong in persons who were caries-inactive and weaker in those who were caries-active in the primary dentition.

Numerous previous studies have shown a significant correlation between caries experience in the primary and permanent dentitions.[1] However, there has been a strong decline in the caries prevalence during the last 10 to 15 years in many countries, including Finland. While 10 years ago only 10–20% of the 5-year-old children living in Helsinki were caries free, 60% of 5-year-old children are currently caries free. As an example of caries prevalence in the permanent dentition, the corresponding DMFT for 15-year-old children in 1975 and 1985 were 12.4 and 5.6. It has been shown that the decline in caries also is reflected in the levels of salivary *Streptococcus mutans* and lactobacilli (Klock and Krasse 1985), which measures have been used to indicate caries activity in a child population.[2] In this longitudinal study the object was to determine whether this decline in caries has affected the association between caries in the primary and permanent dentitions. The authors also wanted to evaluate the levels of *S. mutans* and lactobacilli in saliva of the child group and determine whether their present caries activity can be confirmed using bacteriologic tests.

[1] Adler 1968; Hill et al. 1967; Klein et al. 1981; Parfitt and Parfitt 1954; Poulsen and Holm 1980.
[2] Klock and Krasse 1979; Zickert et al. 1982; Zickert et al. 1983.

Methods and Materials

The study group consisted of 129 Finnish children living in Helsinki, part of a larger follow-up study on oral health and dental development (Nyström 1982). The children were examined annually from the age of 6 months. Preventive and restorative dental care was provided for all children at public dental care centers. Treatment was provided on a yearly basis and included dietary information, oral hygiene instructions, and topical fluoride treatment. Fluoride mouth rinses were given at school every second week beginning at the age of 7 years. Fluoride tablets were given for about one-third of the children from the age of 6 months to the age of 12 years. From the age of 6 months to the age of 8 years two-thirds of the children were given mineral preparations which consisted of bone meal.

During each visit in the present study the children were motivated for caries prevention and, if necessary, sent to have preventive and restorative care. At the final examination, the children were 12–17 years old (mean age 15.5).

Carious lesions were recorded according to Möller (1966). Radiographic examination has been performed in susceptible cases to aid in clinical diagnosis. The incipient lesions, including visible decalcified spots on the enamel and enamel surface lesions in the radiograph, were not recorded. DMFS, DS, and dmfs indices (decayed, missing, and filled surfaces) were used. In the primary teeth the cumulative dmfs index was calculated by counting all affected surfaces up to the age of 9 years.

The level of salivary *Streptococcus mutans* and lac-

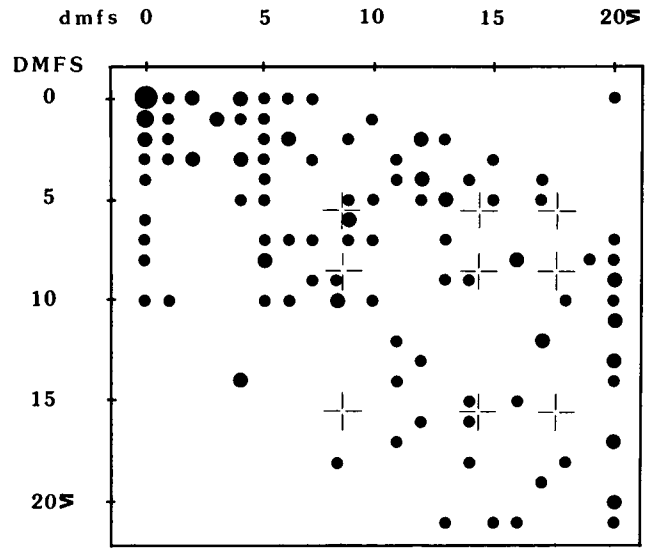

FIG 1. Distribution of decayed, missing, and filled tooth surfaces in the primary and permanent dentition. The smallest ball represents 1 individual, the next size 2-3 individuals, the next 4-7, and the biggest ball 8 individuals. Levels of screening and validation criteria are marked with crossing lines.

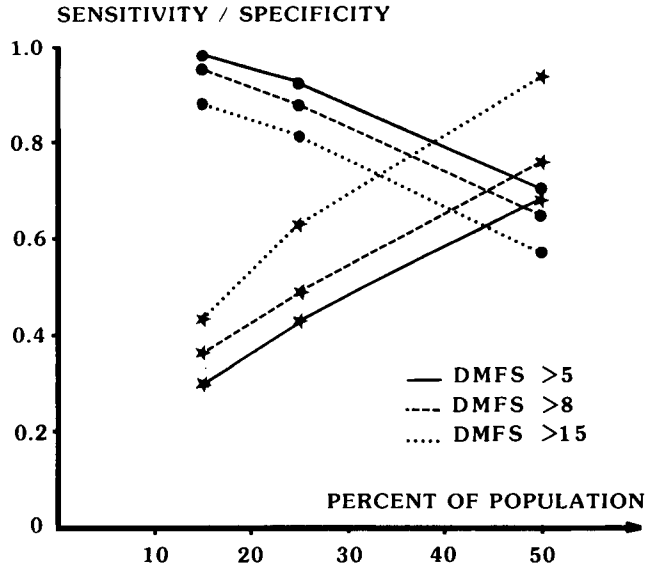

FIG 2. Sensitivity ★ and specificity ● of screening criteria based on the 85th, 75th, and 50th percentiles and validation criteria DMFS > 5, DMFS > 8, and DMFS > 15.

tobacilli were evaluated in connection with the final examination. Six children with fixed orthodontic appliances were not accepted for the microbial evaluation, because it has been shown that fixed appliances increase the microbial levels (Scheie et al. 1984). The association between the final DMFS increment and microbial levels was assessed only for those children who had had full permanent dentition for 3 years (N = 85), in order to avoid a variable stage of dental development.

For the tests, paraffin-stimulated saliva was collected for 2 min. The microbial cultivations were performed using dip-slide techniques, in which undiluted saliva is poured over a culture medium. *Streptococcus mutans* was cultured on mitis salivarius agar[a] slide supplemented with sucrose and bacitracin tablets, according to the method introduced by Alaluusua et al. (1984). Two bacitracin discs which contained 5 μg bacitracin were placed 2 cm apart on the contaminated agar. The slides were incubated at 37°C in a tube containing a CO_2-producing tablet for 2 days. The growth density around bacitracin discs was categorized as negative—score 0; low—score 1 (~ 5×10^3 CFU/ml); medium—score 2 (~ 5×10^4 CFU/ml) and high—score 3 (> 10^5 CFU/ml). A dissecting microscope was used for the evaluation of the growth density. Lactobacilli were cultivated on Dentocult® (Larmas 1975).[b] The slides were incubated aerobically at 37°C for 4 days and the growth density was compared with the model chart according to the manufacturer's instructions. The categories of density were negative—score 0; low—score 1 (~ 10^3 CFU/ml); medium—score 2 (~ 10^4 CFU/ml); and high—score 3 (> 10^5 CFU/ml).

[a] Difco; Detroit, MI.
[b] Orion Diagnostica; Espoo, Finland.

Data Analysis

Spearman's rank correlation coefficient was computed using the cumulative dmfs index and the annual DMFS values as variables (Conover 1971). The association between the final DMFS increment and microbial levels also were assessed by rank correlation analysis. DMFS and DS indexes of the final examination were compared with each other and with the microbial levels using rank correlation analysis. The microbial levels were tested separately and in combination. In the evaluation of the combined effects of the tests, the sum of the scores was used to represent the microbial level. The 1-tailed interpretation was used in testing the statistical significance of the results. Sensitivity, specificity, prediction values, and risk ratio based on the classification of the individuals according to various screening and validation criteria of dmfs and DMFS were calculated (Thorner and Remein 1961). The levels of the screening and validation criteria are marked in Fig 1.

Results

The mean cumulative dmfs index of the group was 9.7 (SD 8.88). The DMFS increased from the mean of 3.8 (SD 4.01) at the age of 12 to 9.3 (SD 5.68) at the age of 17.

Annual DMFS correlated positively to the cu-

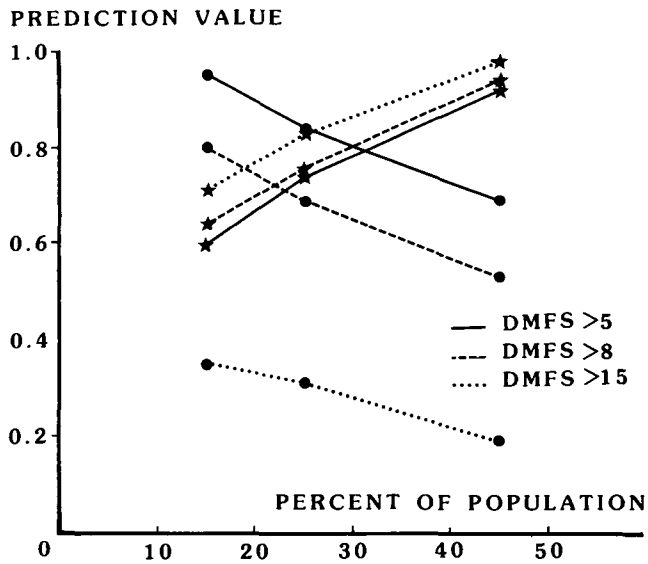

FIG 3. Prediction values of a positive ● test and a negative ★ test based on the 85th, 75th, and 50th percentiles and validation criteria DMFS > 5, DMFS > 8, and DMFS > 15.

mulative dmfs index from the age of 12 to the age of 17 ($P < 0.001$). The distribution of the dmfs and DMFS at the final examination is shown in Fig 1. The corresponding correlation coefficient value is 0.54 ($P < 0.001$).

New DS formed within the past 1-year period correlated positively to the DMFS of the final examination ($r = 0.53$, $P < 0.001$).

Indexes of sensitivity and specificity for the three screening and validation criteria are presented in Fig 2. The upper fourth corresponding to the 75th percentile (dmfs > 14) had to be included in order for the indexes of sensitivity to exceed 0.40 at all levels of validation criteria. At this screening level the indexes of specificity were still relatively high (> 0.80). A marked increase in the sensitivity could be observed by using the 50th percentile as a screening criterion, but this decreased the indexes of specificity to 0.70 or less.

Prediction values of a positive and a negative test for different screening and validation criterion levels are presented in Fig 3. Negative prediction values corresponding to the 75th and 50th percentiles were fairly high or high (0.74–0.98) while the corresponding positive prediction values were high or fairly high only in the 85th and 75th percentiles when the upper two validation criteria were selected. Because of the high negative prediction values at the 50th percentile, the risk ratio also was high. Thus, in this study population there was an average 8.8-fold risk for those who had more than 8 dmfs surfaces to get more than 8 DMFS compared to those who have less than 9 dmfs.

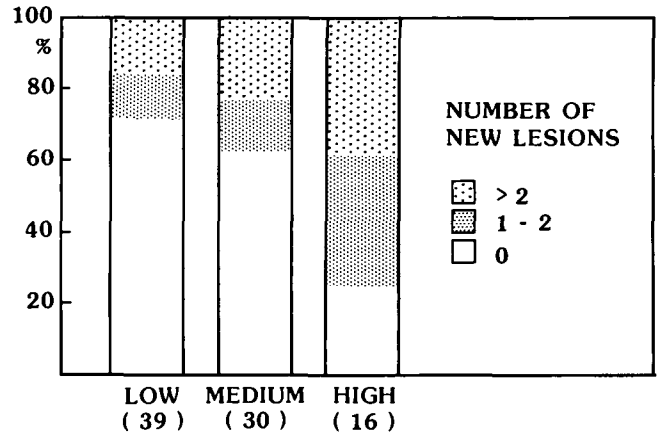

FIG 4. Distribution of caries increment levels during the past year in children with low, medium, and high salivary *S. mutans* levels. Number of subjects in parentheses.

Salivary levels of *S. mutans* and lactobacilli are given in Table 1. A significant positive correlation was found between the final DMFS and salivary levels of *S. mutans* ($r = 0.26$, $P < 0.005$) and lactobacilli ($r = 0.26$, $P < 0.005$) as well as between new DS formed within the past year and salivary levels of *S. mutans* ($r = 0.29$, $P < 0.005$) and lactobacilli ($r = 0.23$, $P < 0.005$). A significant positive correlation was found between the final DMFS increment and salivary levels of *S. mutans* ($r = 0.31$, $P < 0.005$) and lactobacilli ($r = 0.27$, $P < 0.025$). The correlation was strengthened when a combination of microbial levels was used in comparisons ($r = 0.41$, $P < 0.005$). The higher the levels of *S. mutans* and lactobacilli in saliva the lower was the number of children with no new carious lesions during the past year (Figs 4, 5). The association was most prominent when both *S. mutans* and lactobacilli levels were high (Fig 6).

Discussion

Caries prevalence in the permanent dentition of the study group was low. Thus at age 12, the DMFT of the members of the study group was 2.6, a value which is lower than those gathered by WHO from several countries, concerning DMFS at the age of 12 (FDI Report, 1985). In the entire city of Helsinki the corresponding DMFT value in 1983 was 3.0. It has

TABLE 1. Correlation of *S. mutans* and Lactobacilli Levels

CFU Lactobacilli per ml Saliva	*CFU* S. mutans *per ml Saliva*				
	ND	$<10^4$	10^4–10^5	$\geq 10^5$	*Total*
ND	5	6	4	—	15
$<10^4$	5	15	9	3	32
10^4–10^5	6	6	9	3	24
$\geq 10^5$	6	11	21	14	52
Total	22	38	43	20	123

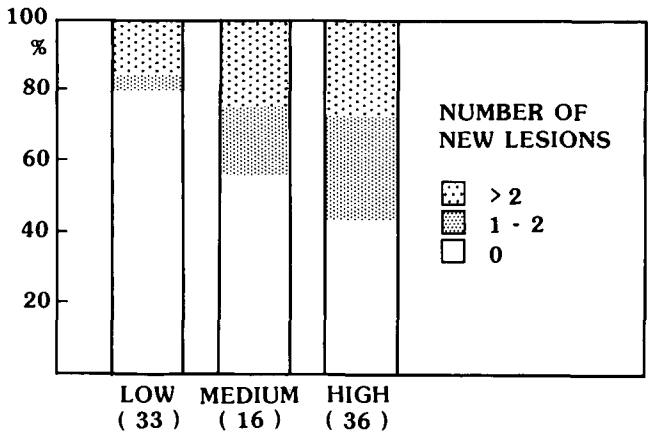

FIG 5. Distribution of caries increment levels during the past year in children with low, medium, and high salivary lactobacilli levels. Number of subjects in parentheses.

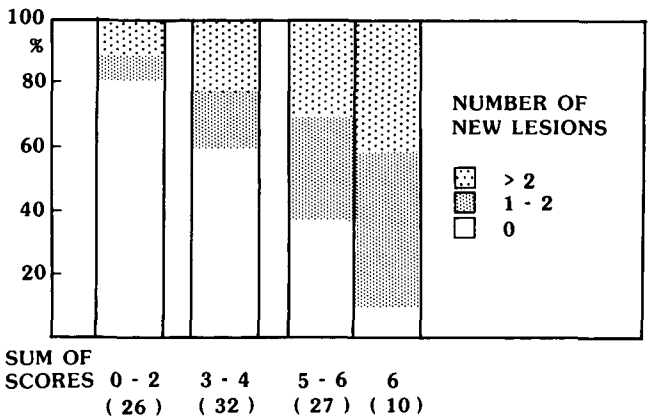

FIG 6. Distribution of caries increment levels during the past year in children with various levels of combined *S. mutans* and lactobacilli counts. (Score 0—not detected, 1—low count, 2—medium count, 3—high count.) Number of subjects in parentheses.

been shown in previous studies that there is a positive correlation between caries prevalence in the primary and permanent dentition.[3] The correlation coefficient values have varied in these studies between 0.28 and 0.53.

The decline in caries prevalence could alter the correlation between the caries prevalence in primary and permanent dentitions in 2 ways. First, it has been shown in previous studies and in the present study, that if a child is relatively free from caries in the primary dentition there will also be a minimum amount of caries in the permanent dentition, thus indicating a strong correlation (Hill et al. 1967; Parfitt and Parfitt 1954). If the number of these individuals increases in the population, the correlation also increases. On the other hand, it was shown that if a child has experienced extensive caries in primary teeth, this does not necessarily indicate extensive caries in permanent teeth. This phenomenon decreases the correlation (Hill et al. 1967). As a "net result" the value of the correlation coefficient was 0.54, which is higher than in many previous studies. The association of caries experience up to age 9 in the primary dentition with caries experience in the subsequent young permanent dentition was evaluated in the present study. The more homogenous group as regards the chronological and dental age of the children at the final examination would have made the association of caries in the 2 dentitions more precise.

Longitudinal studies have shown that groups of individuals with a large amount of *S. mutans* in their saliva have significantly higher caries activity than those who have lower numbers of these bacteria.[4] It has been possible to correlate high lactobacillus counts with high caries activity as well (Crossner 1980). The levels of salivary *S. mutans* and lactobacilli of youngsters in their teens were low in this study group compared with those previously reported in Scandinavia.[5] The levels had, however, a significant positive correlation with DMFS, DMFS increment, and DS recorded at the final examination. This confirms the results of the previous studies of caries activity by microbial tests.[6]

The change in caries rate in the permanent dentition could have been caused by the extended preventive dental care and the regular annual dental treatment. The effect of caries prophylactic information distributed via the examiners of the present study for the children over the years cannot be discounted either. While a change in the caries rate decreases the correlation of caries prevalence in primary and permanent dentitions, it also results in a number of false positives which in turn produce a lower specificity index and a lower predictive value of a positive test. A positive interpretation of this is, however, that although a child is very caries-active in the primary dentition, there is a good chance to change his/her caries rate in the permanent dentition. An example of this in the present study population was a girl who had 28 lesions in the primary dentition, but was caries free in the permanent dentition at the age of 16.

In children with extensive caries in the primary dentition, subjective information given by the parents about diet, oral hygiene habits, and exposure to fluorides has some predictive value for future caries

[3] Adler 1968; Hill et al. 1967; Klein et al. 1981; Parfitt and Parfitt 1954; Poulsen and Holm 1980.

[4] Klock and Krasse 1979; Zickert et al. 1982; Zickert et al. 1983.

[5] Alaluusua et al. 1984; Conover 1971; Crossner 1980; FDI Technical Report no. 24 1985; Larmas 1975; Möller 1966; Nyström 1982; Scheie et al. 1984; Stecksen-Blicks 1985; Thorner and Remein 1961; Zickert et al. 1983.

[6] Crossner 1980; Klock and Krasse 1979; Stecksen-Blicks 1985; Zickert et al. 1982.

development. As also shown in this study, caries-related salivary microbial tests can be used to monitor the caries activity of a child. The tests give objective information and add to the reliability of prediction (Stecksen-Blicks 1986). Since it has been shown that salivary levels of *S. mutans* and lactobacilli each, or in combination, are good indicators for caries development (Zickert et al. 1985), they may give valuable additional information especially in problematic cases of caries prediction and help the clinician in causative prevention of caries.

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Fluoride in foods

Researchers at Eastman Dental Center in New York found that adding small amounts of fluoride to sugar in the diets of laboratory rats significantly reduced dental decay on the smooth tooth surfaces of the animals. The presence of fluoride in the mouth appears to be most effective against cavities when it is present at the time acid attacks the tooth enamel. Using sugar as the vehicle for administering fluoride when it is most needed and most effective seems to be a logical approach to decay prevention.

While fluoride in food is not available in the United States, it has been introduced in certain foods in England, Scotland, Hungary, and Switzerland.