Breast-feeding and Other Mother-Child Factors Associated With Developmental Enamel Defects in the Primary Teeth of Brazilian Children

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ABSTRACT

Purpose: The purpose of this study was to examine the association between developmental defects in the enamel (DDE) of the primary teeth and low birth weight or prematurity.
Methods: A case-control study was carried out in Itajaí, Southern Brazil, involving 3- to 5-year-old children. The case group was composed of 102 children presenting at least 1 dental surface with DDE. The control group comprised 113 children without DDE matched by sex and age and enrolled in the same day care centers. All teeth were clinically examined using the Modified Index of Developmental Defects of Enamel. The outcome variable of the study was DDE in at least 1 dental surface, and the independent variables were: (1) birth weight; (2) gestational age; and (3) breast-feeding. Maternal schooling and health problems of the mother during pregnancy and of the child during the first year of life were collected as potential confounding factors. Simple and conditional multiple logistic regression analyses were performed, providing crude and adjusted odds ratio and 95% confidence intervals.
Results: Prematurity (OR=2.6; 95% CI=1.0-6.4) and children who did not breast-feed (OR=3.2; 95% CI=1.2-8.4) were associated with defects in tooth enamel after adjusting for possible confounding variables.
Conclusions: In this study, premature children and those who did not breast-feed could be considered at risk for developing defects in tooth enamel. (J Dent Child 2006;73:70-78)

KEYWORDS: ENAMEL DEFECTS, CASE CONTROL, PREMATURITY, PRIMARY DENTITION, BREAST-FEEDING

Tooth enamel is the only hard tissue in the body that is not remodeled. As a result, all changes in its structure resulting from insults during its development will be permanently registered.[1] Defects in the enamel's structure can develop in the pre-, neo-, and postnatal periods.[2] The extension of the enamel defect depends on the:

1. intensity of the etiological factor;
2. time over which it was present; and
3. period in which the factor was present during the formation of the crown.[3]

More than 90 different factors have been associated with developmental defects in the enamel of the primary and permanent dentition. These factors can be divided in 2 groups:

1. those that cause localized defects limited to 1 or only a few teeth, such as trauma, infections, ankylosis, and irradiation; and
2. those that cause generalized defects affecting the majority or all of the teeth.

These generalized defects can be caused by environmental factors or hereditary conditions. The principal environmental factors are: (1) infections; (2) neonatal, endocrine, and nutritional disturbances; (3) hemolytic disorders; (4) external intoxication; and (5) cardiac, renal, and gastrointestinal illnesses.[2]

Prematurity and low birth weight have been associated with defects in the enamel of primary and permanent teeth.

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An inverse relationship between birth weight and the prevalence of hypoplasia of the enamel was identified in a study by Seow et al,[4] while Aine et al[5] found that defects in the enamel were associated with prematurity.

Slayton et al[6] reported the prevalence of enamel hypoplasia and isolated enamel opacities in a cohort of healthy, well-nourished 4- to 5-year-old children. Six percent of the children examined had at least 1 tooth with enamel hypoplasia, and 27% had at least 1 tooth with isolated enamel opacities. Significantly more boys than girls had enamel opacities as a whole. The most affected teeth with enamel hypoplasia and with isolated opacities were mandibular second molars and maxillary second molars, respectively.

Children with very low birth weight and who were born prematurely had a higher prevalence of enamel defects in the permanent first molars and lateral incisors than in the normal birth weight children.[7]

Teeth with hypoplasia of the enamel are more susceptible to caries, since they present retentive areas that favor the accumulation of bacterial plaque. Hypocalcification or opacities, meanwhile, can lead to a more rapid progression of carious lesions.[8]

This study's aim was to examine the existence of an association between:

1. the occurrence of developmental defects in the enamel of primary teeth in 3- to 5-year-old children; and
2. mother-child conditions, in particular prematurity and low birth weight.

METHODS

This study was carried out in the municipality of Itajaí, a coastal city in the state of Santa Catarina in Southern Brazil. According to UNICEF data,[9] among the 5,488 municipalities in this country, Itajaí is ranked 428th on the basis of its child development index (CDI=0.651) and had, in the year 2002, an infant mortality rate of 14/1,000 live births.[10]

This study was carried out in 2 stages. The first, a study of the prevalence of defects in the enamel of primary teeth, was carried out with a sample of 431 children from 3 to 5 years of age matriculated in public day care centers. All teeth were examined by a single examiner, previously calibrated, and the enamel defects were assessed. The prevalence of DDE was 24% (95% CI=20.3-28.5). Diffuse opacities were the most common defects found (18%), followed by hypoplasia (11%) and demarcated opacities (6%). The teeth most affected were the second molars (44%), followed by the first molars (24%). Defects were observed more frequently in the upper arch (58%). Assessing the enamel hypoplasias separately, a prevalence of 15% (95% CI=11.7-18.5) was observed—with canines (34%) and second molars (34%) being the teeth most affected. Hypoplasias of the enamel also were more frequent in the upper arch (52%). One quarter of the preschool children presented with enamel defects, with diffuse opacities being the most prevalent.[11]

The study's second stage, the subject of this paper, was case controlled. The 3 types of enamel defects assessed were: (1) diffuse opacities; (2) hypoplasias of the enamel; and (3) demarcated opacities. They were diagnosed and classified according to the Modified Index of Development Defects of Enamel.[12]

A single examiner performed all examinations. The examiner was blinded for the children's exposure status. The buccal, lingual/palatal, and occlusal/incisal surfaces of all teeth were examined with flat clinical mirrors and periodontal probes. The clinical examinations were performed on the patio of the day care centers, under natural light without prophylaxis or prior to tooth-brushing. When necessary for improved visualization, however, the teeth were cleaned and dried using gauze. The results of the examinations were recorded by a dental nurse who had been previously trained.

Regarding the calibration process, initially a theoretical study of the diagnostic criteria in the index of developmental defects in the enamel was conducted with the aid of color photographs showing typical examples of hypoplasias and demarcated and diffuse opacities in permanent teeth.[13] In the second phase, 150 children from one kindergarten not selected for the study were examined. From these, 20 photographs of primary teeth with various types of enamel defects. These photographs were assessed independently by the researcher and by a standard examiner experienced in the use of the index in the permanent dentition. When the diagnoses differed, the photograph in question was re-examined and discussed by both and a single code was arrived at by consensus. On a third occasion, the children with enamel defects who had provided the photographs were examined once again by the researcher to confirm and finalize the diagnosis.

This case-control study included 215 children aged between 3 and 5 years old. The case group comprised 102 children who presented with enamel defects on at least 1 surface in the primary teeth in the prevalence study. The controls were 113 children who had not presented such defects. For each case, a control was selected of the same sex and age and who attended the same day care center. Eleven additional children were added to the control group to compensate for eventual dropout when the questionnaires were applied.

The outcome variable in this study was the occurrence of a developmental defect in the enamel that was transformed into a dichotic variable (without a developmental defect in the enamel and with a developmental defect in the enamel of at least 1 surface). The independent variables in the study were: (1) birth weight; (2) gestational age; and (3) breast-feeding. Low birth weight was considered to be below 2,500 g, and adequate birth weight indicated the child was equal to or greater than 2,500 g. The gestational age was classified as "born at term" (at 37 or more weeks of gestation) and "born premature" (with less than 37 weeks of pregnancy).

In addition, information was collected regarding:

1. maternal health problems during pregnancy (diabetes [yes or no]);

2. problems with blood pressure (yes or no);
3. heart problems (yes or no);
4. infections (yes or no);
5. use of drugs during pregnancy (yes or no);
6. smoking during pregnancy (yes or no);
7. mother's height and weight at the beginning of pregnancy, which enabled calculation of the body mass index (BMI; normal, high, or low);
8. pregnancy type (single or multiple);
9. delivery type (vaginal or caesarean);
10. mother's age at the child's birth (15-19 or 20-41 years);
11. maternal education at the child's birth (>8, 4-7, ≤3 years of study);
12. child's sex (male or female);
13. child's age (36-48 months, or 48-60 months, or 60-72 months);
14. breast-feeding (yes or no);
15. breast-feeding duration (≥6 months, ≤6 months, or did not breast-feed);
16. health problems in the child's first month of life (respiratory problems at birth [yes or no], jaundice after delivery [yes or no], infections [yes or no], complications during delivery [yes or no], requirement for admission after delivery [yes or no], and intubation postdelivery [yes or no]);
17. Apgar index at 5 minutes (>8 or ≤8);
18. health problems in the child's first year of life (infections [yes or no]);
19. chronic illness (yes or no);

Table 1. Association Between Maternal Variables and Occurrence of Developmental Defects in the Enamel (DDE) of the Primary Teeth of Preschool Children in Itajaí, Santa Catarina, Brazil, in 2003 (Chi-squared Test; No Matched Data)

	Cases (n=102)		Controls (n=113)		Chi-square	P
Variables/categories	**n**	**%**	**n**	**%**		
Illness in pregnancy					4.076	.043
No	71	44	61	56		
Yes	31	60	21	40		
Mother's BMI					3.642	.162
Normal	62	53	56	48		
High	20	44	25	56		
Low	18	37	31	63		
Hypertension in pregnancy					0.271	.602
No	90	48	97	52		
Yes	12	43	16	57		
Mother's age (ys)					0.124	.724
20-41	76	47	85	53		
15-19	19	44	24	56		
Use of drugs in pregnancy					0.102	.750
No	83	48	90	52		
Yes	19	45	23	55		
Infections in pregnancy					0.076	.783
No	88	48	96	52		
Yes	14	45	17	55		
Diabetes in pregnancy					0.005	.942
No	101	47	112	53		
Yes	01	50	01	50		
Maternal schooling (ys)					1.770	.413
≥8	21	53	19	48		
4-7	27	51	26	49		
≤3	47	42	64	58		
Pregnancy type					0.039	.843
Single	91	46	105	54		
≥2	04	50	04	50		
Delivery type					0.105	.746
Vaginal	75	47	84	53		
Caesarean	20	44	25	56		

20. prolonged use of medicines by the child for more than 30 days (yes or no); and
21. current nutritional diagnosis of the child (eutrophia or overweight or malnutrition).

These variables were regarded as controls, since they could have represented possible confounding factors between the outcome and the exposure under investigation.

QUESTIONNAIRE

Information relating to the mother and the child was obtained by means of a questionnaire, from data contained in the live birth declaration and by the nutritional assessment of the 215 children.

Structured questionnaires were given by the day care center coordinators after receiving orientation and training from the researcher, and these were completed by the children's mothers. The questionnaires contained information relating to:

1. the occurrence of health problems and/or maternal complications during gestation and at the point of delivery;
2. problems concerning the child during gestation, at delivery, and in the postdelivery period;
3. child health problems occurring in the first month and up to the first year of life; and
4. breast-feeding.

The pretest for the questionnaire was carried out by the researcher on 20 mothers of children from a public kindergarten not included in the study.

LIVE BIRTH DECLARATION (LBD)

In 1990, the Brazilian Health Ministry established the Live Births Information System (Sistema de Informação sobre Nascidos Vivos).[14] This system uses the LBD (Declaração de Nascido Vivo), which is standardized throughout the country, as the document entered on the system. The following information was obtained from the LBD and used in

Table 2. Association Between Child Postbirth Variables and Occurrence of Developmental Defects in the Enamel (DDE) of the Primary Teeth of Preschool Children in Itajaí, Santa Catarina, Brazil, in 2003 (Chi-squared Test; No Matched Data)

	Cases (n=102)		Controls (n=113)		Chi-square	P
Variables/categories	**n**	**%**	**n**	**%**		
Gestation duration					6.586	.010
Full-term	74	4e	99	57		
Premature	21	68	10	32		
Children's sex					1.028	.311
Male	48	44	61	56		
Female	54	51	52	49		
Apgar index					0.326	.568
>8	45	45	56	55		
≤8	50	49	53	52		
Birth weight					1.251	.263
≥2,500	87	46	104	55		
<2,500	08	62	05	39		
Delivery complications					0.256	.613
No	85	47	97	53		
Yes	16	52	15	48		
Hospitalization necessary					0.053	.818
No	93	48	102	52		
Yes	16	52	15	48		
Respiratory problems					1.155	.283
No	93	48	99	52		
Yes	08	36	14	64		
Intubation postdelivery					0.039	.843
No	95	47	106	53		
Yes	07	50	07	50		
Jaundice postdelivery					1.152	.562
No	79	49	83	51		
Yes	21	42	29	58		

this study: (1) mother's name; (2) child's date of birth; (3) duration of gestation; (4) pregnancy type; (5) delivery type; (6) child's Apgar index at the fifth minute; (7) child's birth weight; and (8) mother's age and schooling at the time of the child's birth. This LBD information is available in electronic data banks accessible for public consultation.

NUTRITIONAL ASSESSMENT

Data collection was carried out by nutrition students. The variables collected were weight and height, obtained in the following format:

1. Confirmation of weight (kg)**:** a digital balance (Kratos-Cas, with a limit of 150 kg and a precision of 0.05 kg) was used. The child was weighed, with light clothing and without shoes, in the orthostatic position on the center of the balance plate, with an attempt made to keep the subject still and upright.
2. Confirmation of height (cm): A digital equipment (Soehnle) was used. The children were measured in the orthostatic position, with the feet together, looking forwards, with the head and the top of the ear level, and with the external angle of the eye in a line parallel to the ceiling (Frankfort plane).

Along with data for weight, height, date of birth and sex, all the children were assessed and classified using Epi-Info software, version 2000 (Centers for Disease Control and Prevention, Atlanta, Ga), following cut-off points recommended by Frisancho[15]: (1) normal; (2) acute malnutrition; (3) chronic malnutrition; (4) previous malnutrition; (5) overweight; and (6) overweight with previous malnutrition.

The research project was submitted to and approved by the Committee for Ethical Research in Humans of the Universidade Federal de Santa Catarina (UFSC, Florianópolis, Santa Catarina, Brazil). The children's clinical examination and nutritional assessment were carried out after a consent form had been signed by the children's parent or guardian, at which time an explanation was given of the study's risks and benefits.

Table 3. Association Between Current Child Variables and Occurrence of Developmental Defects in the Enamel (DDE) of the Primary Teeth of Preschool Children in Itajaí, Santa Catarina, Brazil, in 2003 (Chi-squared Test; No Matched Data)

	Cases (n=102)		Controls (n=113)		Chi-square	P
Variables/categories	**n**	**%**	**n**	**%**		
Children's age (mos)					6.819	.033
36-48	35	59	24	41		
48-60	39	49	41	51		
60-72	28	37	48	63		
Breast-feeding					0.241	.624
Yes	88	47	100	53		
No	14	52	13	48		
Breast-feeding duration (mos)					6.802	.033
≥6	39	45	47	55		
<6	43	43	58	57		
Did not breast-feed	19	70	08	30		
Child illness in first month of life					0.025	.875
No	83	48	91	52		
Yes	19	46	22	54		
Child illness in first year of life					0.758	.384
No	55	45	67	55		
Yes	47	51	45	49		
Chronic illness child					0.376	.540
No	59	46	70	54		
Yes	43	50	43	50		
Medicine use for 30 days by child					0.490	.484
No	84	46	97	54		
Yes	18	53	16	47		
Child nutritional diagnosis					2.482	.289
Eutrophia	84	46	98	54		
Overweight	06	40	09	60		
Malnourished	11	65	06	35		

The same researcher who performed the examinations was responsible for data entry. Data processing, together with statistical analyses, was gathered using the program SPSS 10.0 for Windows (SPSS Inc., Chicago, Ill).[16]

To test the hypothesis of the existence of a relationship between exposure and outcome, that is, between low birth weight and prematurity and the presence of developmental defects in the enamel, the statistical analysis included a:

1. bivariate analysis between the outcome (presence of defects in the enamel) and the independent variables; and
2. conditional multiple logistic regression analysis designed to detect the factors associated after adjusted for confounding with the outcome (changes in the enamel).[17]

RESULTS

None of the mothers declined to participate in the study. There were 3 losses, however, that corresponded to adoptive mothers who were unable to respond to questions about their pregnancy, leaving the case group with 102 rather than 105 children. The prevalence of developmental defects in the enamel (DDE) was 24% (95% CI=20.3-28.5). The defects were more common in girls (51%) than in boys (44%), although this difference was not statistically significant. Among all the variables listed and analyzed in Tables 1, 2, and 3 relating to the maternal variables, child variables postbirth, and current child variables, only the following factors were found to be associated with the occurrence of enamel defects (P<.05): (1) occurrence of maternal illness during the pregnancy; (2) prematurity; (3) younger children; and (4) absence of breast-feeding.

The prevalence of DDE was higher in the group of children born with low weight (62%) than in children born with normal weight (46%). This difference, however, was not statistically significant. Regarding the nutritional assessment, of the 17 children who presented with malnutrition, 11 (65%) also presented with defects in the enamel while 6 (35%) did not. Once again, however, this difference was not statistically significant.

Both simple (Table 4) and multiple (Table 5) logistic regression analyses were performed. The variables with P<.20 in the simple regression analysis were inserted into the multiple analysis in descending order, according to their level of statistical significance.

In the bivariate analysis, the following were associated with the outcome:

1. the absence of breast-feeding (OR=2.9; 95% CI=1.1-7.2);
2. prematurity (OR=2.8; 95% CI=1.2-6.3); and
3. maternal illness during pregnancy (OR=1.9; 95% CI=1.0-3.6).

Prematurity of the child and the absence of breast-feeding were found to be associated with the outcome. Children born at less than 37 weeks of gestation were 2.6 (CI 95%=1.0-6.4) times more likely to be affected by some kind of developmental defect in the enamel, compared with children born at term. Meanwhile, children who were not breast fed were 3.2 (95% CI=1.2-8.4) times more likely to be affected by developmental defects in the enamel, compared with children that were breast fed (95% CI=1.2-8.4). Interactions between breast-feeding and prematurity and between prematurity and birth weight were tested, but were not detected (Table 5).

DISCUSSION

Among the numerous factors associated with developmental defects in the enamel of the primary teeth, the studies on prematurity and low birth weight have achieved particular prominence. In this study, DDE were found in 68% of the

Table 4. Association Between Mother–Child Variables and Developmental Defects in the Enamel (DDE) of the Primary Teeth of Preschool Children in Itajaí, Santa Catarina, Brazil, in 2003 (Simple Conditional Logistic Regression Analysis)

Variable	Crude OR (95% CI)*	P
Breast-feeding (mos)		.004
≥6	1.0	
<6	0.9 (0.5-1.6)	
Did not breast-feed	2.9 (1.1-7.2)	
Prematurity (wks)		.013
37-41	1.0	
<37	2.8 (1.2-6.3)	
Illness in pregnancy		.045
No	1.0	
Yes	1.9 (1.0-3.6)	
Children's age (mos)		.035
36-48	1.0	
48-60	0.7 (0.3-1.3)	
60-72	0.4 (0.2-0.8)	
Mother's BMI		.165
20-25	1.0	
>25	0.7 (0.4-1.4)	
<20	0.5 (0.3-1.0)	
Maternal schooling (ys)		.414
≥8	1.0	
4-7	0.9 (0.4-2.1)	
<4	0.7 (0.3-1.4)	

OR=odds ratio; CI=confidence interval

premature children and in 43% of those born at term, with this difference being statistically significant ($P<.01$). A similar prevalence in premature children was found in other studies.[4,5] Regarding the birth weight, the prevalence of DDE was greater in the low birth weight group than in children of normal weight. This difference, however, was not statistically significant, contrasting with some studies in which DDE were significantly more prevalent in low birth weight children than in children born with normal weight.[18,19] The apparent absence from this study of an association between DDE and low birth weight may be explained by the fact that the statistical analyses were carried out on low birth weight and DDE as a whole. It is possible that, by analyzing the low birth weight with hypoplasias individually, the authors would find an association, as was seen in another study.[18]

Table 5. Final Model of the Conditional Multiple Logistic Regression Analysis for Factors Associated With the Developmental Defects in the Enamel of the Primary Teeth in Preschool Children in Itajaí, Santa Catarina, Brazil, in 2003*

Variable	OR (95% CI)*	P
Prematurity		.043
No	1.0	
Yes	2.6 (1.0-6.4)	
Breast-feeding (mos)		.020
≥6	1.0	
<6	0.9 (0.5-1.8)	
Did not breast-feed	3.2 (1.2-8.4)	

***Model adjusted for child's birth weight, age, and sex and mother's schooling.
†OR=odds ratio; CI=confidence interval.**

In this investigation, the premature children were 2.6 times more likely to be affected by some type of developmental defect of the enamel than children born at term, after controlling for birth weight, child's sex, and maternal education. According to the literature, this result reinforces the already strong association between prematurity and defects of enamel in the primary teeth.[5,20,21]

While the association between prematurity and enamel defects in the primary teeth is well established, the exact mechanism by which the damage occurs at the tissue level remains unclear. Premature children can be affected by serious disturbances in calcium metabolism during the neonatal period, caused not only by prematurity, but also by the numerous complications present in these children.[8] A study by Seow et al[22] showed that, in one group of premature children affected by neonatal rickets, all children exhibited hypoplasias of the enamel. In children small for their gestational age (or of low weight), morbidity and mortality are more prevalent as a result of a series of perinatal complications such as asphyxia, meconium aspiration syndrome, hypothermia, polycythemia, and hypoglycemia, to all of which these children are more vulnerable.[23]

Very low-weight newborns (<1,500 g) normally present with a series of organic problems such as pulmonary, cardiovascular, gastrointestinal, hepatic, immunological, and renal immaturity as well as reduced metabolic reserves,[24] which can affect the development of the dental structures. The number of children in this category in the present study, however, was very small and did not permit the testing of this hypothesis.

The association between defects in the tooth enamel and a lack of breast-feeding was an unexpected finding. A vast amount of scientific evidence has supported the benefits of breast-feeding in terms of reduced infant morbidity and mortality.[25-28] In this study, children who were not breast fed presented with more developmental defects in the enamel than children who were, a finding that matches those of other studies.[29-31] Explanations for such a finding are centered initially on the composition of maternal milk, with its nutrients available in appropriate quantity and quality for the normal growth and development of the child, including in this case the formation of the dental organ. Another possible explanation is based on the immunological and anti-infectious properties of human milk in the reduction of illnesses, especially during the first year of the child's life—a period in which, according to Nóren et al,[32] the mineralization of the primary teeth is being completed.

Adverse conditions experienced in the child's first years are intimately related to health problems in the future. Therefore, the promotion of breast-feeding as well as the control of risk factors for premature and underweight newborns should be a multidisciplinary and objective public policy of all health professionals.

Recall and selection bias are common problems in case-control studies. Information given relating to the gestational period and the child's first year of life is subject to memory lapses in the mothers, especially mothers of older children. The data collected in the LBD are, however, generally reliable due to the quality and availability of information. A question of some importance that arose during this work relates to the diagnosis of the developmental defects in the enamel. Both the enamel hypoplasias and the demarcated opacities are easily detected by their characteristic clinical aspect.

This is a situation different from that of the diffuse opacities, which are less specific changes in which there is no clear border with the adjacent normal enamel, resulting in a lack of certainty at the point of diagnosis. This diagnostic difficulty is even greater in the primary teeth as a result of its color being whiter than that of the permanent teeth, in which the contrast between healthy enamel and the defect is much greater. Another important methodological aspect is related to the statistical analysis employed in this study. Studies on the present theme investigated and controlled for possible confounding variables are not common in the literature. In this study, numerous factors possibly associated with defects in the enamel were investigated, with

these being controlled during the statistical analysis through multiple logistic regression analysis.

Since population-based epidemiological studies concerning enamel defects in the primary teeth were not previously found in Brazil, further studies on the theme are strongly recommended. This is especially relevant in poorer regions, where the risk factors for this insult are expected to be more prevalent. Thus, it would be possible to obtain a panorama of prevalence and distribution of this insult across the child population and to establish collective measures for the prevention of caries and the early treatment of such defects.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. Premature birth was associated with developmental enamel defects of the primary dentition.
2. A lack of breast-feeding was also associated with developmental enamel defects of the primary dentition.
3. Both prematurity and lack of breast-feeding were associated with developmental enamel defects, regardless of other variables such as birth weight, age, child's sex, and mother's education.

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