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ORIGINAL ARTICLE

Influence of mode of delivery, family and nursing determinants on early childhood caries development: a prospective cohort study

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ABSTRACT

Introduction: Conflicting results exist regarding mode of delivery and caries. We investigated the influence of the mode of delivery and selected family- and nursing factors during the first 2 years of life on the prevalence of dental caries at 5 years.

Materials and methods: 551 infants were invited to a prospective medical study with focus on growth and overweight prevention. The parents of 346 infants (179 boys and 167 girls) accepted this invitation and at the age of 2-years, 336 of them agreed to dental check-ups and salivary samplings. At the ages of three and five years, 302 (90%) and 292 children (87%) could be re-examined with respect to caries by one of two calibrated examiners. All stages of caries lesions were scored on tooth and surface level. Background maternal and nursing data were collected semiannually through validated questionnaires and interviews.

Results: The caries prevalence (initial + cavitated lesions) was 5.6% at 3 years of age and 18.9% at 5 years. The 5-year-olds delivered with caesarian section displayed a significantly elevated risk of having caries (relative risk [RR] 2.2; 95% confidence interval (CI) 1.4–3.6; $p < .05$). Parental smoking and siblings with caries were the most influential family determinants ($p < .05$) while drinking juice to meals at 2 years of age ($p < .05$) was most outstanding among the nursing factors ($p < .05$).

Conclusions: In this cohort, the mode of delivery (caesarian section) had a significant impact on the risk of early childhood caries (ECC) but also other family and infant nursing determinants were related to the development of the disease.

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Introduction

Early childhood caries (ECC) is a complex biofilm-mediated disease, associated with impaired oral health-related quality of life and high costs for the families and society in general [1,2]. Systematic reviews have identified numerous biological, behavioral and social risk factors related to ECC [3,4], but also the influence of parents' attitudes, knowledge and beliefs has been recognized [5]. It has been suggested that mode of delivery may be one of several determinants for caries development since children born via caesarian section (C-section) have been shown to display an altered composition of the oral biofilm when compared with vaginally delivered children [6–9]. The long-term impact of this microbial shift on caries development later in life remains, however, controversial; some researchers have shown an elevated caries occurrence among children delivered with C-section [10,11] while others have found more caries in vaginally born children [12]. The available information is, however, mainly generated from cross-sectional or case–control study designs, and data from prospective birth cohorts are to our knowledge scarce up to date. We had the opportunity to map maternal, family and nursing factors in a birth cohort located in south-west Sweden and to follow them for a period of 5 years. The aim of this communication was to investigate the influence of the mode of delivery and selected family- and nursing factors during the first 2 years of life on the prevalence of dental caries at 5 years.

Material and methods

Study group

The study cohort consisted of 551 infants that together with their parents were invited to a prospective medical study with focus on growth and overweight prevention. The cohort was composed by merging 395 randomly selected infants from a population-based birth-cohort comprising 2666 infants, born in 2007–2009 [13] with 156 infants delivered with C-section between May 2010 and May 2012. The reason to include the latter group was to increase the power of the study with respect the research question. All children were born and citizens of the Halland region, located in south-western Sweden. The parents of 346 infants (179 boys; 52% and 167 girls; 48%) accepted the invitation and at the age of 2-years, the families of 336 children volunteered for a baseline dental check-up and salivary samplings at the Maxillofacial Unit, Halland hospital. At the ages of 3 years

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and 5 years, 302 and 292 children, respectively, were re-examined with respect to caries. The main reason for the attrition was family relocation although a few families claimed lack of interest or time. A flow-chart is shown in Figure 1. The study was approved by the Regional Ethical Review Board in Lund, and written informed consent was obtained from the custodians. All the children had parallel access to regular preventive-oriented dental care during the entire project, provided free of charge by the regional Public Dental Care. The fluoride level in the piped drinking water was <0.3 ppm in the part of the region from which the infants were recruited.

Questionnaires

A set of validated comprehensive questionnaires covering maternal and birth-related factors was distributed at the baseline of this project and additional medical data, such as history of neonatal care and prescription of antibiotics, were extracted from the hospital records. Data on family and nursing factors were collected continuously during the first 3 years of life through questionnaires. In addition, information on sucking habits (pacifier, finger, comfort blankets, etc.) and dental variables, such as the tooth brushing routines and the use of toothpaste, etc., was captured through personal interviews.

Clinical examinations

The children were visually and tactile examined in a fully equipped pediatric dental office by one of two experienced and calibrated examiners. The occurrence of manifest caries (cavitated lesions) was scored on tooth and surface level according to the WHO-criteria [14]. In addition, initial non-cavitated early lesions were defined as any visual "whitish" change of the enamel with a rough surface but without enamel breakdown. The caries prevalence was expressed as the proportion of children with a sum of initial and cavitated, missed or filled teeth (dmft) >0. Radiographs were exposed on the 5-year-olds based on the individual need. At each visit, the parents were given the opportunity to discuss lifestyle issues related to oral health and the importance of using fluoride toothpaste twice daily basis was reinforced. The families were also encouraged to limit the intake of free sugar intake and avoid soft drinks. At the implementation of the project, the two examiners scored 10 preschool children independently and any discrepancies were discussed and solved through consensus. The inter-examiner agreement was 90%.

Statistical methods

All data were processed with the IBM SPSS software (version 23.0). The influence of the background on the presence of caries (early + cavitated lesions) at 5 years of age was analyzed with chi-square tests and expressed as relative risk (RR). A multivariate logistic regression was then performed on categorical data, taking account of the confounding effects of individual-level variables. Adjusted odds ratios (aORs) were thereby estimated, reflecting the effects of each explanatory variable. The relationship with continuous variables was processed by correlation tests. We considered p values less than .05 as statistically significant.

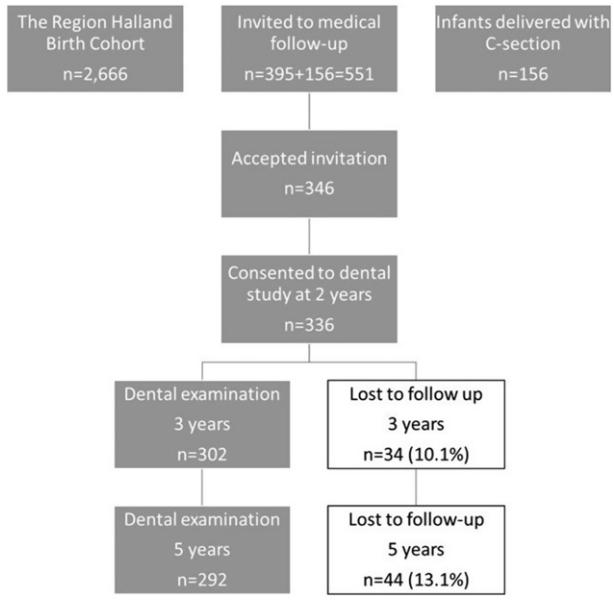

Figure 1. A flow-chart of subjects. The study group comprised 395 infants from the original Halland birth cohort, delivered vaginally or with C-section, and 156 children exclusively delivered with C-section.

Results

In total, 302 children (155 boys and 147 girls) were clinically examined at the age of 3 years and 292 children (146 boys and 146 girls) at the age of 5. Thus, the attrition rates from the 2-year inclusion were 10.1% and 13.1%, respectively. The main characteristics are summarized in Tables 1 and 2. The group of C-section children displayed higher proportions of preterm birth and neonatal hospital care than those delivered vaginally ($p < .05$). The proportion of obese mothers was higher in the C-section group ($p < .05$). Breastfeeding was more common in the vaginally delivered group during the first 3 months of life ($p < .05$). Siblings to children that were delivered with C-section displayed a significantly lower prevalence of dental caries ($p < .05$) compared to siblings to vaginally delivered children. The caries prevalence and frequency in the birth cohort is shown in Table 3. At three years, 5.6% of the children had detectable caries lesions, the majority being at early stages (68.0%). The corresponding figure at five years was 18.9% and 59.0% of the lesions were non-cavitated.

The variables that significantly were related to the presence of early childhood caries at 5-years are presented in Table 4. The corresponding adjusted odd ratios estimated from the multiple logistic regression is shown in the same table. C-section displayed a two-fold increased RR of having caries at the age of 5 years ($p < .05$). Parental smoking and siblings with caries were the most influential family factors ($p < .05$) while the intake of gruel and juice/sweet drinks to meals also exhibited a significant relationship with caries

Table 1. Characteristics expressed as mean (SD) and/or percent distribution in the birth cohort under study and sub-grouped according to mode of delivery.

Variables	Total birth cohort $n = 336$	Vaginal $n = 223$	Caesarian section $n = 113$
Birth-related factors			
Mother's BMI	24.2 (4.7)	23.6 (3.6)	25.2 (5.9)
Obese mothers (BMI >30)	9.1%	5.9%	14.4%*
Birth Length (cm)	50.7 (2.8)	51.1 (2.3)	50.0 (3.4)
Birth weight (g)	3538 (644)	3618 (491)	3404 (824)
Gestational age (weeks)	39.5 (3.5)	40.0 (4.0)	38.6 (2.3)
Preterm birth (week 31–<37)	6.9%	1.1%	16.5%*
Preterm birth (before week 35)	2.7%	0%	8.3%*
Neonatal hospital care	11.5%	3.2%	25.5%*
Antibiotics during pregnancy	17.1%	15.3%	20.2%
Antibiotics prescribed to child, 0–12 mo	24.8%	24.3%	25.7%
Antibiotics prescribed to child, 13–24 mo	35.9%	39.0%	29.9%
Family factors			
Born outside Sweden, mother/father	6.8%/7.2%	7.5/7.7%	6.4%/6.4%
Education level, university, mother/father	64.0%/45.0%	63.1%/44.3%	64.9%/47.3%
Smoking, mother/father	3.0%/5.0%	2.1%/3.8%	3.6%/7.3%
Siblings at 2 years/siblings with caries	66.6%/19.3%	67.1%/27.4%	65.5%/15.2%*

*Statistically significant different proportions between those delivered with C-section and vaginally ($p < .05$).
BMI: body mass index (kg/m^2); C-section: caesarian section; mo: months of age.

Table 2. Selected nursing factors during the first 2 years of life in the birth cohort under study ($n = 336$). Values are given for mode of delivery (vaginal/caesarian section) in percent.

Variable	Newborn	3 mo	6 mo	12 mo	18 mo	24 mo
Any breastfeeding	93.7/86.5*	81.7/71.7*	66.7/58.2	10.4/10.1	2.4/3.1	0.6/1.0
Formula milk	26.3/54.5*	59.0/76.2*	69.2/78.0	88.5/88.1	82.8/75.5	66.9/63.0
Pacifier	71.9/77.1	83.6/89.8	75.0/81.8	77.9/77.6	75.0/76.5	72.2/70.0
Gruel	–	0.0/0.0	36.0/43.8	82.0/74.4	79.8/74.5	66.9/59.6
Night meal	–	76.1/71.2	60.7/66.0	29.1/28.6	11.3/16.7	8.9/9.6
Juice to meals	–	0.0/0.0	0.5/0.0	8.7/3.7	21.0/16.0	28.2/18.0
Started tooth brushing	–	1.9/4.9	42.4/36.5	96.6/95.2	99.5/98.1	100/100

*Statistically significant different proportions between those delivered with C-section and vaginally ($p < .05$).
mo: months of age.

Table 3. Dental caries prevalence (initial + cavitated lesions) and frequency at 3 and 5 years and sub-grouped according to mode of delivery.

Variable		3 years ($n = 302$)	5 years ($n = 292$)
Caries prevalence (dmft >0), all children		5.6%	18.9%
	Vaginal	6.6%	13.0%
	Caesarian section	3.8%	29.0%
Number of decayed and filled teeth (mean dmft, SD)		0.04 (0.39)	0.22 (0.90)
	Vaginal	0.06 (0.47)	0.17 (0.76)
	Caesarian section	0.02 (0.19)	0.31 (1.09)
Number of teeth with initial lesions (mean, SD)		0.11 (0.61)	0.39 (1.01)
	Vaginal	0.14 (0.72)	0.31 (1.0)
	Caesarian section	0.06 (0.34)	0.52 (1.01)

dmft: decayed, missed, filled teeth; SD: standard deviation.

Table 4. RR (95% CI) for having initial and cavitated caries lesions (dmft >0) at the age of 5 years. aOR (95%CI) denote adjusted odds ratio, estimated from binary logistic regression.

Variables	Caries at 5 years, RR	aOR
C-section	2.2 (1.4–3.6)*	2.5 (1.7–4.0)
Mother smoking (at birth)	2.7 (1.2–6.3)*	2.6 (1.2–5.6)
Father smoking (at birth)	3.1 (1.7–5.5)*	3.0 1.7–4.9)
Siblings with caries (24 mo)	2.2 (1.2–3.8)*	2.1 (1.1–3.5)
Juice to meals (24 mo)	2.4 (1.3–4.4)*	2.4 (1.2–4.2)
Gruel/cereal drink (24 mo)	2.1 (1.1–3.9)*	1.2 (0.7–2.5)

mo: months of age.
*Statistically significant, $p < .05$.

prevalence at 5 years ($p < .05$–.01). There was a significant positive correlation between the intake frequency of candy, cookies, ice-cream and sweets at baseline (2 years of age) and caries prevalence at 5 years ($r = .35$–.41; $p < .05$). On the other hand, the variables gestation age, preterm birth, parents' native country and education level, mothers BMI at birth, breastfeeding, use of antibiotics and tooth brushing habits appeared uncorrelated to caries development.

Discussion

The main and most interesting finding was the significant association between the mode of delivery and the prevalence of dental caries. To the best of our knowledge, this has not previously been observed in a longitudinally followed birth cohort. Notably, a recent register-based retrospective study from Sweden came to the opposite conclusion with

even a tendency to less caries in 7-year-old children delivered by C-section [15]. Our present finding may be understood in the context that children delivered with C-section display a less diverse salivary microbiome, with fewer beneficial bacteria than vaginally born children [6–8]. The sequence and timing of exposure to microbes largely dictates the composition of the gut and oral microbiomes on a "first come, first served" basis and children delivered with C-section are in that aspect disadvantaged [16]. Furthermore, it should be emphasized that caries is a non-communicable biofilm-mediated disease (NCD), resulting from a complex interaction between the commensal microbiota, host susceptibility and environmental factors [17], with shared risk factors with many other NCDs. In other words, caries development is linked to oral biofilm dysbiosis and reduced diversity, most commonly driven by extensive sugar consumption and inadequate oral hygiene and suboptimal exposure to fluoride [18]. The vertical mother–child transmission of caries-associated mutans streptococci is another key event for early caries development which could be affected by the mode of delivery [19–21]. Salivary samples are collected from the present cohort, from baseline up to 5 years, which will be processed with respect to the complete microbiome. This will hopefully elucidate the microbial aspects of the present research topic.

Our finding that a number of other family and nursing determinants were linked to caries prevalence was neither novel nor surprising in the light of previous research. Children to parents with immigrant background and/or low socio-economic status have been identified as vulnerable for caries development in numerous clinical trials [22,23]. Likewise, maternal obesity [24], parental smoking, frequent sugar intakes, as well as neglected oral hygiene have been reported as risk factors for early caries development [4,25–28]. Interestingly, we were unable to demonstrate a protective role of breast-feeding in this birth cohort which was in contrast to systematic reviews and meta-analysis on the topic [29–31]. The vast majority of all children in the cohort were breast-fed during the first 6 months of life and less than 10% were formula fed. Previous research has shown that formula feeding is associated with a reduced diversity in the gut microbiome [32] and with fewer lactobacilli species in saliva, as compared with breastfed babies [33].

One recent cohort study from Thailand has shown an inverse relationship between preterm children (<37 weeks gestation) and caries [34], but the caries prevalence was very high (88%) in that population. Our negative finding to duration of gestation was therefore more in harmony with Tanaka et al. [35], but it should be stressed that there were relatively few preterm cases (born before week 37) in our material. Other notable variables that remained non-related to caries in the present cohort were the indirect measures of socio-economy (parent's native origin and level of education), the maternal/child use of antibiotics and mothers body mass index (BMI) at the time of delivery.

The strength of this study was the prospective design and the comparatively low attrition rate. We also consider the information retrieved from the questionnaires and interviews as reliable since the participating families were highly motivated and wanted to contribute to the study objectives. We collected nursing data up to the age of 5 years, but in this report we only utilized the information up to two years since we wanted the focus on factors foregoing the disease rather than cross-sectional associations. A shortcoming was that the two examiners were not continuously calibrated throughout the study, albeit the inter-examiner was excellent at the implementation of the project. Moreover, young children are not always fully cooperative for a thorough clinical examination so it is likely that the true caries prevalence was somewhat underscored, particularly among the 3-year-olds. This insecurity was the main reason for refraining from any statistical evaluations in this age group. It should also be underlined that the proportion of children delivered with C-section was higher than the national average (17%) in the present material which was explained by the targeted and selective invitation to families with that mode of delivery, born between May 2010 and May 2012.

Conclusions

In this prospective birth cohort, children delivered with caesarian section exhibited a significantly increased risk of having early childhood caries at the age of 5 years. However, there were also other family and nursing-related determinants that contributed to development of this disease.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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