Analysis of caries-related factors in infants and toddlers living in Sweden

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The aims of this study were 1) to investigate whether oral hygiene and dietary habits established at 1 year of age are maintained at 2 years of age and 2) to analyze caries-related factors with regard to oral health between the age of 1 and 3 years by using the salutogenic theory—that is, focusing on behavioral factors that do *not* result in impairment of health. Altogether 289 children were examined at 1, 2, and 3 years of age, and their parents were interviewed about the children's oral hygiene and dietary habits at 1 and 2 years of age. The result shows that caries-related habits, such as oral hygiene and dietary habits, established during infancy are maintained throughout early childhood. The principles of the salutogenic theory were found to be applicable when studying caries-related habits and oral health. Thus, if a dietary risk behavior is established at 1 year of age, the chance of remaining caries-free until 3 years of age is highest if good oral hygiene habits, including the use of fluoride toothpaste, are present at 2 years of age. We therefore conclude that comprehensive knowledge of a child's future dental health can be obtained by using chairside information—that is, interview of the parents and clinical examination of the children.

☐ *Dental caries; dietary habits, oral hygiene; pre-school children; salutogenic theory*

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Dental caries is still prevalent in infants and toddlers. Epidemiologic studies carried out in Sweden have shown that 7% of children develop carious lesions between 1 and 2 years of age and 20% between 2 and 3 years (1, 2). In newly erupted primary teeth the caries development may be rapid due, for example, to intake of sugar-containing liquid during the night (3, 4).

On a group level a correlation has been found between early establishment of mutans streptococci in plaque, oral hygiene, and dietary habits in 1- and 2-year-olds, on the one hand, and the caries experience in 3-year-olds, on the other (5–7). However, by studying the same factors, Schröder et al. (8) found no or only small possibilities of predicting caries on an individual level in the primary dentition at an early age. This is in accordance with studies on prediction of caries in older pre-school children (9, 10).

Many attempts have been made to find methods that could help the clinician to identify children with high caries risk. Most studies have been devoted to exploring the pathogenic hypothesis—that is, how risk factors in infancy and early childhood are predictive of later caries development. However, scanty information is available on the *maintenance* of caries-related factors over time during early childhood. Such information could be valuable in the planning of dental care programs for infants and toddlers. Furthermore, only limited attention has been paid to children who are exposed to one or more caries risk factors but do *not* develop carious lesions. This strategy has been presented by Antonovsky (11, 12) in the so-called salutogenic theory, to understand the emergence of health. According to this model, one should focus on i) health factors rather than risk factors, and ii) high risk behavior that does not result in impairment of health. No studies that we are aware of have been carried out using this model to analyze the relationship between caries-related factors and dental health.

The aims of the present investigation were therefore 1) to investigate whether oral hygiene and dietary habits established at 1 year of age are maintained at 2 years of age, and 2) to analyze caries-related factors with regard to oral health between the age of 1 and 3 years by using the salutogenic theory.

Materials and methods

Population

This study is part of a prospective, longitudinal study of oral health in 671 pre-school children, followed from the age of 1 year to the age of 3 years. All 1-year-old children in 1988 living within the area of four child welfare centers in the community of Jönköping, Sweden, were invited to take part in the study. Details of participation, drop-outs, caries incidence, oral hygiene, and dietary habits have been given previously (1, 2, 6, 7).

Of the original group of 671 children (Fig. 1), 632 were examined by a dentist at 1 year of age. Of these, three had developed carious lesions and were therefore

excluded from the present investigation. Of the 629 children caries-free at 1 year of age, 325 were randomly selected for a re-examination by a dentist at 2 years of age. Twenty-seven children had moved from the community or did not show up for the examination. Thus, 298 children were examined. Of these, 22 had detectable caries. In the group of children not invited for re-examination by a dentist at 2 years of age, two children were discovered to have carious lesions by dental nurses at child welfare centers. These children were included in the present study. At 3 years of age, another seven children examined at 2 years of age had moved from the community. A total of 293 children underwent a new examination by a dentist at 3 years of age. Of the children examined at 1, 2, and 3 years of age, four children, all caries-free at 3 years of age, were excluded owing to incomplete answers at the interviews with the parents at 2 years of age. Thus, 289 children participated in the present investigation. Two hundred and six of them were caries-free at 3 years of age, 23 had developed caries at 2 years, and 60 had developed caries at 3 years of age (Fig. 1).

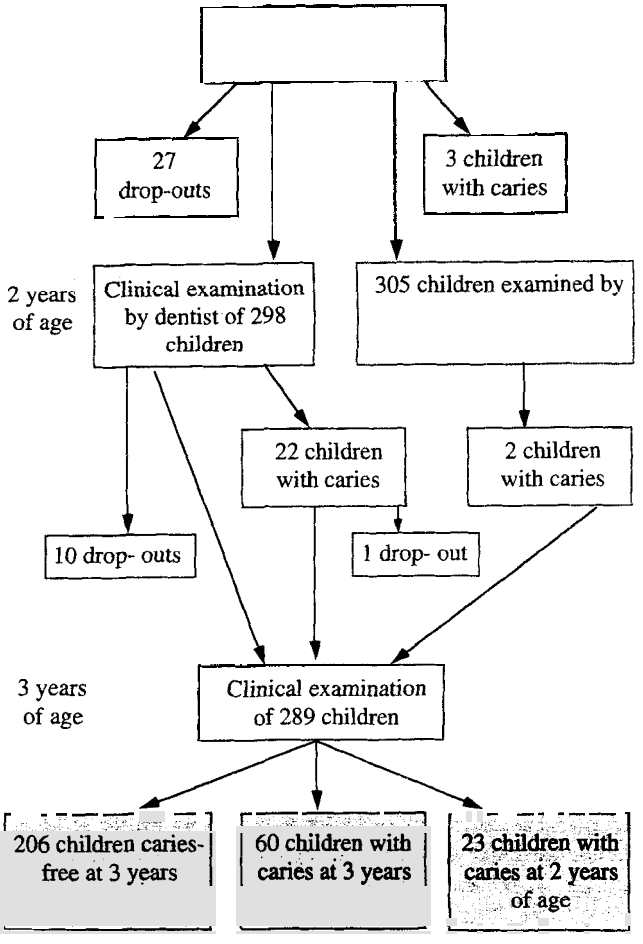

Fig. 1. Selection of the children with regard to age and dental caries. Only children in the shaded boxes are included in the present study.

Clinical examination and diagnostic criteria

All examinations were conducted between 1988 and 1990 by one of the authors (L.-K. Wendt). The presence of caries, including initial carious lesions, was clinically diagnosed on all tooth surfaces by visual examination and probing. In the 3-year-olds radiographic examinations were performed when proximal contacts existed that made the clinical examination impossible. In 1- and 2-year-olds plaque was noted when it was visible on the buccal surfaces of the maxillary incisors. Details of caries criteria and the clinical examination have been presented elsewhere (1, 2).

Bacteriologic analysis

At 1 year of age 128 children were randomly selected for a longitudinal, microbiologic examination of salivary counts of mutans streptococci. At 2 years of age eight children had moved from the community, and three could not be reached. At 3 years of age an additional four children had moved from the area. Thus, 113 children, examined at 3 years of age, participated in the microbiologic tests both at 1 and at 2 years of age.

The method used has been developed by Köhler & Bratthall (13). In brief, it involves the following four steps: i) the sample is collected by rotating a wooden spatula in the mouth, to wet it with saliva; ii) the spatula is pressed directly against a plate with mitis salivarius agar with bacitracin (MSB); iii) the plate is incubated anaerobically for 2 days at 37 °C; iv) the number of colony-forming units on a predetermined area of the plate is counted. On the basis of the data presented by Schröder & Edwardsson (14), the distinction between 'high' and 'low' caries risk was considered to be the presence or the absence of mutans streptococci in the sample.

Interview

As an integral part of the examination of the 1- and 2-year-olds, the accompanying parents were interviewed by the same person as made the clinical examination. Using a semistructured form, the parents were asked about the children's dietary and oral hygiene habits during the past year. In a previous study of the same population, a strong correlation between various dietary habits and future caries development was demonstrated (7). Thus, about 50% of the children with one of the following four habits established at 1 year had at 3 years of age developed carious lesions: 1) still breast-fed; 2) intake of sugar-containing liquid in a feeding bottle; 3) intake of sugar-containing liquid when thirsty; and 4) intake of sugar-containing liquid during the night. The data on oral hygiene habits, such as toothbrushing frequency and use of fluoride toothpaste, have been presented elsewhere (6).

Table 1. Maintenance of oral hygiene habits

Oral hygiene habits at 2 years of age	Oral hygiene habits at 1 year of age: No toothbrushing (n = 63)	Toothbrushing sometimes (n = 69)	Parents brush the children's teeth at least once a day (n = 157)
Parents brush the children's teeth at least once a day	71%	80%	96%
	NS	***	***
F-toothpaste at least once a day	65%	86%	92%
	**	NS	***

*p < 0.05; **p < 0.01; ***p < 0.001.

Statistical analysis

The chi-square test was used to determine the significance of differences between two independent groups when the data consisted of frequencies in discrete categories. When the smallest expected frequency was less than five, Fisher's exact test was used. Stepwise logistic regression analysis was used as described by Hosmer & Lemenshow (15). In the regression analysis, presence of carious lesions (manifest or initial) at 3 years of age was the dependent variable. Nine independent variables from the examination at 1 year of age were included: 1) good oral hygiene (defined as parents brushing the children's teeth at least once a day); 2) intake of soft drink seldom or never; 3) intake of ice cream seldom or never; 4) intake of sweets seldom or never; 5) visible plaque; 6) breast-fed; 7) intake of sugar-containing liquid when thirsty; 8) intake of sugar-containing liquid in a feeding bottle; and 9) intake of sugar-containing liquid during the night. The nine following variables from the examination at 2 years of age were also included: 1) good oral hygiene (defined as parents brushing the children's teeth at least once a day with fluoride toothpaste); 2) intake of soft drink, 3) ice cream, or 4) sweets at most once a week; 5) visible plaque; 6) breast-fed; 7) intake of sugar-containing liquid when thirsty; 8) intake of sugar-containing liquid in a feeding bottle; and (9) intake of sugar-containing liquid during the night. The odds ratios and 95% confidence intervals were determined for each statistically significant variable. For those 113 children who participated in the microbiologic examination, another stepwise logistic regression analysis was conducted with two variables added to those mentioned above—that is, the presence of mutans streptococci 1) at 1, and 2) at 2 years of age.

All tests were performed two-tailed and at the 0.05 significance level.

Results

Maintenance of oral hygiene habits

The results are presented in Table 1. Children who received help with toothbrushing at least once a day at 1 year of age more often received help with brushing and used fluoride toothpaste at 2 years of age than children who received help with toothbrushing only sometimes or who never brushed their teeth at 1 year of age.

Maintenance of dietary habits

At 1 year of age 48 children received sugar-containing liquid when thirsty. Of these, 56% were still drinking sugar-containing liquid when thirsty at 2 years of age, compared with 16% of those who drank water or milk when thirsty at 1 year of age (p < 0.001).

Of the 124 children who drank soft drinks at least once a week at 1 year of age, 87% were drinking this type of product more than once a week and 45% at least once a day at 2 years of age, compared with 62% and 16%, respectively, of those who drank soft drinks less than once a week at 1 year of age (p < 0.001).

At 1 year of age ice cream was consumed at least once a week by 173 children. At 2 years of age 66% of these children consumed this type of product more than once a week, and 16% at least once a day, compared with 16% and 5%, respectively, of those who consumed ice cream less than once a week at 1 year of age (p < 0.001 and p < 0.01, respectively).

Sweets were consumed at least once a week at 1 year of age by 92 children. Of these, 57% were consuming this type of product more than once a week and 16% at least once a day at 2 years of age, compared with 21% and 4%, respectively, of those who consumed sweets less than once a week at 1 year of age (p < 0.001).

Table 2. Oral hygiene and dietary factors at 2 years of age in 14 children breast-fed at 1 year of age

		Oral hygiene factors at 2 years of age		Dietary factors at 2 years of age			
		Good oral hygiene habits	Visible plaque	Breast-fed	Nocturnal meals	Sugar-containing liquid when thirsty	Consumption of caries risk products >3 times a day
Children caries-free at 3 years of age	1	+	–	–	–	–	–
	2	+	–	–	–	–	–
	3	+	–	–	–	–	–
	4	+	–	–	–	–	–
	5	+	–	–	–	–	+
	6	+	–	–	–	–	+
Children who developed caries between 2 and 3 years of age	7	+	–	–	–	+	–
	8	+	–	–	–	+	+
	9	–	+	–	–	+	–
Children who developed caries between 1 and 2 years of age	10	+	–	+	+	–	–
	11	–	+	+	+	+	+
	12	–	–	+	+	+	+
	13	–	+	–	–	–	+
	14	–	+	–	–	–	+

Breast-feeding habits in a salutogenic perspective

The results are presented in Table 2. At 1 year of age 14 children were breast-fed both during the day and night. Of these children six were caries-free at 3 years of age, whereas five children developed caries between 1 and 2 years of age and three between 2 and 3 years of age.

Children who remained caries-free all had good oral hygiene habits (defined as help with toothbrushing and use of fluoride toothpaste at least once a day) at 2 years of age. None of these children showed any visible plaque either at 1 or at 2 years of age. None of the caries-free children were breast-fed at 2 years of age, none received nocturnal meals, and none were given sugar-containing liquid when thirsty.

Nocturnal meals in a salutogenic perspective

At 1 year of age 61 children received nocturnal meals. Forty-three of these children (14% of the caries-free children and 19% of the children with caries at 3 years of age) received formula, 14 were breast-fed, and 4 children received sugar-containing liquid. At 2 years of age 39 children still received nocturnal meals, 32 children (10% of the caries-free children and 13% of the children with caries) received formula, and 3 children were breast fed.

The four children who received sugar-containing liquid during the night at 1 year of age continued with this habit at 2 years of age, and they had all developed caries before 3 years of age. Those three children who had carious lesions at 1 year of age and therefore were excluded from this investigation had all received sugar-containing liquid during the night. As all the children who received sugar-containing liquid during the night developed caries, the salutogenic analysis could not be applied to that risk factor.

Sugar-containing liquid in a feeding bottle in a salutogenic perspective

The results are presented in Table 3. Children who received sugar-containing liquid in a feeding bottle at 1

Table 3. Oral hygiene and dietary factors (in percentage) at 2 years of age in children who got sugar-containing liquid in a feeding bottle at 1 year of age (n = 51)

	Oral hygiene at 2 years of age		Dietary factors at 2 years of age			
	Good oral hygiene	Visible plaque	Consumption of caries risk products >3 times a day	Nocturnal meals	Sugar-containing liquid when thirsty	Candy > once a week
Children caries-free at 3 years of age (n = 28)	79%**	7%**	46%*	0%	32%	4%**
Children with caries at 2 or 3 years of age (n = 23)	39%**	39%**	78%*	9%	44%	30%**

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 4. Oral hygiene and dietary factors (in percentage) at 2 years of age in children who got sugar-containing liquid when thirsty at 1 year of age (n = 48)

	Oral hygiene at 2 years of age		Dietary factors at 2 years of age			
	Good oral hygiene	Visible plaque	Consumption of caries risk products >3 times a day	Nocturnal meals	Sugar-containing liquid when thirsty	Candy >once a week
Children caries-free at 3 years of age (n = 23)	78%**	4%***	78%	0%	52%	4%**
Children with caries at 3 years of age (n = 25)	36%**	48%***	88%	8%	60%	36%**

*p < 0.05; **p < 0.01; ***p < 0.001.

year of age but who remained caries-free until 3 years of age received more help with toothbrushing, used fluoride toothpaste more frequently and consumed caries risk products less frequently at 2 years of age than children who at 1 year of age got sugar-containing liquid in a feeding bottle and developed carious lesions before 2 or 3 years of age.

Sugar-containing liquid when thirsty in a salutogenic perspective

The results are presented in Table 4. Children who received sugar-containing liquid when thirsty at 1 year of age but who remained caries-free until 3 years of age received more help with toothbrushing, used fluoride toothpaste more frequently, consumed caries risk products less frequently at 2 years of age than children who received sugar-containing liquid when thirsty at 1 year and who developed carious lesions before 2 or 3 years of age.

Stepwise logistic regression

The results are presented in Table 5. Of the 18 (9 + 9) analyzed variables, 6 were significantly associated with the presence of carious lesions at 3 years of age. The two variables most strongly associated were visible plaque at 2 years of age ($p < 0.01$) and no good oral hygiene habits at 2 years of age ($p < 0.01$). The logistic regression analysis including the microbiologic variables showed no statistically significant association between the presence of mutans streptococci at 1 or at 2 years of age and carious lesions at 3 years of age.

Discussion

The main finding in the present investigation is that oral hygiene and dietary habits during early childhood were related to dental caries. Furthermore, caries-related habits established during infancy are often maintained throughout early childhood. This is in accordance with findings by Rossow et al. (16) and Grytten et al. (17). In the present study we found, for example, that if a child was drinking water or milk when thirsty at 1 year of age, it was likely that this habit persisted at 2 years of age. Moreover, if a child received ice cream or sweets less than once a week at 1 year of age, misuse of these products was unlikely at 2 years of age. Furthermore, almost all children who received help with toothbrushing at 1 year of age also received help with

Table 5. Multivariate logistic regression analysis with no carious lesions at 3 years of age as the dependent variable. Only statistically significant variables are shown

Factor	Odds ratio	95% confidence interval	p value
No visible plaque at 2 years of age	3.55	1.78–7.09	0.003
Good oral hygiene at 2 years of age	2.86	1.49–5.49	0.002
No sugar-containing liquid when thirsty at 1 year of age	2.26	1.07–4.77	0.033
No sugar-containing liquid during nighttime at 2 years of age	23.66	2.15–260.77	0.010
No visible plaque at 1 year of age	4.50	1.58–12.83	0.005
Soft drinks less than twice a week at 2 years of age	2.42	1.14–5.13	0.021

brushing at 2 years of age, and it was likely that the child used fluoride toothpaste at that age. This implies that it is of limited value to repeat a standardized preventive dental care message once good oral health behavior has been established. If risk behavior, such as giving the child sugar-containing liquid when thirsty, is established at 1 year of age, the chance of his or her remaining caries-free until 3 years of age is highest if good oral hygiene habits, including the use of fluoride toothpaste, and no visible plaque are present at 2 years of age. These observations indicate the importance of finding the right balance between bad and good habits with regard to caries.

Although the number of children still breast-fed at 1 year of age in this investigation was small, the results indicate that those who remained caries-free until 3 years of age had at 2 years of age received more help with toothbrushing, used fluoride toothpaste more frequently, and consumed caries risk products and nocturnal meals less frequently than children who had developed carious lesions at the same age. These findings are important in the light of 'The Innocenti Declaration', approved at a meeting arranged by WHO and UNICEF in 1990. In this declaration it was proclaimed that it is desirable that children are partly breast fed to at least 2 years of age. The present study confirmed earlier findings (7, 18, 19) that it is not the breast-feeding per se that causes dental caries but rather that other caries-promoting habits, like poor oral hygiene or intake of sugar-containing liquid when thirsty, co-exist in these children. All the children who received sugar-containing liquid during the night at 1 year of age had developed caries at 3 years of age. Although there were few of these children in the present investigation, it seems reasonable to assume that the habit of giving children sugar-containing liquid during the night is so caries-promoting that the only way to stop caries progression is to encourage parents to bring this habit to an end.

In a study by Granath Kinnby & Widenheim (20) 60% of parents of 4-year-olds considered oral hygiene to be very important for caries prevention. Of the factors diet, oral hygiene, and fluoride, only 24% of the dental personnel gave oral hygiene the highest priority. The results of the present study support the parents' opinion that of 20 analyzed variables, the 2 most strongly associated with no carious lesions at 3 years of age were no visible plaque and good oral hygiene (including use of fluoride toothpaste) at 2 years of age. This is in accordance with studies by Wendt et al. (6) and Alaluusua & Malmivirata (21). They found that visible plaque on labial surfaces of maxillary incisors of a young child is a sign of caries risk. Thus, the parents of an infant should be recommended to start brushing their child's teeth with fluoride toothpaste from 1 year of age. Moreover, the dental personnel should pay extra attention to children with bad oral hygiene habits at 2 years of age.

Although some studies have shown that, on a group level, early establishment of mutans streptococci indicates a high risk of caries in the young primary dentition (22, 23), other studies have shown that the association between caries in pre-school children and the presence of mutans streptococci in saliva is rather weak on an individual level (5, 8, 24). The results of the stepwise logistic regression analysis in the present investigation confirm that salivary tests on mutans streptococci are not useful in predicting dental caries in pre-school children. The multifactorial nature of caries make prediction of future caries development in pre-school children difficult. However, this study has demonstrated that by using chairside information (that is, interview of the parents and clinical examination of the children), comprehensive knowledge of the child's future dental health can be obtained. This is in agreement with a pilot study by Isokangas et al. (25), who investigated the clinician's ability to identify—without microbiologic or salivary tests—those children who will develop caries within a year after the prediction. The result from Isokangas's study suggested that the clinician can reach the same level of prediction in descriptive measures that is generally reached by a single or by a combination of salivary tests.

This study has clearly shown that the principles of the salutogenic theory were applicable when studying caries-related habits and oral health. It could, however, be questioned whether this way of analyzing the data has any advantages over the more conventional stepwise logistic regressions analysis. The advantage of the salutogenic perspective is that the interactive effect of various caries-related factors could be obtained, whereas regression analysis only gives a relative ranking order of the factors. On the basis of the results of the present study, the two methods of analyzing the data seem to be complementary to each other. Attitudes to health and willingness to adopt health-promoting habits vary between different subgroups of a community. Therefore, further studies using a salutogenic perspective on dental caries in infants and toddlers should be carried out to evaluate the method further.

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