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ORIGINAL ARTICLE

Does early establishment of favorable oral health behavior influence caries experience at age 5 years?

TOVE I. WIGEN & NINA J. WANG

Department of Paediatric Dentistry and Behavioural Science, Institute of Clinical Dentistry, University of Oslo, Oslo, Norway

Abstract

Objective. The purpose was to study associations between tooth brushing frequency, use of fluoride lozenges and consumption of sugary drinks at 1.5 years of age and having caries experience at 5 years of age. ***Methods.*** This study was based on data from the Norwegian Mother and Child Cohort Study conducted by the Norwegian Institute of Public Health and by the Public Dental Services. A total of 1095 children were followed from pregnancy to the age of 5 years. Questionnaires regarding oral health behavior were completed by the parents at 1.5 and 5 years of age. Clinical and radiographic examination of the children was performed at the age of 5 years. ***Results.*** In multiple logistic regression, having caries experience at 5 years of age was associated with; at 1.5 years of age having the teeth brushed less than twice daily (OR = 2.1, CI = 1.3–3.6) and being offered sugary drinks at least once a week (OR = 1.8, CI = 1.1–2.9) when controlled for family characteristics and oral health behavior at 5 years of age. ***Conclusions.*** Tooth brushing frequency and consumption of sugary drinks in early childhood were related to caries development during pre-school age, independent of family characteristics and oral health behavior at 5 years of age. The results indicate that early established habits regarding tooth brushing and consumption of sugary drinks have long-term effects on caries development. Parents encountering difficulties in establishing favorable oral health behavior in children's first years of life should receive special attention from health personnel.

Key Words: *children, fluoride lozenges, MoBa, tooth brushing frequency*

Introduction

Dental caries is still a common disease in pre-school children, although a decline in caries prevalence has been documented during the last decades [1]. It is documented that children who develop caries in early childhood have higher caries increment during pre-school age and that children with caries in primary dentition are at high risk of developing caries in the permanent dentition, giving lifelong consequences for oral health [2,3].

Caries development in pre-school children is influenced by oral health behavior such as diet, plaque control and the use of fluoride, which in turn is influenced by social factors [4]. The decline in caries prevalence is attributed to widespread use of fluoridated toothpaste, but other factors like changes in oral hygiene and sugar consumption also contribute [5]. Oral health behavior is established in early life and transferred from parents to children. Behaviors conducted regularly, often on a daily basis, turn into habits, and habits performed daily have been shown to be resistant to changes [6].

Sugar intake has been related to caries development in pre-school children in some studies [7,8], while no association between diet and caries development has been reported [9]. Frequency of sugar use has been shown to have a greater influence on caries development than total sugar intake [10]. Sugar exposure at meals and snacks has been shown to increase from child age 1 to 5 years [11] and snacking habits established during early childhood appear to be maintained throughout adolescence [12]. One study has shown that consumption of sweets at 1 year of age was associated with caries prevalence at 15 years of age [13]. The relationship between sugar consumption and caries has been considered to be weaker in the modern age of fluoride exposure [14].

Correspondence: Tove I. Wigen, Department of Paediatric Dentistry and Behavioural Science, Institute of Clinical Dentistry, Box 1109, Blindern, 0317 Oslo, Norway. Tel: +47 22 85 20 00. E-mail: wigen@odont.uio.no

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Use of fluoride is well documented to prevent caries development among pre-school children [15]. In Norway, use of fluoridated toothpaste is almost universal among pre-school children [16] and fluoride supplements are, as in most countries in Europe and in the US, recommended to children considered being at risk of developing caries [17–19].

Tooth brushing frequency and plaque accumulation are associated with caries development in pre-school children [20,21]. Tooth brushing behavior established during infancy is often maintained during pre-school age [16,21,22] and even throughout adolescence and into adulthood [23]. We have previously studied children's oral health behavior from 1.5–5 years of age using data from a Norwegian cohort. The results from that study showed that at 1.5 years of age half of the children had their teeth brushed twice daily and that, during pre-school age, 28% changed brushing habits from once daily to twice daily [16].

Although studies have shown that some established health behavior is maintained over time [6], knowledge regarding the association between oral health behavior established in early childhood and caries development during pre-school age in low caries populations is limited and especially prospective studies are scarce.

The aim of the present analyses was to study, using a longitudinal design, associations between tooth brushing frequency, use of fluoride lozenges and consumption of sugary drinks at 1.5 years of age and having caries experience at 5 years of age.

Materials and methods

Study population

This study was based on data from the Norwegian Mother and Child Cohort Study conducted by the Norwegian Institute of Public Health [24,25] and data from dental examination of 5-year-old children in the Public Dental Services.

The Mother and Child Cohort Study is a prospective pregnancy cohort study including 108,000 pregnancies recruited from 1999–2008. Participants were recruited by postal invitation in connection with routine ultrasound examination offered to all pregnant women in Norway at 17–18 weeks of gestation and 39% of all invited pregnant women agreed to participate. Data were collected by questionnaires completed by each mother in pregnancy and early childhood. The current study was based on quality-assured data files (version 3) released for research in 2007 and was restricted to 1607 children born in 2002 in the county of Akershus. Clinical data from dental examination in the Public Dental Services was obtained for 1366 of the children. In 512 children, data were incomplete and these children were excluded. Among the excluded children a higher proportion of non-western parents, mothers with low education and children with caries experience was found ($p < 0.05$). The final study population consisted of 1095 children, 586 boys and 509 girls.

Clinical dental examination

The clinical dental examination of the children was performed by 44 dental hygienists as part of the regular dental recall examination in the Public Dental Services. The examination was performed in a fully equipped dental clinic using plane mirror and sharp probe after the teeth had been dried with air. Bitewings were taken when indicated in accordance with standard routines in the Public Dental Services (bitewings when visual inspection of approximal surfaces was impossible), and were used in 68% of the children in adjunct to the clinical caries registration.

Caries experience was registered as the sum of teeth (t) recorded as decayed (d), filled (f) or missing (m) due to caries. Five caries grades were initially recorded both in the clinical examination and in the radiographs using the tooth surface as the unit of measurement [26]. In this study, the term 'caries' was used to denote carious lesions extending into dentine. In the analyses, children were categorized as having (dmft >0) or not having (dmft = 0) teeth with caries experience.

Intra- and inter-examiner agreement was tested using 20 bitewing radiographs of primary molars including eight approximal surfaces in each radiograph. The first author had previously been calibrated [27] and the registrations by the first author were used as the 'gold standard' and compared with the dental hygienists' registrations. The mean value of Cohen's kappa for inter-examiner agreement was 0.86 (SD = 0.10) and the mean intra-examiner agreement was 0.85 (SD = 0.12). Details on intra- and inter-examiner agreements have been described earlier [27,28]. Clinical calibration of the dental hygienists was not performed due to practical reasons. However, the dental hygienists were regularly calibrated as part of the routines in the Public Dental Services. Both written and oral information about the clinical caries criteria was given to and discussed with the dental hygienists in groups before data collection started.

Questionnaire to parents

Exposure data was obtained from questionnaires answered by the parents at 1.5 and 5 years of age. The parents were asked about the children's tooth brushing, use of fluoride lozenges and consumption of sugary drinks at 1.5 and 5 years of age. Tooth brushing frequency was reported as brushing twice daily or more often, once daily or sometimes and categorized in the analyses as brushing twice daily and less than

Table I. Description of family characteristics (n = 1095).

Family characteristics		% (n*)
Gender	Boy	54 (586)
	Girl	46 (509)
Age at dental examination	48–59 months	31 (341)
	60–71 months	65 (713)
	72–80 months	4 (41)
Maternal education	High	67 (736)
	Low	33 (357)
Parental origin	Both western	96 (1057)
	One or both non-western	4 (38)
Family status	No change	91 (960)
	Change	9 (97)

*Reduced because of internal drop-out.

twice daily. Use of fluoride lozenges was reported as daily, sometimes or never and in the analyses categorized as daily and less than daily. Consumption of sugary drinks was reported as more seldom than once a week, 1–6 times a week or daily and in the analyses categorized as less than once a week and at least once a week. The children being offered sugary drinks at night at 1.5 years of age were reported as never, sometimes and each night.

Family characteristics controlled for in the analyses were parental national background, maternal education, stability of family status, age at dental examination and gender. National background was recorded according to country of birth of the mother and father. This information was combined to distinguish both parents being of western origin from one or both parents being of non-western origin. Non-western origin included parents born in Asia, Africa, South America, Central America and Eastern Europe. Maternal education was reported during pregnancy and included completed and ongoing education. High education was defined as more than 12 years at school and low education was defined as 12 years or less at school. The stability of family status was measured by registering whether the mother and father lived together or not in pregnancy and when the child was aged 5 years and dichotomized as having changed or not changed from two parents to one parent in the period. Description of family characteristics is given in Table I.

Statistical analyses

The statistical analyses were performed using IBM SPSS, version 20. Bivariable and multivariable logistic regression analyses were conducted with having caries experience at age 5 years of age as the dependent variable. Spearman's Rank correlation was used to explore colinearity between the independent variables before multivariable analyses were conducted. The association between oral health behavior at 1.5 and having caries experience at 5 years of age was explored using logistic regression analysis controlled for family characteristics and oral health behavior at 5 years of age. In the first multivariable logistic regression, family characteristics and oral health behavior at 1.5 year of age were included. In the second multivariable logistic regression oral health behavior at 5 years was included in addition. Interaction between the oral health behaviors at 1.5 and 5 years of age was explored by including interaction terms in the analysis. Including interaction terms did not change the results, none of the interaction terms reached statistical significance in the analysis and were not included in the final analysis. Results were reported using frequencies, odds ratios (OR) and 95% confidence intervals (CI).

Ethical approval

Written, informed consent was obtained from all parents. The investigation was approved by the Regional Committee for Medical Research Ethics in South-Eastern Norway and the Norwegian Data Inspectorate.

Results

Caries experience in the children at 5 years of age was low, 10% of the children had caries lesions extending into dentine.

In Table II the oral health behavior at 1.5 and 5 years of age are presented. During the pre-school

Table II. Description of oral health behavior in the children at 1.5 and 5 years of age (n = 1095).

Oral health behavior	1.5 years of age, % (n*)	5 years of age, % (n*)
Tooth brushing frequency		
Twice daily or more often	51 (561)	76 (826)
Less than twice daily	49 (531)	24 (267)
Fluoride lozenges		
Daily	36 (397)	74 (809)
Less than daily	64 (698)	26 (281)
Sugary drinks		
Less than once a week	50 (529)	24 (254)
At least once a week	50 (526)	76 (829)
Sugary drinks at night†		
Never	84 (886)	—
Sometimes	10 (108)	—
Each night	6 (66)	—

*Reduced because of internal drop-out.
†Question not posed at 5 years of age.

Table III. Caries experience (dmft >0) at 5 years of age related to oral health behavior at 1.5 years of age. Bivariable ($n = 1095$), multivariable[a] ($n = 973$*) and multivariable[b] ($n = 950$*) logistic regression analyses.

	dmft >0 at 5 years of age		
Oral health behavior at 1.5 years of age	Bivariable OR (95% CI)	Multivariable[a] OR (95% CI)	Multivariable[b] OR (95% CI)
Tooth brushing frequency			
Twice daily or more often (ref)			
Less than twice daily	2.7 (1.8–4.2)	2.3 (1.4–3.7)	2.1 (1.3–3.6)
Fluoride lozenges			
Daily (ref)			
Less than daily	1.6 (1.0–2.5)	1.2 (0.8–2.0)	1.0 (0.6–1.7)
Sugary drinks			
Less than once a week (ref)			
At least once a week	1.9 (1.2–2.9)	1.7 (1.1–2.8)	1.8 (1.1–2.9)
Sugary drinks at night			
Never (ref)			
Sometimes	1.8 (1.0–3.3)	1.5 (0.8–2.8)	1.4 (0.7–2.7)
Each night	3.0 (1.6–5.7)	2.2 (1.1–4.5)	2.1 (1.0–4.4)

[a]Controlled for family characteristics; parental origin, maternal education, stability in family situation, gender and age at dental examination.
[b]Controlled for family characteristics and oral health behavior at 5 years of age.
*Reduced because of internal drop-out.

period, the proportion of children who brushed twice daily and used fluoride lozenges daily from 1.5–5 years of age increased, while the proportion of children being offered sugary drinks less than once a week decreased. Sugary drinks at night were offered to 16% of the children at the age of 1.5 years.

Table III shows the results from bivariable analyses and multivariable analyses exploring the associations between oral health behavior at 1.5 years of age and having caries experience at 5 years of age. The results from the first multivariable analysis controlling for family characteristics showed that tooth brushing frequency at 1.5 years of age, being offered sugary drinks at 1.5 years of age and being offered sugary drinks each night at 1.5 years of age were related to having caries experience at 5 years of age. Use of fluoride lozenges at 1.5 years of age was not associated with caries development during pre-school age.

To control for the influence of the oral health behavior at 5 years of age on caries development, oral health behavior at 5 years of age was included in the multivariable regression. Including oral health behavior at 5 years of age did not change the statistical significant associations, except for reducing the association slightly for sugary drinks at night. The results from the second multivariable analysis showed that the odds ratio for having caries experience at 5 years of age was 2.1 for children who had their teeth brushed less than twice daily at 1.5 years of age compared with children who had their teeth brushed twice daily. For children being offered sugary drinks at least once a week at 1.5 years of age the odds ratio for having caries experience at 5 years of age was 1.8 compared with children being offered sugary drinks less than once a week.

Discussion

The main findings in this study were that tooth brushing frequency and consumption of sugary drinks at 1.5 years of age were related to having caries experience at 5 years of age after controlling for oral health behavior at 5 years of age and family characteristics.

This study was based on data from the Norwegian Mother and Child Cohort Study. The cohort study design, with data collection several times during early childhood, has the advantage of reducing the risk of bias resulting from parents' ability to recall the oral health behavior. In this study, the proportion of parents of non-western origin and the proportion of mothers with low education were lower than in the Norwegian population [29,30], probably due to self-selection and loss to follow-up, known findings in studies with longitudinal designs [31]. Selection bias influence the level of the variables but to a lesser extent the associations between the variables; and previous analyses of variables in the Mother and Child Cohort Study have shown no statistically significant differences in association measures between participants and the total population regarding exposure–outcome associations [32].

The role of sugar in caries development has been debated in areas with regular use of fluoride [14]. The present study showed that frequency of sugar consumption in early childhood was related to having caries experience and we have previously shown that maternal total sugar consumption was related to having caries experience in pre-school children [33]. The findings regarding sugar consumption in early childhood are in line with results from one Finnish study where children's sugar use and night feeding were associated with caries increment from 1.5–5 years of age [7]. A recent review of risk factors during the first year of life and caries in pre-school children concluded that feeding practices were related to caries development [34]. The results indicate that information to parents about the association between frequency and amount of sugar consumed in early childhood and caries development is still warranted.

In this study, tooth brushing frequency at 1.5 years of age was related to having caries experience at 5 years of age. Parents who establish brushing twice daily regularly in early childhood have been shown to continue the behavior throughout pre-school age [16,21,22]. Brushing teeth of young children may be challenging, in one study half of the parents reported problems with tooth brushing at child age 2 years [21]. This may indicate that parents who have difficulties with tooth brushing when children's teeth erupt should receive special attention from dental personnel so that tooth brushing routines are established early and risk of caries development reduced.

Use of fluoride lozenges at 1.5 years of age was not associated with caries development during pre-school age in these children. One reason may be that the majority of children using fluoride lozenges at 1.5 years of age also brushed twice daily with fluoridated toothpaste (results not shown), indicating that parents having established one favorable behavior had established several favorable oral health behaviors [16].

One important implication of these results is that parents should receive information about introducing favorable oral health behavior in children during infancy. These results confirm the assumption that early establishment of favorable oral health behavior has long-term benefits. Parents who do not brush the child's teeth twice daily from eruption of the first tooth should receive information and guidance on how to establish tooth brushing as daily routines in the family [6]. Frequent sugar consumption in early childhood seems to be detrimental to future oral health in children, despite extensive use of fluoridated toothpaste in the population. Parents should, before eruption of the child's first tooth, receive information about the influence of consumption of sugary drinks on dental health in children. It is known that established health behavior is resistant to changes. Establishing favorable oral health behavior early in life has the potential to reduce resources required to restore carious teeth in the long run and prevent children from painful dental treatment. Collaboration between general health services and dental services regarding information to parents about establishing favorable oral health behavior in early childhood could benefit pre-school children's oral health.

In conclusion, tooth brushing frequency and consumption of sugary drinks in early childhood were related to caries development during pre-school age after controlling for family characteristics and oral health behavior at 5 years of age. Parents encountering difficulties in establishing favorable oral health behavior in children's first years of life should receive special attention from health personnel.

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