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Dentin caries risk indicators in 1-year-olds. A two year follow-up study

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ABSTRACT

Background: Early childhood caries (ECC) risk factors are suspected to vary between regions with different caries prevalence.

Aim: Identify ECC risk factors for 1-year-olds predicting dentin caries at 3 years of age in a region with low caries prevalence.

Design: Caries risk was assessed by dental hygienist or dental assistant in 779 one-year-olds. The oral mutans streptococci (MS) score was performed from a tooth surface or (in pre-dentate children) from oral mucosa. A parental questionnaire with questions regarding family factors (siblings with or without caries), general health, food habits (night meals, breastfeeding, other beverage than water), oral hygiene habits and emerged teeth were answered by parents of the 1-year-olds. Dentin caries was assessed when the children were 3-year-olds. Simple and multiple logistic regression analyses were used for identification of caries-associated factors.

Results: An increased caries risk was assessed in 4.4% of the 1-year-olds. Dentin caries was found in 2.6% of the 3-year-olds. Caries risk at 1 year was associated with caries at 3 years (OR = 6.5, $p = .002$). Multiple regression analysis found the variables *Beverages other than water* (OR = 7.1, $p < 0.001$), *Caries in sibling* (OR = 4.8, $p = .002$), *High level of MS* (score 2–3) (OR = 3.4, $p = .03$) and *Night meal* (OR = 3.0, $p = .03$) to be associated with caries. The single variables *Beverage other than water between meals* and *Caries in sibling* were more reliable than *Caries risk* assessed performed by dental personnel.

Conclusions: Behavioural, family and microbial factors are important when assessing caries risk among 1-year-olds in a region with low caries experience.

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Introduction

Early childhood caries (ECC) is defined as dental caries in children before the age of 6 years and is known to have a negative effect on children's quality of life, mainly due to pain and infection.[1–5] Thus, early identification of individuals with a high caries risk is important in order to minimize negative experiences and subsequent dental fear.[2,4] Although prevalence varies in different parts of the world, ECC is clearly a public health problem in both developing and industrialized countries.[6–10]

Caries risk-based prevention has been found to improve quality of life and provide long-term economic gain [11] but also an important health gain.[12] The use of microbiological screening to improve the prediction of caries risk has been used successfully with both clinical and economic benefits in preschool- and older children.[13–16] Within a few years, the dentists and dental hygienists at the Vidablick Public Dental Clinic, Norrköping, Sweden observed indications of an increasing incidence of caries among 3-year-old children at their first visit to the dental clinic. Therefore, a project was started to screen 1-year-old children in order to identify caries risk factors like night meal, meal frequency, beverage between meals, family factors and presence of mutans streptococci (MS).[17,18]

The aim of this study was to identify possible caries risk factors among 1-year-olds, who were subsequently clinically examined for dentin caries at the age of 3 years.

The hypothesis was that a caries risk assessment of 1-year-olds made by a dental hygienist or dental assistant is more reliable – defined as having a higher odds ratio (OR) for predicting presence of dental caries 2 years later – than any independent variable.

Materials and methods

Examination at 1 year

Each year, parents of all the about 170 children per year, who had their 1-year birthday, and lived in the catchment area of the Vidablick Public Dental Clinic, between 2002 and 2010 were invited by regular mail to a meeting including information about child dental care and possible participation in the study. Parents of the 1-year-olds received a questionnaire (Table 1) on caries-associated and other relevant

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Table 1. Questionnaire items and variables. The questionnaire items were recorded at age one.

Item	Variable
Does the child have any siblings?	*Sibling*
Have any of the siblings had dental caries?	*Caries in sibling*
Does the child eat or drink anything except water at night?	*Night meal*
Is the child still breastfed?	*Breastfeeding*
Does the child have any illness/disease?	*Disease*
Does the child regularly take any medication?	*Medication*
Does the child drink anything except water between the meals?	*Beverage other than water*
Do you brush the child's teeth?	*No toothbrushing*
How many teeth are visible in the mouth?	*Number of teeth*

factors before visiting the clinic and were asked not to brush their child's teeth the morning of the visit. Children who did not turn up or whose parents had not completed the questionnaire were excluded from the study. During the visit, parents received information on oral health, including how to avoid dental caries.

The clinical examination comprised a visual inspection of the teeth, an assessment of visible dental plaque, and collection of one bacterial sample with a Quick-Stick® (Dentsolv AB, Saltsjö-Boo, Sweden). If a tooth – preferably an upper incisor – had emerged, a bacterial sample was taken from the buccal surface close to the marginal gingival sulcus. If no tooth had emerged, the bacterial sample was taken – in a similar way as from the teeth – from the tongue and cheek on one side of the mouth. Plaque on the Quick-Stick® was transferred to an incubation strip and cultivated according to the manufacturer's instructions for the Dentocult® Strip Mutans test (Orion Diagnostica, Espoo, Finland). The sample was incubated in a heat chamber (model; Memmert GmbH, Hannover, Germany) at the clinic for 48 h at 37 °C before analysis. A dental hygienist assessed the number of adherent colonies according to a chart supplied by the manufacturer and assigned a score between 0 and 3 to indicate low to high levels of MS. An MS score of 0 included all MS bacterial samples with less than 10^4 CFU/ml.[18]

Only one dental professional, a dental hygienist or a dental assistant, was present at each visit and examined the child. In total, four experienced dental professionals were involved in the examinations during the study period. The four examiners were well trained in the examination procedures and bacterial sample evaluation. Assessment of caries risk followed the recommendations of the Östergötland County Council caries risk programme, including medical-, family- or social factors and visual plaque. Caries risk was considered to be present if the child was expected to develop dental caries during the next 2 years. Caries risk was evaluated based on clinical and anamnestic findings including responses from the questionnaire (Table 1). If the child was assessed to have a caries risk, a caries preventive programme with further information to the parents was implemented.

Examination at 3 years

At age 3 years, the children were invited for a dental examination at the Public Dental Service Clinic. A dental hygienist or a dentist recorded the findings from this dental examination in the clinic's electronic patient file system. The clinical examination was done in the dental chair; no X-rays were taken. The clinician diagnosed dentin caries (d_3) using visual tactile inspection with a dental mirror and a dental explorer, according to the criteria of Koch.[19] Enamel caries was not taken into account.

Children who had been assessed at the Public Dental Service Clinic at the age of 1 year and who were examined in the Public Dental Service in Östergötland County at the age of 3 years (2004–2012) were included in the study.

Children, whose families had moved from the county, who had chosen a private dental clinic, or who for other reasons had not been examined in the Public Dental Service in Östergötland County during the year of their 3rd birthday, or whose dental records from the visit to the Public Dental Service Clinic at age 3 years were incomplete, were excluded from the study.

The Regional Ethics Board at Linköping University, Linköping, Sweden approved the study.

Statistical analysis

Simple and multiple logistic regression analyses were used to identify which caries risk factors at age 1 year were associated with dentin caries prevalence (deft >0) at age 3 years. The significance level was set to 5%.

Results

The study group comprised 1042 children (525 boys, 517 girls) aged 1 year. Twenty-nine were excluded due to an incomplete questionnaire at their first visit at the age of 1 year. At age of 3 years, 234 children, who had been examined at age 1, were excluded from the study. One-hundred-forty-nine children had switched to a private dental clinic, 24 had moved from the county, the dental records of 1 child had been sealed due to privacy reasons, 59 dental records of the exam at age 3 were incomplete, and 1 child was not examined during the calendar year of the 3rd birthday.

Thus, 779 children (391 boys, 388 girls) (75% of the 1042 children examined at baseline) were assessed at the ages of 1 and 3 years. At age 1, the dental hygienist or dental assistant assessed 34 (4.4%) of the children to be at risk of developing dental caries in the next 2 years.

According to the questionnaire responses, only 23 children had a disease and only 13 were taking medication on a regular basis. None of the diseased or medicating children had dental caries at 3 years of age, why these two variables were excluded from the regression analyses. The number and proportion of children with positive answers to the separate questions (variables) from the questionnaire (Table 1) at the 1-year examination are presented in Table 3.

At the age of 3 years, 20 (2.6%) of the children (11 boys, 9 girls) were diagnosed with dentin caries lesions (Table 2). The mean (±SD) caries prevalence (deft) at 3 years was 0.07 (±0.6). Four (12%) of the 34 children with positive caries risk assessments at 1 year had developed dentin caries at 3 years age, and 16 (2%) of the 745 one-year-olds, who were not

Table 2. Frequency distribution of dentin caries (d_3) at the age of 3 years ($N = 779$).

d_3t	*N*	%
0	759	97.4
1	5	0.6
2	8	1.0
3	2	0.3
4	4	0.5
9	1	0.1

d_3t primary teeth diagnosed with dentin caries.

Table 3. Results from simple regression analyses of the associations of *Gender*, *Caries risk*, the questionnaire variables, and MS scores at age 1 with dental caries experience (deft > 0) at 3 years of age ($N = 779$). See Table 1 for an explanation of the variables.

Variable	*N* (%)	Odds ratio	*p* Value	95% CI
*Caries risk**	34 (4.4)	6.5	.002	2.0–20.7
Male gender	391 (50)	1.2	.66	0.5–3.0
Caries in sibling	86 (11)	6.8	.001	2.2–21.4
Night meal	242 (31)	3.4	.008	1.4–8.5
Breastfeeding	85 (11)	0.9	.88	0.2–4.0
Beverage other than water	207 (27)	8.7	<.001	3.1–24.3
*No toothbrushing***	39 (5.0)	0.5	.31	0.1–2.1
*Presence of MS****	220 (28)	3.2	.011	1.3–7.9
High level of MS (score 2–3)	61 (7.8)	5.5	.001	2.0–14.8
Number of teeth	–	1.0	.36	0.9–1.2

*Since *Caries risk* in the 1-year-olds was assessed after considering other risk factors, it was excluded from the multiple regression analyses.
**Seven of the 39 children, who had not started toothbrushing at the age of 1 year, had no emerged teeth at that time.
***The *Presence of MS* variable was excluded from the multiple regression model, since it was expected to interfere with the *High level of MS* (score 2–3) variable.

Table 4. Multiple logistic regression analyses of the variables measured at age one year that might be associated with presence of dentin caries at 3 years of age ($N = 779$). See Table 1 for an explanation of the variables. The variable *Number of teeth* was dichotomized before statistical analysis.

Variable	Odds ratio	*p* Value	95% CI
Caries in Sibling	4.8	.002	1.8–13.3
Night meal	3.0	.03	1.1–8.1
Breastfeeding	0.3	.17	0.01–1.6
Beverage other than water	7.1	<.001	2.5–20.5
No toothbrushing	0.5	.49	0.1–2.9
High level of MS (score 2–3)	3.4	.03	1.1–10.8
>8 emerged teeth	0.8	.81	0.3–2.5

Since *Caries risk* in the 1-year-olds was assessed after considering other risk factors, it was excluded from the multiple regression analyses.
The *Presence of MS* variable was excluded from the multiple regression model, since it was expected to interfere with the *High level of MS* (score 2–3) variable.

assessed to have a high caries risk, had, in contrast to the assessment, developed dentin caries at the age of 3 years. Positive caries risk assessment at 1 year of age was significantly associated with dentin caries (deft > 0) at 3 years of age (Table 3).

Table 3 presents analyses of the association between the questionnaire variables (Table 1) at age 1 year and dentin caries (deft > 0) at age 3 years using a simple regression method. It shows that the highest odds ratio was found for the variables *Beverage other than water* (OR = 8.7, $p < .001$), *Caries in sibling* (OR = 6.8, $p = .001$) and *Caries risk* (OR = 6.5, $p = .002$), followed by *High level of MS* (OR = 5.5, $p = .001$), *Night meal* (OR = 3.4, $p = .008$) and *Presence of MS* (OR = 3.2, $p = .011$).

When a multiple regression method was used (Table 4) for the analyses, the variables *Beverage other than water* (OR = 7.1, $p < .001$) and *Caries in sibling* (OR = 4.8, $p = .002$) was followed by *High level of MS* (OR = 3.4, $p = .03$) and *Night meal* (OR = 3.0, $p = .03$).

Discussion

Study group

Due to ethical considerations, we did not investigate the reasons for not participating at the 1-year visit. Possible reasons for nonparticipation at baseline could be: parents who had previously attended a 1-year appointment with an older sibling may have considered it less important to attend the 1-year appointment again, since the focus of the visit was information; parents may have had difficulties planning their schedules; and some parents may simply have been uninterested in their child's oral health, which other studies found.[20] This last group may include parents who neglected their children to some extent in several areas of life. Children from such families have been found to suffer a high risk of dental caries.[21] One reason for the lower proportion of children with dentin caries in our group of children compared to county-wide statistics could be that the proportion of parents who were interested and engaged in their children's dental care was higher among those who decided to participate than among those who did not participate, a relationship observed in a previous study.[20] These circumstances should be kept in mind when assessing the results from the present study. While some of the children, who dropped out between the examinations at 1- and 3-year, may have dropped out due to the same reasons as mentioned above regarding the non-participating 1-year-olds, some families had moved away from the county council and were not available for the 3-year examination. The major reason for drop-outs during the study period was anyhow the parents' choice to leave the Public Dental Service and bring their child to a private dental clinic, why they were not invited to the 3-year examination at the Public Dental Clinic. Approximately 15% of the children in the county council chose private dental care for their children. Only children who participated in the examinations at both 1- and 3-year age were included in the study.

Various dentists and dental hygienists who had not been calibrated performed the dental examinations of the 3-year-olds. This is a limitation of the study. But because the regional clinical guidelines includes clear, well-established, well-known and internationally accepted criteria for the diagnosis of dentin caries, and since dentin caries lesions often occur in sites simple to detect and are easier to detect than initial/enamel caries lesions, and since the examiners were well trained according to the methods, we consider the methods used for the diagnosis of dental caries reliable. Epidemiological data for 2012 from the County of Östergötland, the site of the present study, show that ECC (not including enamel caries) occurred in 6% of the 3-year-olds, which is a higher prevalence than we found for the 3-year-olds in our study.[22] The lower dentin caries prevalence found in the study group as compared to the population (according to registrations of the epidemiological data from

the county) is reflecting the better oral health found among those who attend and complete a dental scientific study. It also indicates that the non-attenders and drop-outs have a worse dental health than those we manage to include in scientific dental studies. The low caries prevalence in our study should be taken into account when comparing our results with other studies.

The strong association between the caries risk assessment at the age of 1 year and dentin caries (deft > 0) at the age of 3 years indicates that the assessment of caries risk at the age of 1 year was reliable. The higher OR for the caries risk assessment than for most of the other variables indicates that it is better to perform a risk assessment comprising several factors than rely on separate factors for the evaluation. This is in accordance with the known multi-factorial aetiology of caries disease, which gives a higher accuracy in determining caries risk when a variety of risk factors are included in the assessment.[23–25] The importance of the 'gut-feeling' among dental professionals has previously been discussed and our study supports the findings of other authors.[17,25,26]

Gender

Gender differences in oral health have been found among both adults and children.[27,28] Caries prevalence is usually reported to be higher in females, a finding that our study did not support.[28] Our results agree with Mohebbi et al. [29], who found no difference between the genders in the prevalence of ECC among 1- to 3-year-old Iranian children. On the other hand, Peressini et al. [30] found that 3- to 5-year-old American boys had a higher prevalence of ECC than girls, which is in contrast to the findings of Declerck et al. [28], who found a higher caries prevalence among 3- to 5-year-old Belgian girls. We assume that cultural differences influence oral hygiene habits and habits for food and beverage intake, which could explain the different outcomes in the association between caries and gender in studies from various countries. The different caries prevalence reported for varying international regions makes comparisons of studies from different cultures and population subgroups challenging.[31]

Siblings with caries

We found that the 1-year-old children, who had siblings with caries, had a higher risk of developing caries during the next 2 years, which confirms the results of other studies that describe caries as a family-related disease.[24,32] Poureslami et al. [24] described caries as a transmissible disease with both vertical (from mother to child) and horizontal (between members of a group) transmission of caries-related bacteria.[33] Our findings agree with Kawashita et al. [34], who found that children with siblings, who had severe dental caries, have a higher risk of development of dental caries. Although the similarities regarding caries prevalence between siblings has been regarded as a transmission of bacteria and sharing of habits between siblings, there is always an additional vertical transmission with the parents.[24,34,35] Other familial characteristics are associated with caries in siblings. The parents' lifestyle will influence the care for their child regarding e.g. dental awareness, dental hygiene and food habits.[24,32]

Night meal

Our finding in both the simple and multiple regression analyses, that *Night meals* (most commonly breastfeeding or bottle feeding) at 1 year of age were associated with dental caries at 3 years of age, agrees with the findings of Prakash et al. [36], who found that night meals including breastfeeding and bottle feeding increased the prevalence of ECC in Indian children. Declerck et al. [28] presented similar results, that sweetened drinks at night were associated with dental caries in 3- to 5-year-old Belgian children. Mohebbi et al. [37], who studied 1- to 3-year-old Iranian children, stated that bottle feeding of milk at night should be avoided; our findings support this.

Breastfeeding

Breastfeeding was often occurring together with *Night meal*. The possible influence of breastfeeding on ECC is contradictory.[38] Breast feeding at age one was not associated with dentin caries at 3 years of age, which is in agreement with studies from Brazil,[39] USA [40] and Iran.[37] Contrary to these studies, Chaffee et al. [41] found a higher prevalence of ECC in Brazilian 3-year-olds from low income families when breastfeeding had been prolonged until the age of 2 years. The relationship between breastfeeding and ECC is complex and confounded by several behavioural factors, such as sugar intake and social variables,[42] which are more likely – than the breastfeeding *per se* – to be etiological factors when studying the relationship between breastfeeding and ECC.[42]

Beverage other than water between meals

Our finding that *Beverage other than water* between meals at the age of 1 year was associated with dentin caries at the age of 3 years agrees, for example, with Declerck et al. [28], who found that sweetened drinks were associated with caries prevalence among Belgian preschool children. *Beverage other than water* between meals had the highest OR (7.1) in our multiple regression analyses, which is why preventive dental care programmes for preschool children should highlight this.

No toothbrushing

The finding that toothbrushing had not yet started in 5% of the 1-year-olds shows that not all parents in Sweden follow the generally accepted recommendation to begin toothbrushing when the first tooth appears. The finding that *No toothbrushing* at the age of 1 year was not significantly associated with the development of dentin caries at the age of 3

years is contrary to Wendt et al. [43], who found an association between enamel and dentin caries and oral hygiene in Swedish 1-year-olds. Mattila et al. [44] also described an association between dental plaque and the prevalence of dental caries in Finnish 3- to 5-year-olds. The correlation between neglected toothbrushing and dental caries, which Hsieh et al. [45] found among Taiwanese 2- to 5-year-olds, also disagreed with our findings. The inclusion of enamel caries and the higher caries prevalence among the participants in the study by Wendt et al. [43] and the older age of the children participating in the studies of Mattila et al. [44] and Hsieh et al. [45] may explain their disagreements with our results.

Mutans streptococci

In a simple regression model, we found that, independent of the MS score, *Presence of MS* at 1 year of age was associated with dentin caries at 3 years of age (Table 3). (This finding is supported by Köhler and Andréen,[46] who found that children who were colonized by MS at an early age developed more caries than those who were colonized with MS later in life.) Thorild et al. [47] reported similar results; they found that caries prevalence at age 3 years was significantly related to MS colonization at the age of 18 months. Thus, it is useful to analyse *Presence of MS*, even though cultivation and analysis methods vary. We did not analyse if the different microbial sampling techniques used before and after tooth emergence had any impact on the results, which could be considered when interpreting the results of the microbial analyses.

Assessments of an association between the MS score at the age of 1 year and caries at 3-years-age, anyhow, found a higher OR (Table 3) for a high level of MS (score 2–3) than for the *Presence of MS* variable. Thus, we excluded *Presence of MS* from the multiple regression analysis (Table 4) to avoid bias. Our findings are in line with Parisotto et al., who found that high MS levels are strong risk indicators for ECC.[16] The use of topical antimicrobial treatment (e.g. with chlorhexidine-containing gel, toothpaste or varnish) in mothers with high levels of MS could be considered as an additional caries preventive treatment option to prevent or delay infant infection by cariogenic microorganisms.[23]

Number of teeth

In a previous study, we found that the *Number of teeth* among 1-year-olds was correlated to the MS score, a finding confirmed by others.[18,48] Although development of dental caries is closely related to the level of MS,[16] we found no association between *Number of teeth* at 1 year of age and caries at 3 years of age in our study, which is in agreement with results from a previous study in Sweden.[49]

Other factors

Socio-economic factors are known to influence the prevalence of dental caries.[32,43,49,50] In our study, we included no socio-economic variables in the analysis, which limits the impact of the results. There was a concern about that parents would find questions about family income and education level offensive, why socioeconomic factors were excluded from the questionnaire. We assume that the caries risk assessment of the dental assistant or dental hygienist included knowledge about the home address of the family and factors influencing their 'gut feeling', including possible social factors.[51]

The presence of illness and intake of medication was recorded at the age of 1 year, but could have changed considerably before the age of 3 years, which in turn could influence the caries risk considerably. Possible changes regarding environmental and social influencing factors should always be kept in mind when planning the individual caries preventive programme for each individual child.

Risk assessment

Our finding that the caries risk assessment of 1-year-olds made by a dental hygienist or dental assistant had a higher OR than all other individual variables – with the exception of *Beverage other than water* and *Sibling with caries* – shows the importance of a multivariate approach to risk assessment. Mejàre et al. [17] and Hallet,[51] for example, have discussed the importance of 'gut feeling' when assessing caries risk, and this intuitive evaluation probably contributed to the good risk assessment found in our study. However, the hypothesis was rejected, since the caries risk assessment made by a dental hygienist or a dental assistant had a lower OR than two of the independent variables used for caries risk assessment.

Several studies from various regions around the world with differing prevalence of ECC have stressed the importance and success of screening and early caries risk assessment.[6,17,52,53] Interactions between the different risk factors in the multifactorial caries disease makes it necessary to include several variables in the risk analysis.[23,24] The multiple regression analysis used in our study is one way to find out which factors are most closely associated to ECC. Individual variations are in any case present, and should always be considered when designing caries preventive programmes.

Conclusion

In the assessment of caries risk among 1-year-olds, *Beverage other than water* between meals, *Caries in sibling*, *High level of MS* (score 2–3) and *Night meal* were variables significantly associated with the presence of dentin caries at 3 years of age in a multiple regression analysis. As a supplement to these variables, *Presence of MS* was a significant risk factor for a simple regression model. The caries risk assessment made by a dental hygienist or dental assistant was more reliable than other independent variables, with the exception of the variables *Beverage other than water* between meals and *Caries in sibling*.

Our study highlights that certain social and microbiological factors already at the age of 1 year should be considered as risk factors for ECC at the age of 3 years.

There is a need for further long-term follow-up studies with multifactorial approach to optimize the caries risk assessment and caries preventive measures in early childhood.

Why this paper is important to paediatric dentists

- It shows that a thorough assessment of relevant caries risk factors at the age of 1 year can contribute to a reliable caries risk evaluation.
- It shows that if a 1-year-old child uses other beverages than water between the main meals or if caries has been diagnosed in a sibling of the 1-year-old the risk of ECC at 3 years age is significantly increased.
- This study supports the idea that dentists should motivate parents to attend caries prevention and dental service utilization programmes for their children at an early age to prevent ECC.

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Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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