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Maternal health and lifestyle and caries experience in preschool children. A longitudinal study from pregnancy to age 5 yr

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Abstract

In this study, associations were explored between maternal health and lifestyle during pregnancy and in early childhood and preschool children's caries experience. The study is based on the Norwegian Mother and Child Cohort study conducted by the Norwegian Institute of Public Health and on data from the Public Dental Services. A total of 1348 children were followed from pregnancy to age 5 yr. A clinical dental examination was performed at age 5 yr. Questionnaires were completed by the mothers during pregnancy and the first 18 months of life, and as part of the dental examination. Results from the multivariable logistic regression analysis showed that having an obese mother (OR 2.3, 95% CI 1.3–4.1), with a diet containing more fat (OR 1.6, 95% CI 1.1 – 2.5) or sugar (OR 1.5, 95% CI 1.1–2.3) than recommended, with low education (OR 1.5, 95% CI 1.1–2.3) or having one or both parents of non-western origin (OR 5.4, 95% CI 2.8–10.6) were statistically significant risk indicators for caries experience at age 5 yr. In conclusion, maternal weight and intake of sugar and fat in pregnancy were associated with caries experience in preschool children. These characteristics may enable early referral to the dental services and preventive care to be delivered.

Keywords

caries risk indicators; dental caries; obesity; social determinants; sugar consumption

Identification of children at risk of developing caries in early childhood is of interest in populations with low prevalence of dental caries. Identification of children can be performed by primary health care personnel that have contact with the families during pregnancy and in early childhood. It is well accepted that the environment can affect the carious process and caries development in children (1, 2). In a conceptual model, several levels of the environment have been described: child-level; family-level and community-level, indicating direct and indirect influence from factors related to community, family and child on oral health conditions in children (3). At the family level, possible risk indicators are structural relationships in the family and maternal health and lifestyle.

Lifestyle is associated with oral health behaviours, and maternal health and lifestyle in pregnancy and a child's early life may influence the mother's ability to take appropriate care of the child's oral health. Maternal health and lifestyle habits such as diet, physical activity, weight and tobacco smoking influence the children and the establishment of children's oral health behaviours. Children's dietary intake has been shown to be strongly associated with their mothers' dietary intake (4), and the children's own dietary habits are developed early in

life (5, 6). Other parental factors that have been shown to be associated with caries experience or caries increment in their offspring include parental intake of sugar-containing beverages (7), maternal weight early in pregnancy (8) and parental tobacco smoking (9–11). Knowledge regarding associations between maternal health and lifestyle in pregnancy and early childhood, and caries development in preschool age is limited.

It is known that socio-demographic factors such as parental national background and education (7, 12–14), family status (15, 16), family income (14, 17), maternal age at child birth (14, 15, 18), child birth weight and premature birth (19–21) are associated with development of dental caries in young children. These characteristics should be considered background factors that may be associated with the lifestyle and should be controlled for when studying health and lifestyle.

In Norway, children are, by law, offered free dental care in the Public Dental Services. The first regular contact with the Public Dental Services is at age 3 yr. Before age 3 yr, preventive dental care is mainly given by primary care personnel, who give information about dental care for children to the parents as part of their general care promotion. The caries prevalence is low in preschool children and the distribution of the caries experience is skewed (22). Identification of characteristics associated with children's risk of developing caries should preferably be available before clinical caries is visible so that preventive strategies may be put in place and early contact to the dental services established. We have previously demonstrated associations between parents' oral health behaviours and parents' access to dental care, and caries experience in children in a cross-sectional study (7, 23), and associations between maternal education, parental national background and family status, and caries experience in preschool children in a longitudinal study (16).

In this study, we explore associations between maternal health and lifestyle during pregnancy and the child's early life, and the caries experience of the preschool child using longitudinal data. Based on previous research, it was hypothesized that maternal general health and lifestyle during pregnancy and the child's early life were associated with caries experience in early childhood.

Material and methods

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

The Mother and Child Cohort Study is a prospective cohort study including more than 100 000 pregnancies recruited from 1999 to 2009. Participants were recruited by postal invitation in connection with routine ultrasound examination offered to all pregnant women in Norway at 17–18 wk of gestation; 44% of all invited pregnant women agreed to participate. Data were collected by questionnaires completed by the mother in pregnancy, and when the child was 6, 18 and 36 months old. The current study was based on quality-assured data files (version 3) released for research in 2007, and is restricted to consider children born in 2002 in the county of Akershus. Altogether, 1607 mother and child dyads participated, representing 27% of the children born in Akershus in 2002 (26).

Clinical data from dental examination in the Public Dental Services was obtained for 1366 of the children (16). For 241 children clinical data from the dental examination could not be obtained. The reason is not known, but is most likely due to administrative or practical problems in the Public Dental Services. Eighteen children were excluded from the analyses because of incomplete data. The final study population consisted of 1348 children.

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

Caries experience was registered as the sum of teeth recorded as decayed, filled or missing due to caries. Five caries grades were initially recorded both in the clinical examination and in the radiographs (27), using the tooth surface as the unit of measurement. In this study, the term “caries” was used to denote carious lesions extending into dentine. In the analyses, children were categorized as having or not having teeth with caries experience.

Intra- and inter-examiner agreement in the dental study was tested using 20 bitewing radiographs of deciduous molars including eight approximal surfaces in each radiograph. The first author had previously been calibrated (7), and the registrations by the first author were used as the “gold standard” and compared with the dental hygienists’ registrations. Intra- and inter-examiner agreement was calculated using Cohen’s kappa. The mean inter-examiner Kappa-value was 0.86 (SD 0.10) and the mean intra-examiner Kappa-value was 0.85 (SD 0.12). Details of the intra- and inter-examiner agreement have been described earlier (7, 16). 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.

Exposure data was obtained from questionnaires answered during pregnancy and the first 18 months of life, and from a questionnaire completed by the accompanying parent at the dental examination. The questionnaires included information about maternal health and lifestyle habits; whether mother had had any long lasting diseases, her diet, weight and height, physical activity and smoking habits.

Maternal disease was reported if she had had any long-lasting chronic disease: asthma, allergy, diabetes, coronary disease, rheumatism, cancer, psychiatric disorders or other unspecified diseases. The diseases were categorized into allergy (including asthma), psychiatric disorders and somatic diseases. Maternal body mass index (BMI) was calculated as $\text{weight} \times \text{height}^{-2}$ ($\text{kg} \times \text{m}^{-2}$) on the basis of reported weight and height before pregnancy (28). BMI was categorized as normal (< 25), overweight (25–29) and obese (> 29).

Physical activity during work and leisure time was reported at four points in time: at the beginning of the pregnancy, during pregnancy and at child ages 6 months and 18 months. Physical activity (active at least once a week/active less than once a week) was reported at all four registrations. The recordings were combined to one variable, not physically active, partly physically active (physically active at one or several, but not all recordings) and physically active at all recordings.

Maternal smoking (yes/no) was reported at four points in time: at the beginning of the pregnancy; during pregnancy and at child ages 6 months and 18 months. The recordings were combined to one variable, not smoking, partly smoking (smoking at one or several, but not all recordings) and smoking at all recordings.

The mothers completed a food frequency questionnaire in pregnancy. The information recorded was used to calculate daily intake of nutrients (29, 30). In this study, intake of

sugar, intake of fat and total energy intake were used to calculate the proportion of total energy intake from sugar and fat. In Norway, the health authorities have made nutritional recommendations based on the Nordic Nutrition Recommendations (31). Intake of sugar should be less than 10% of total energy intake, and energy from dietary fat should be less than 35% of total energy intake (32). Both dietary sugar intake and the fat intake were therefore dichotomized accordingly into < 10% of total energy intake/ $\geq$ 10% of total energy intake, respectively < 35% of total energy intake/ $\geq$ 35% of total energy intake.

The child's birth weight was dichotomized as less than 2500 g or 2500 g or higher. Preterm birth was defined as being born before pregnancy week 35.

Maternal education was reported during pregnancy and included completed and ongoing education. High education was defined as > 12 yr at school and low education was defined as $\leq$ 12 yr of schooling. National background was recorded according to the mother's and father's country of birth. This information was combined to distinguish between both parents being of western origin and 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.

The statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, Chicago, IL, USA), version 16.0. Bivariate and multivariable logistic regression analyses were conducted with children's caries experience at age 5 yr as the dependent variable. Spearman's Rank correlation was used to explore associations between the independent variables before the multivariable analysis was conducted. Multivariable logistic regression using backward stepwise selection was performed. The p-value for removal was set at $p > 0.10$. In the model, the key exposure variables maternal disease, smoking, physical activity, diet, and the background variables maternal education, parental origin, birth weight, prematurity and the child's age at the dental examination were entered simultaneously. Results were reported using frequencies, odds ratios (OR) and 95% confidence intervals (CI).

Two of the independent variables (maternal smoking and physical activity) had at least 10% missing answers. Missing answers in these variables were replaced using multiple imputations to reduce the loss of data for the multivariable analysis. All independent variables included in the analyses were used as predictor variables during multiple imputations. A fully conditional specification method with five imputations was used. Multiple imputations did not change the statistical significance of the key exposure variables. The level of statistical significance was set at 5%.

Written, informed consent was obtained from all parents. The investigation was approved by the Regional Committee for Medical Research Ethics, The Norwegian Social Science Data Services and The Norwegian Data Inspectorate.

Results

The dentine caries experience in the 5-yr-old children was low, only 11% of the children had any dentine caries experience. Details of the caries experience have been presented earlier (16). The distributions of parents and children according to maternal health, maternal diet, maternal lifestyle and family characteristics are presented in Table 1 which also presents the results from the bivariate analyses. Statistically significant associations were found between children's caries experience and having one or both parents of non-western origin (OR 5.0), having a mother defined as obese (OR 2.4) or overweight (OR 1.5), with low education (OR 2.0), who reported smoking (OR 1.9), who consumed more sugar than recommended (OR 1.6) and having a mother without asthma or allergy (OR 1.4).

The results of the multivariable logistic regression analysis showed that maternal obesity and high sugar and fat intake were statistically significantly related to caries experience in the child at 5 yr of age, in addition to maternal low education and non-western parental origin. Children whose mothers was defined as obese had a 2.3 times higher odds of having caries experience at the age of 5 yr than children whose mothers was defined as being of normal weight. Children whose mothers consumed more sugar than recommended had 1.5 times higher odds of having caries experience at the age of 5 yr than children whose mothers had consumed less sugar. Children whose mothers consumed more fat than recommended had 1.6 times higher odds of having caries experience at the age of 5 yr than children whose mothers had consumed less fat. Children having one or both parents of non-western origin had a 5.4 times higher odds of having caries experience at the age of five than children both of whose parents were of western origin, and children with mothers with low education had 1.5 times higher odds of having caries at the age of five than children with mothers with high education (Table 2).

Discussion

The aim of this prospective study was to explore associations between dental caries in children at the age of 5 yr and maternal health and lifestyle during pregnancy and early childhood to identify characteristics associated with caries development in preschool children. Identification of such characteristics may enable early referral to the dental services and preventive care to be put in place before clinical caries is visible. The main results were that children with an obese mother or one whose diet was rich in sugar and fat early in pregnancy, had higher probability of having caries at age 5 yr than other children.

This study was based on data from the Norwegian Mother and Child Cohort Study. Relative to a more traditionally designed study, this cohort study design with data collection several times during pregnancy and early childhood has the advantages that it reduces the risk of bias resulting from parents' ability to recall events. The food frequency questionnaire used in this study produces reasonably valid intake estimates and is considered a valid tool for the ranking of the mothers according to low and high intakes of energy, nutrients and food (29). Likewise, significant positive association between the measures of self-reported exercise activities and objectively measured physical activity has been found (33). Non-participation among invited subjects and low participation in prospective studies may cause attrition bias and systematic errors in prevalence results (34). However, analyses have shown no statistically significant relative differences in association measures between participants in the Mother and Child Cohort Study and the total population regarding exposure-outcome associations (35).

Maternal weight before pregnancy was related to caries experience in children at 5 yr of age in this study. Maternal obesity has previously been associated with child obesity, and has also been linked to long-term detrimental consequences for child health, such as development of cardiac disease, obesity and diabetes later in life (36). One explanation for the link between maternal obesity and child obesity is the "developmental over-nutrition hypothesis". This states that maternal glucose, free fatty acids and amino acid concentrations result in permanent changes in appetite control, neuroendocrine function and energy metabolism in the developing fetus, leading to adiposity in later life (37). Lack of appetite control in children may influence dietary habits, leading to increased numbers of meals, which again is associated with development of dental caries.

In this study, maternal intake of sugar and fat during pregnancy was related to caries experience in children at age 5 yr. Mothers whose diet is rich in sugar are likely to introduce the same diet to the children, leading to high sugar consumption in children (4). It has been

shown that children whose diet is rich in sugar in early life may continue with a diet rich in sugar during childhood and adolescence (5, 6, 38). A study from Finland has shown that children introduced to a diet rich in sugar exceeded the recommended sugar intake already at the age 2 yr (38). An association between a diet rich in sugar in early childhood and caries experience at age 10 yr has been reported (39). The results of the present study indicate that information about maternal diet during pregnancy and early childhood, and efforts towards changing maternal unhealthy diet, should be considered when planning preventive dental care for preschool children.

Maternal smoking was not statistically significantly related to caries experience in children in the final multivariable analysis although a bivariate association was found. One explanation may be that in this child population with low occurrence of caries, high education level among the mothers' and few mothers reporting smoking, the study lacked the power to demonstrate association between maternal smoking and caries experience. Certainly, our finding is in contrast with the results of previous studies where an association between parental smoking and caries experience in preschool children has been shown (9–11). The explanation for the differences in findings could be differences in measurement of smoking, measurements at one or several occasions, including one or both parents and different variables controlled for in the analysis. Further studies are needed to explore association between parental smoking and dental caries in children.

Socioeconomic indicators such as education and national background are known risk indicators for caries development in preschool children (7, 12–14). Education and national background influences lifestyle and general health and were included in the multivariable analysis. These analyses confirmed that caries experience in preschool children was associated with maternal education and national background.

In conclusion, maternal lifestyle in pregnancy and the early childhood were associated with caries experience in children before age 5 yr. Obesity and a diet rich in sugar and fat in the mothers can be considered risk indicators for caries in preschool children. These characteristics could be used in adjunct to other factors to identify children at risk of developing caries early and used to target preventive dental care for children before clinical caries is visible.

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Table 1

Description of independent variables for all children and children with caries experience. Bivariate logistic regression analyses with caries experience in children as the dependent variable.

	All children (n = 1348)		Children with caries (n = 147)		Bivariate logistic regression	
	%	(n)	%	(n)	OR	95% CI
Maternal disease						
Allergy						
Yes	63	(846)	70	(103)		
No	37	(502)	30	(44)	1.4	1.0 – 2.1
Psychiatric disorders						
No	92	(1236)	93	(137)		
Yes	8	(112)	7	(10)	0.8	0.4 – 1.5
Somatic disease						
No	77	(1032)	75	(110)		
Yes	23	(316)	25	(37)	1.1	0.8 – 1.7
Maternal smoking						
Not smoking	69	(660)	67	(58)		
Partly smoking	23	(221)	19	(17)	0.9	0.5 – 1.5
Smoking	8	(79)	14	(12)	1.9	1.0 – 3.6
Maternal physical activity						
Not physically active	5	(30)	4	(2)		
Partly physically active	46	(248)	46	(22)	1.4	0.3 – 6.1
Physically active	49	(265)	50	(24)	1.4	0.3 – 6.2
Maternal diet during pregnancy						
Sugar (% of energy intake)						
< 10	62	(791)	53	(72)		
≥ 10	38	(484)	47	(65)	1.6	1.1 – 2.2
Fat (% of energy intake)						
< 35	78	(1000)	74	(102)		
≥ 35	22	(275)	26	(35)	1.3	0.9 – 1.9

	All children (n = 1348)		Children with caries (n = 147)		Bivariate logistic regression	
	%	(n)	%	(n)	OR	95% CI
Maternal BMI (pre-pregnancy)						
Normal	70	(867)	58	(73)		
Overweight	21	(261)	25	(32)	1.5	1.0 – 2.4
Obese	9	(116)	17	(21)	2.4	1.4 – 4.1
Child's birth weight (g)						
≥2500	96	(1292)	94	(138)		
<2500	4	(53)	6	(9)	1.7	0.8 – 3.6
Child born preterm						
No	98	(1287)	97	(141)		
Yes	2	(28)	3	(4)	1.4	0.5 – 4.0
Child's age at dental examination (months)						
48–59	31	(419)	35	(52)		
60–71	65	(881)	60	(88)	0.8	0.5 – 1.1
72–80	4	(48)	5	(7)	1.2	0.5 – 2.8
Maternal education						
High	65	(876)	50	(73)		
Low	35	(468)	50	(72)	2.0	1.4 – 2.8
Parental origin						
Both western	96	(1294)	87	(128)		
One or both non-western	4	(54)	13	(19)	5.0	2.8 – 8.9

Results significant at 5% level marked in bold

Table 2

Multivariable logistic regression analysis of associations between caries experience in children and maternal health, maternal diet, maternal BMI, maternal smoking, maternal physical activity, children's birth weight, children born preterm, maternal education, parental origin and children's age at dental examination (n = 1187).

	OR	95% CI
Maternal dietary sugar (% of energy intake)		
< 10 (ref)		
≥ 10	1.5	1.1 – 2.3
Maternal dietary fat (% of energy intake)		
< 35 (ref)		
≥ 35	1.6	1.1 – 2.5
Maternal BMI		
Normal (ref)		
Overweight	1.6	1.0 – 2.5
Obese	2.3	1.3 – 4.1
Maternal education		
High (ref)		
Low	1.5	1.1 – 2.3
Parental origin		
Both western (ref)		
One or both non-western	5.4	2.8 – 10.6

Results significant at 5% level marked in bold

ref = reference category