

Association between mother-infant salivary contacts and caries resistance in children: a cohort study

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Abstract

We selected 327 7-month-old infants and divided them into two groups based on the frequency of salivary close contacts between mother and infant. Five to seven years later, all first-born children ($N = 55$) whose dental development had been followed regularly, were examined for dental caries and prevalence of salivary mutans streptococci (MS) and lactobacilli. The children with frequent maternal close contacts (F group, $N = 21$) had significantly less MS in saliva than the children with rare close contacts (R group, $N = 34$, $P = 0.02$). Only 19% of the children in F group compared with 56% in R group had experienced caries in their primary molars and/or canines ($P < 0.01$). A significantly greater proportion of the children in F group (57%) than in R group (27%, $P < 0.05$) had a high intake of sugar-containing foods and drinks in a 2-day dietary history. The F and R groups did not differ significantly with respect to other children's caries risk factors, or in age, sex, stage of dental development, dental treatment, or the social aspects studied. There were no significant differences between F and R groups in maternal caries experience, salivary MS or lactobacillus counts, or in maternal background factors (age, breast feeding, or education). Frequent transfer of maternal saliva to the mouth of the baby before tooth eruption was negatively associated with oral infection by MS and to caries in the primary dentition, possibly due to protective immune mechanisms. (*Pediatr Dent* 16:11–16, 1994)

Introduction

Mutans streptococci (MS), especially *Streptococcus mutans* and, to a lesser extent, *Streptococcus sobrinus*, are the principal bacterial species that initiate human dental caries.¹ MS are usually not detectable in infants' mouths before tooth eruption.^{2–4} MS do not survive long on inanimate objects outside the mouth. Therefore, salivary transfer from one person to another is required to spread MS infection.⁵ The earlier the infection of teeth by *S. mutans*, the greater is the risk of caries in the primary dentition.^{6–8}

Studies using bacteriocin typing,^{9–11} tracing of rare serotypes,¹² plasmids,¹³ or strains with identical chromosomal DNA profiles^{14, 15} strongly suggest that infants most often acquire MS from their mothers.

In our earlier studies^{16, 17} children who had frequent salivary close contacts with their mothers at age 7 months, had significantly more serum IgG antibodies against *S. mutans* at the ages of 4 and 7 years than the children of mothers who had avoided such close contacts. In addition, children with frequent close contacts more often had antibodies to the Epstein-Barr virus, another orally transmitted pathogen.^{16, 18} These results suggest that maternal habits of infant care (frequent use of the same spoon, licking of the pacifier, kissing on the mouth) represent important routes by which maternal oral microbes are transferred to a baby's mouth.

High levels of serum IgG antibodies against *S. mutans* may either increase a child's resistance to oral infection by *S. mutans*,^{16, 19} or inhibit the virulence of *S. mutans*,²⁰ thus protecting primary teeth from caries.^{18, 21} A hypothesis can be presented that such factors that in-

crease an infant's exposure to MS antigens during the predentate period, causing an increased serum anti-*S. mutans* IgG level in children,¹⁷ might protect the primary dentition of children from MS colonization and from carious attack.

Because our previous study¹⁶ suggested that frequent maternal salivary close contacts is one potential factor to increase the antigen challenge and immune response in infants, we wanted to test in another population whether this factor could be discriminated from other determinants of dental caries in a prospective epidemiological study. Since the first results obtained from that study (when the children were 4 years old²²) supported the research hypothesis, we continued the followup in a restrained cohort sample. The methods have been extended to determine salivary levels of MS and lactobacilli in the mothers and children. Only first-born children have been included to reduce variation in maternal background variables and to minimize the possibility of other than maternal transmitters of MS infection.

Subjects and methods

Study population

The study was conducted in Lohja, a nonfluoridated (< 0.2 ppm F⁻) city of 33,000 inhabitants in southern Finland. Between 1983 and 1985, 404 mothers of 7-month-old (mean 7.0 ± 1.6) babies were interviewed by health nurses at six child health counseling offices of the Lohja District Health Center to assess the frequency of mother-infant salivary close contacts. A precoded questionnaire was used, and the answers were scored

- A) Do you feed your child with a spoon that you have used for tasting?
 2 Quite often
 1 Seldom
 0 Never
- B) Do you have a habit to clean or wet the pacifier in your own mouth before you give it to your child?
 3 Yes
 0 No
- C) Do you kiss your child directly on his/her mouth?
 1 Quite often
 0 Never or only seldom

Fig. Questions used in our studies of salivary close contacts. Numbers before the alternative answers express scoring values (additively ranging from 0 to 6).

from 0 to 6 (Fig). The validity of this scoring system was evaluated as described earlier.^{16,18} Analysis found that 32% of the mothers had frequent close contacts (F group, scores 3–6) and 49% had rare close contacts (R group, scores 0–1). When the children were 4–5 years old, 228 of the original mother-child pairs were re-examined. The distribution of children with frequent and rare close contacts was similar in nonparticipants and those in the study. All first-born babies ($N = 62$) and their mothers who belonged to the F and R groups and who had not moved from the district were invited to participate in the study in April 1990. Of these, 55 children (21 in F group and 34 in R group) and 54 mothers formed the sample for studies on dental caries and prevalence of salivary MS and lactobacilli.

Dental examinations

In April 1990, the same dentist (ASA) carried out all dental examinations in fully equipped dental units in the Lohja District Health Center. The investigator had not met the participants before, but their earlier dental records were at hand. Written consent was obtained from the mothers. The children had attended annual dental examinations in the health center from the age of 2 or 3 years. Dentists treating the children and mothers did not know which study group (F or R) the children were in. Both the investigator (whose diagnostic reliability had been evaluated earlier¹⁸) and the local dentists used usual visual-tactile methods and the general recording system directed by the National Board of Health in Finland. Only cavities extending to dentin were included in the caries indices (d/D). The data for the decayed, filled primary tooth surfaces (dfs) index at age 4 (mean 4.05 ± 0.17 years) were obtained from health center records.²² In cases of extracted or naturally shed primary teeth, the last recorded number of affected surfaces was used in the cumulative decayed, filled primary and permanent tooth surfaces (dfsDFS) index, and in the decayed, filled primary molar and primary canine surfaces index. The number of intermolar spaces²³ was assessed by local dentists in 43

children (78%) when they were 4 years old. The space was diagnosed as existing if, when observed occlusally, gingiva was entirely distinguishable between the primary molars. The number of dental visits and topical fluoride treatments between 2 and 5 years of age was recorded from the health center records.

The dental treatment during pregnancy could be determined for 52 mothers. The caries incidence rate between the last dental visit in the treatment period nearest to parturition and the examination date was assessed for each mother by dividing caries incidence (CI) by the corresponding observation time (mean 6.3 ± 1.3 years). CI was expressed as the percentage of the net increment in the number of tooth surfaces attacked by caries during the observation period out of the number of intact surfaces at the beginning of the observation.

The periodontal health of the mothers was assessed by the CPITN index²⁴ when the children were 4–5 years old and at the examination in April 1990.

Microbiological assays

In connection with the dental examination in 1990, paraffin-stimulated whole saliva samples were collected from the mothers and their children for dip-slide tests for lactobacilli (Dentocult-LB®, Orion Diagnostica, Espoo, Finland).²⁵ From the same samples 0.1 ml of saliva was taken to a transport tube containing tryptic soya broth, with 20% glycerol as a cryopreservant, for MS analysis. The tubes were stored frozen (-20°C) until analyzed for MS on MSB-agar as described earlier.¹⁶ Both the absolute MS counts and their proportions of the total aerobic growth on blood agar (MS/TA) were determined. There was a high correlation between MS and MS/TA (the Spearman $r = 0.968$ for the children, and $r = 0.830$ for the mothers). The MS/TA values were used in the calculations of coefficients of correlation between variables. The Dentocult-LB test slides were incubated at room temperature for 7 days, and scored as follows:

- 0 = no growth
- 1 = $1-10^3$
- 2 = 10^3-10^4
- 3 = 10^4-10^5
- 4 = $> 10^5$ colony-forming units (CFU) per ml of saliva.

Background surveys

At the interview, when the babies were 7 months old, the mothers were asked about their consumption of sweets and their use of sugar with coffee. Sweets consumption more often than once a week was scored as 2, once a week as 1, and less frequently as 0.

When the children were 4–5 years old, a questionnaire was mailed to the mothers; details of the survey have been described earlier.²²

In 1990, the mothers recorded dietary histories of themselves ($N = 53$) and of their children ($N = 54$) for two normal weekdays preceding the examination.

Based on these data the diurnal acid-attack time was calculated as the mean of the daily sums of the half-hours during which sugar-containing foods or drinks were consumed.

Statistics

The two-tailed Mann-Whitney U-test or the chi-square test was used to analyze differences between the groups. The Spearman rank correlation coefficients were used to show any dependencies between variables. Values of $P < 0.05$ were considered statistically significant.

Rationale for hypothesis testing

The study design was based on the expectation that the test groups (F and R) would be homogenous with respect to the known determinants of dental caries and environmental proxy factors. In that case the null hypothesis would state that there is no difference in the outcome factors (prevalence of salivary MS and caries in children) between F and R groups. To facilitate evaluation of the background factors, a description of dental caries in the whole study group is given in the results section before the comparison between the test groups.

Results

Dental caries and its determinants in children

In the whole study group ($N = 55$) seven children had experienced incisor caries with a total of 24 decayed and/or filled surfaces. One primary molar had been extracted due to pulpal inflammation, and 57% of the total number of decayed and/or filled surfaces in all teeth were diagnosed as filled at the final examination. Altogether 131 first permanent molars had erupted in 39 children; in these teeth a total of 14 decayed and/or filled surfaces were detected in seven individuals. Occlusal fissure sealants were detected in 48% of the

permanent molars. Only one child had fissure sealants applied on primary molars also.

The children with caries experience ($\text{dfsDFS} \geq 1$, $N = 25$) had significantly more ($P < 0.001$) *mutans* streptococci (MS) in their saliva samples ($\text{CFU} \times 10^3/\text{ml}$, median 128, range 5–4950) than the children without caries experience ($N = 30$, median 1.5, range 0–260) (Table 1). MS was not detected in 11 children who were all caries free. Children's salivary MS correlated significantly with dfsDFS ($N = 55$, $r = 0.72$, $P < 0.001$). Also children's salivary lactobacilli correlated significantly with dfsDFS ($N = 55$, $r = 0.45$, $P < 0.001$).

Seventeen children (31% of all) had received bottle-feeding with juices before sleeping (Table 1). This habit (scored by duration) was significantly associated with children's dfsDFS ($N = 55$, $r = 0.31$, $P < 0.05$). Children's diurnal acid-attack time was not related to their caries experience. The acid-attack time, however, was in accordance with other variables of sugar consumption in children (Table 1). It correlated significantly with the children's indices of consumption frequency of sweets and added sugar ($r = 0.35$, $P < 0.01$), and of refined foodstuffs and sugar ($r = 0.31$, $P < 0.05$) between ages 4 and 5. These two variables for their part were associated with caries (dfs) at the age of 4 ($P < 0.05$, data not shown).

Dental caries occurred ($\text{dfsDFS} \geq 1$) significantly more often (63% vs. 34%) in children ($N = 19$) who had not used fluoride tablets regularly during ages 4–5 years, than in those ($N = 35$) who had used them regularly ($P < 0.05$).

At ages 4–5 years, 85% of all children brushed their teeth at least once a day, 67% used toothpaste, and 85% brushed their teeth usually under parental guidance. None of these variables was related to caries occurrence at the final examination.

Salivary MS were detected in 98% of the mothers (N

Table 1. Variables related to consumption of sugar during the course of the longitudinal study in children with and without dental caries

	Children with Caries ($N = 25$)	Children Free of Caries ($N = 30$)
Age at the examination (years, mean \pm SD)	6.5 \pm 0.8	6.3 \pm 0.6
Salivary <i>mutans</i> streptococci ($\text{CFU} \times 10^3/\text{ml}$, mean \pm SD)	495 \pm 1124*	21 \pm 51
Dentocult-LB lactobacilli test, range 0–4 (mean)	2.2*	1.0
Maternal use of sugar in coffee, when the child was 7 months old (percentage of mothers)	60%†	24%
Bottle-feeding with juices (percentage of children)	40%	23%
Frequent consumption of sweets and added sugar (> median, percentage of children at age 4 to 5)	44%	40%
Frequent consumption of refined foodstuffs and sugar (\geq median, percentage of children at age 4 to 5)	56%	53%
Diurnal acid-attack time (\geq 2 hours, percentage of children at the examination)	33%	43%

* Significant difference between the groups of children with caries and free of caries in the two-tailed Mann-Whitney U-test ($P < 0.001$).

† Significant difference between the groups of children with caries and free of caries in the chi-square test ($P < 0.01$).

= 54, mean 276, median 119, range 0–3550, CFU \times 10³/ml). Nine percent of the mothers were free of salivary lactobacilli. Maternal salivary lactobacilli were significantly associated with children's dfsDFS index ($r = 0.30$, $N = 54$, $P < 0.05$), but maternal MS were not. There were no significant associations between maternal salivary MS or lactobacilli and children's salivary MS or lactobacilli. The number of decayed teeth in mothers ($N = 54$) at the final examination correlated significantly with children's dfsDFS ($r = 0.46$, $P < 0.001$). Maternal postpartum patterns of sugar consumption were associated with dental caries in children. Children ($N = 22$) whose mothers used sugar in their coffee when the child was 7 months old, had significantly higher caries occurrence (dfsDFS ≥ 1 , 68%) than children ($N = 32$) whose mothers did not use sugar in their coffee (31%, $P < 0.01$) (Table 1). The frequency of maternal sweets consumption correlated significantly with children's dfsDFS ($N = 55$, $r = 0.27$, $P < 0.05$).

Comparison between the test groups

Children with frequent maternal salivary close contacts (F group, $N = 21$) had significantly less MS in their saliva samples (CFU \times 10³/ml, median 5, range 0–3020)

than children with rare close contacts (R group, $N = 34$, median 46, range 0–4950, $P = 0.021$) (Table 2). Dental caries was significantly more frequent ($P < 0.05$) among the children in R group both at age 4 (dfs ≥ 1 , 32%) and at the final examination (dfsDFS ≥ 1 , 56%) than in F group (5% and 29%, respectively).

A significantly greater proportion of the children in R group (50%) than in F group (19%) developed new caries in primary teeth after age 4 ($P < 0.05$). Only 19% of the children in F group compared with 56% in R group had experienced caries in their primary molars and/or canines ($P < 0.01$). Children's dfs index in these teeth was significantly higher in R group than in F group (Table 2). Caries occurrence in children's permanent molars in F group did not differ significantly from that in R group, nor did the DFS indices. Of the children who had moved from the district or for some other reason could not participate in the final examination, four of twelve R children and one of five F children had experienced dental caries according to health center records.

A significantly greater proportion of the F group children (57%) than R group (27%, $P < 0.05$) had long diurnal acid-attack times (≥ 2 hr). There were no significant

Table 2. Comparison between the children who had been in frequent (F group) and rare (R group) salivary close contact with their mothers at the age of 7 months

	F group ($N=21$)	R group ($N=34$)
Age (years, mean \pm SD)	6.35 \pm 0.68	6.44 \pm 0.78
Sex (male/female)	10/11	15/19
Salivary mutans streptococci (CFU \times 10 ³ /ml, mean \pm SD)	166 \pm 655*	279 \pm 865
Dentocult-LB lactobacilli test, range 0–4 (mean)	1.2	1.7
Total caries experience (dfsDFS-index, mean \pm SD)	1.4 \pm 2.9	4.3 \pm 5.9
Decayed and/or filled surfaces (dfs) in primary molars and canines (mean \pm SD)	1.0 \pm 2.6*	3.4 \pm 4.5
dfs in primary incisors (total experience, mean \pm SD)	0	0.7 \pm 1.9
dfs-index at the age of 4 years (mean \pm SD)	0.1 \pm 0.4	1.4 \pm 3.3
Maternal use of sugar in coffee, when the child was 7 months old (percentage of mothers)	38%	42%
Bottle-feeding with juices, range 0–3 (mean)	0.7	0.4
Consumption frequency of sweets and added sugar, range 0–5 (mean) [†]	2.4	2.3
Consumption frequency of refined foodstuffs and sugar (mean \pm SD) [†]	5.9 \pm 2.6	5.8 \pm 2.3
Diurnal acid-attack time (hours, $< 2/\geq 2$)	9/12 [‡]	24/9
Percentage of regular users of fluoride tablets [†]	62%	67%
Topical fluoride treatments of teeth between 2 and 5 years of age (mean \pm SD)	1.0 \pm 1.1	0.6 \pm 0.7
Toothbrushing, range 1–3 (mean) [†]	2.1	2.1
Percentage of toothpaste users [†]	67%	68%
Parent's help in toothbrushing (yes/no) [†]	17/4	29/4
Presence of intermolar spaces at the age of four years (no spaces/1–4 spaces)	12/3	16/12
Attendance at day nursery outside home (yes/no) [†]	9/12	19/15

* Significant difference between F and R groups in the two-tailed Mann-Whitney U-test ($P = 0.02$). [†] At the age of 4–5 years. [‡] Significant difference between F and R groups in the chi-square test ($P < 0.05$).

differences between F and R groups in other caries-related factors (bottle feeding, frequencies of sweets, refined foodstuffs, and sugar consumption, fluoride use, and tooth brushing) or in age, sex, stage of tooth eruption, intermolar spacing, fissure sealants, or other modes of dental treatment, nor in the social aspects studied (family size, day nursery attendance, Table 2).

The test groups did not differ significantly in: maternal oral health variables (salivary levels of MS and lactobacilli, number of decayed teeth, DMFS index, postpartum caries incidence rate, need of periodontal treatment, dental treatment during pregnancy); maternal sugar consumption (use of coffee sugar, frequencies of sweets, refined foodstuffs, and sugar consumption; diurnal acid-attack time); or with respect to maternal background variables (age, breast feeding, education).

Discussion

The study was designed to test the hypothesis that variations in the frequency of maternal salivary contacts with a baby might be associated with children's oral infection by MS and with caries development in their primary dentitions. On the basis of the results, the hypothesis can not be rejected. The level of salivary MS was significantly higher and dental caries significantly more frequent in children with rare maternal salivary contact (R group) than in the children with frequent salivary contact (F group). These differences between the R and F groups were even more accentuated by the fact that a significantly greater proportion of the children in F group than in R group had long acid-attack times, i.e., at least four half-hours per day that they consumed sugar-containing foods or drinks.^{7,26}

The test groups were very homogenous with respect to the other dietary and environmental factors, which usually show close relationship with dental caries in epidemiological studies in children. Especially notable was the dependence of children's dental caries upon the patterns of maternal sugar consumption during the first nursing year. This connection can be explained by the fact that mothers and infants have similar patterns of sugar consumption.²⁷ Another explanation could be that the sweet diet had conduced mothers to have high levels of oral MS,²⁸ an infection risk for the child.²⁹⁻³¹

Several studies show a close association between the MS level in maternal saliva and the level of infant infection with these organisms soon after eruption of the first primary teeth,²⁹⁻³¹ after eruption of primary dentition,^{5,32} and during the eruption of permanent molars,^{33,34} suggesting that the mother is a natural source for child infection.

In contrast, our study showed the salivary levels of maternal MS were not related to the levels of these bacteria in saliva of the children at ages 5-7 years. One unlikely explanation for this disagreement could be that by this age the level of salivary MS in many moth-

ers might have changed from the level prevalent during primary molar eruption, the period the child appears to be most susceptible to acquiring MS.³⁵ Another factor possibly affecting this relationship in this study was that only children at the extreme ends of the variable "frequency of close contacts," were chosen for this study—excluding the middle range to increase the probability that the test groups really differed from each other. The babies in R group had seldom been exposed to maternal salivary contacts. However, this infrequent bacterial challenge might also leave the children's immune systems inadequately stimulated against MS, and therefore MS colonization might occur easily via sporadic, even nonmaternal inocula. On the other hand, frequent exposure of babies to antigens of maternal MS before tooth eruption might have induced an immune response strong enough to restrict oral MS colonization when the teeth erupted.^{8,16}

This immunological aspect may explain why F group children had lower numbers of MS and less dental caries than R group children. The results suggest that infant exposure to antigens of maternal cariogenic bacteria prior to tooth eruption might increase the child's resistance to infection by these pathogens. This concurs with an earlier finding that children whose mothers had high levels of salivary aciduric bacteria during the child's predentate phase (the assumed immunization period) and low levels during the dentate phase (the infection period) were significantly less prone to dental caries than those who had been exposed to low immunizing and high infective challenge.³⁶

Köhler and Bratthall⁵ showed that although the mother has very high numbers of oral MS, the child may or may not become infected by age 5. The authors invoked the possibility that antibodies might have made colonization difficult in some children.

In our previous longitudinal studies,¹⁶⁻¹⁸ children who had been in frequent close contact with their mothers had significantly higher titers of serum IgG antibodies to *S. mutans* than those with infrequent close contacts. However, these high antibody levels failed to protect the children with frequent close contacts from dental caries, perhaps because the functional avidities of the antibodies were low in these children.^{17,18} Antibodies were not determined in the present study. Therefore the immunological explanation referred above remains speculative. However, we were not able to show any background factor among the great number of variables studied that could be responsible for the test result. The effect on caries of frequent close contacts appeared to be valid in this strictly limited study sample. The question of external validity—whether the findings apply also to a wider group or population—cannot be answered on the basis of this study. By now, we have surveyed the frequency of close contacts in more than a thousand mother-child pairs in three populations using the same questions (Fig 1). In these

unselected populations frequent close contacts have been associated with male babies, infrequent toothbrushing, frequent sugar consumption in mothers and children, young maternal age, and caries activity in mothers.

In our immunological studies in Karkkila,^{17, 18} frequent close contacts were not related to reduction in caries. In Karkkila, the level of salivary MS in mothers was significantly lower than in the present study in Lohja. There seems to be an interesting interaction between maternal caries incidence rates and salivary close contacts in relation to dental caries in children.²² Forty-four children whose mothers had high postpartum caries incidences and for whom salivary close contact with their mothers had been frequent showed significantly increased resistance to the influence of risk factors of caries (bottle feeding, consumption frequency of sweets, added sugar, refined foodstuffs, and sugar, and infrequent toothbrushing) when compared with the other children in the population of 248 4-year-old children.²²

In conclusion, the results suggest an inverse association of frequent mother-infant salivary close contacts with infection by MS and incidence of caries in primary dentitions in a population of first-born children whose mothers have high levels of oral MS.

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From the Archives

A Victorian era observation on the relationship between oral health and character

I have never known a man or woman willing to live with a mouth full of diseased and rotten teeth who was worthy of trust. I consider it perfectly proper to regard all such persons with extreme prejudice, and the result of years of careful study is that decayed teeth covered with tartar, with the diseased gums, which always result from the putrid condition of the mouth, are a never failing indication of a culpable disregard for decency and cleanliness. You will find that people who never smile frankly never live frankly. In their moral as well as physical lives they will invariably endeavor to cover up the moral uncleanliness which inevitably accompanies physical filth.

in Character Read by the Teeth, Hazel Dell, 1895