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Prevalence of enamel defects related to pre-, peri- and postnatal factors in a Brazilian population.

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Objectives The aim of this paper is to evaluate the prevalence of enamel defects in infants from a socially and economically poor population and the possible association of these defects with disturbances occurring in the pre-, peri- and postnatal periods of human development. ***Participants*** 117 infants aged between 16 and 18 months old were included in four groups based on gestational age and whether part or full term pregnancy. ***Method*** The data were collected in two stages: hospital-based, where gestational and birth records were examined, and home-based, where dental examinations and nutrition were evaluated. The teeth were cleaned and dried with gauze and examined in the open air, avoding direct sunlight in the knee-to-knee position. The enamel defects were coded according to the modified Developmental Defects of Enamel Index. Besides this, body weight and height were considered as anthropometric measures for the evaluation of nutritional status by the National Center for Health Statistics standards. ***Main outcome measures*** The data were analyzed using the chi-square and Fisher Exact tests. Besides these tests, logistic regression models were used. ***Results*** The prevalence of enamel defects was 49.6%, higher in the group of male infants ($p<0.001$). The most frequent type of defect and the most affected surface were, respectively, diffuse opacity (9.5%) and the buccal surface (83.3%), located in the gingival half (6.7%). The logistic regression model showed that educational level, gestational age and intrauterine growth retardation (IUGR), besides a lack of breastfeeding, increased the probability of enamel defects up to level of 5%. ***Conclusions*** The association between enamel defects and the etiologic factors shown in this study suggest the existence of social influences regarding oral health and teeth development.

Key words: Enamel defects; etiology, primary, incisors

Introduction

The development of dental enamel in the primary incisors begins in the fourteenth week of intrauterine life, terminating in the third month of post-natal life. Without the capacity of remodeling, dental enamel is considered a stable structure and changes during matrix secretion or calcification periods may represent permanent injuries in the pre-, peri- and postnatal periods of human development. Pregnancy and delivery are critical periods, imposing a number of organic changes that modify fetus's ameloblastic function (Seow, 1997).

The increased risk of enamel defects as a result of problems during the mother's pregnancy has been assigned to intrauterine malnutrition, calcium and phosphate deficiency and lack of vitamins A, C and D (Drummond *et al*., 1992). Pregnancy disorders such as diabetes, hypertension and a shorter gestational period are also associated with changes in the enamel during a child's prenatal period (Needleman *et al*., 1992; Pimlott *et al*., 1985). Furthermore, in peri- and postnatal periods, prematurity (Pimlott *et al*., 1985), low birth weight, infant malnutrition (Chaves *et al*., 2007) and infections in infancy (Rugg-Gunn *et al*., 1998) are significantly related to enamel defects.

The prevalence of enamel defects in the primary dentition varies and is related to the social variables of the population studied (FDI, 1992) and other factors. In developing countries, social and biological risk factors, such as low-income, nutritional problems and high incidence of infections during infancy were associated with the development of enamel defects (Agarwal *et al*., 2003; Chaves *et al*., 2007; Rugg-Gunn *et al*., 1998). An increased prevalence was found in low-income populations, when compared to those with higher economic standards, including nutritional and social factors (Needleman *et al*., 1992).

This paper aims to evaluate the prevalence of enamel defects in primary incisors in children from a low social-economical level population and its possible association with disturbances occurring during the pre-, peri- and postnatal periods of human development.

Methods

This study evaluated infants born at a public maternity hospital in João Pessoa, capital city of Paraíba, one of the Northeastern states of Brazil. This health facility provides obstetrical and gynecological care to patients from a lower social class. João Pessoa has 597,934 inhabitants and 39% of the families live on half of the minimum national wage. The city presents one of the lowest average incomes in the country. Only 148,000 inhabitants have access to piped water. Fluoride con-

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centration in the public water supply is lower than 0.05 ppm (IBGE, 2000).

A random sample was selected. The sample size calculation was based on the number of premature and intrauterine malnourished newborn (etiologic factors of the enamel defects) residents in João Pessoa, born between July and December, 2003. A total of 3,664 newborns (1,904 girls and 1,760 boys) were registered at the maternity hospital during the given period. However, only 1,558 of these had mothers living in João Pessoa and its adjacent area. 42 of them were classified as "small for gestational age" and separated into two exposed groups: 19 small for gestational age and preterm newborns (SGA/PT), and 23 small for gestational age and full term (SGA/FT) newborns. Regarding two non-exposed groups – newborns appropriate for gestational age and preterm (AGA/PT) and appropriate for gestational age and full term (AGA/FT), a ratio of one exposed for two non-exposed was considered, sorted in a proportional and stratified sample, with a total of 126 newborns.

In order to define the social-economic level of the studied population, we considered the following variables: educational level of the mothers and *per capita* monthly family income. In addition, regarding family income, we considered the "Human Development Index" qualification, which, based on *per capita* income, ranks families below the poverty line (home income *per capita* lower than 25% of the minimum wage) or at the poverty line (home income *per capita* lower than 50% of the minimum wage).

The data were obtained at the hospital and at the mothers' home address. Information relevant to determine gestational risk and birth data were obtained from the birth certificate and hospital records of the mothers and infants. The collected information included the following: gestational age, birth weight, prematurity and index of intrauterine growth, as well as others events that occurred during delivery. Concerning the mothers, information was recorded, determining pregnancy risk, based on the Merck Manual of Medical Information, according to Beers, 2004.

Mothers were interviewed at home when the infants between 16 and 18 months of old were examined. The questionnaire was carried out in order to obtain information about their social-demographic characteristics (age and educational level and per capita monthly family income), the infant's medical history since birth and the nutritional habits (natural or artificial, and weaning age). In the meantime, the infant's primary incisors were examined and a nutritional evaluation was carried out.

The dental examination, including all the primary incisors, was performed in the knee-to-knee position, in open air, avoiding direct sunlight, by the visual method (Seow, 1997). The teeth were dried and cleaned with gauze, and a mirror and blunt probe were used (FDI, 1982; Seow 1997). The type of developmental defects was scored according to the Developmental Defects of Enamel Index (DDE) (FDI, 1992) and adapted from the study of Chaves *et al.* (2007). The buccal and lingual surfaces of each tooth were examined. The defect location was classified according to its position on the crown as gingival half or incisal half. The differential diagnosis for enamel opacities and white spot on the buccal surface of the tooth was made. (Seow, 1997).

The evaluation of the infant's nutritional status used anthropometric measures, such as weight and height. For evaluating weight, a pendulous scale of precision of 250 g was used. The infant was weighed, wearing a minimum of clothing and as motionless as possible at the centre of the scale. For height, an anthropometric ruler was used.

The infant's nutritional status was determined by comparing the measures with the reference standard of the National Center for Health Statistics, using the anthropometric indicators being "height-for-age" and "weight-for-height". Children were diagnosed as:

Eutrophic: children with normal height-for-age (>95% of standard) and normal weight-for-height (>95% of standard).

Wasted: children with normal height-for-age but low weight-for-height (<90% of standard), indicating current acute malnutrition.

Stunted: children with of normal weight-for-height and low height-for-age (<95% of standard), indicating past or chronic malnutrition.

A pilot study for enamel defects and white spots was conducted at Cândida Vargas Maternity Hospital for calibration and confirmation of the methodology. Calibration for scoring enamel defects was obtained, using photographs of the DDE Index (FDI, 1982). The photographs were checked twice on separate occasions, with a time interval of 24 hours.

Ten percent (n=12) of the examined children were randomly selected and re-examined on a separate occasion after 24-hours to determine intra-examiner agreement, without access to the previous records. Cohen's Kappa values for intra-examiner reliabilities for scoring enamel defects were 0.86, while the value for white spot was 0.78.

The data were analyzed using the SPSS 11.0 statistical software. Both descriptive and analytical techniques were used. The relationships between the dependent variable (enamel defects) and the independent variables (mother's education level, per capita income, mother's age, number of prenatal consultations, drug use, hypertension, gestational infections, delivery type, high-risk pregnancy, weight (delivery), prematurity, intrauterine growth retardation, APGAR, neonatal infections, postnatal infections (two to six months), breastfeeding, age of weaning, nutritional status on examination) (Tables 2 and 3) were evaluated using non-parametric tests (chi-square and Fischer's Exact). A probability value of $p < 0.05$ was considered statistically significant. A 95% percent confidence interval was used for the comparisons of different results within subgroups.

Logistic regression analyses were used to determine how each dichotomous variable (Table 4), individually analyzed, was related to the enamel defects. The models also considered some independent variables, having high priority or greater theoretical importance for the models that were moderately significant at the bivariate analysis ($p < 0.20$). Backward elimination was used to reduce the number of variables in the model. The final model included the variables that were significant at $p < 0.05$.

Table 1. Evaluation of the variables: types of enamel defects, surface and site, according to the examined teeth.

Variable	*n*	*%*
Type of enamel defects		
Absence	730	83.3
Demarcated opacity	24	2.7
Diffuse opacity	83	9.5
Hypoplasia (reduced thickness)	22	2.5
Hypoplasia (missing enamel)	7	0.8
Opacity + Hypoplasia	10	1.1
TOTAL	876	100.0
Surface affected for the enamel defect		
Absence	730	83.3
Buccal surface	140	16.0
Lingual surface	6	0.7
TOTAL	876	100.0
Site affected for the enamel defect		
Absence	730	83.3
Gingival half	46	5.2
Incisal half	59	6.7
Both half	41	4.7
TOTAL	876	100.0

Results

Characterization of subjects

A total of 117 infants were examined (84 from the non-exposed group and 33 from the exposed group). Of these infants, 55.6% were female, 41.0% were premature and 51.3% were born with low or very low weight although only 28.2% were considered small for gestational age. The mothers' average age was 24 years old. Most of the mothers had completed their basic education (65.0%) and only one had a college degree. Regarding income, 42.7% of the families were classified as being on the poverty line, followed by those below poverty line (35.9%), characterizing those families as very poor.

Of the 117 infants examined 58 (49.6%) had at least one incisor with an enamel defect. The prevalence was significantly higher among boys (69.2%) compared to girls (33.9%) ($p<0.0001$, OR 2.0-9.6).

The most prevalent types of enamel defects and the most affected surface and site are shown in Table 1. A total of 876 teeth in 117 children were examined for enamel defects. Of these teeth, 730 (83.3%) had no enamel defect. The most common enamel defects found were diffuse opacities (83 teeth, 9.5%). Furthermore, among the infants studied, the prevalence of white spot was 5.1%.

Regarding the sociodemographic variables (Table 2), a significant association between the mothers' educational level and enamel defects ($p = 0.0130$) was observed. The associations between *per capita* income and factors associated with complicated pregnancy (e.g. mother's age, number of prenatal consultations, use of drugs or medication, hypertension, gestational infections, type of delivery or high risk pregnancy) were not statistically significant ($p>0.05$).

The pre- and peri- natal variables that were significantly associated with the development of enamel defects were (Table 3): Weight at birth ($p < 0.0001$), prematurity ($p = 0.0020$), intrauterine growth rate ($p = 0.0004$) and the four experimental groups formed (SGA/PT, SGA/FT, AGA/PT, AGA/FT ($p < 0.0001$). The presented Apgar index did not show significant associations with the development of enamel defects ($p = 0.4539$). Among the considered postnatal variables, only natural breastfeeding ($p = 0.0367$) and nutritional status presented a significant association with enamel defects development ($p = 0.0006$).

A multivariate analysis using a logistic regression model included twelve variables ($p<0.20$) for testing the hypothesis that all of them were risk factors for the development of enamel defects in this population (Table 4). However, only seven were selected for clarifying the proportion of children with enamel defects: age (OR = 5.09, 95% CI = 1.50 – 17.29), mothers' educational level (OR = 5.16, 95% CI = 1.63 - 16.37), *per capita* income (OR = 3.46, 95% CI = 0.96 - 12.51), gender (OR = 4.94, 95% CI = 1.71 - 13.63), gestational age (OR = 7.23, 95% CI = 2.35 - 22.35), intrauterine growth index (OR = 6.59, 95% CI = 2.01 - 21.54) and breastfeeding (OR = 4.71, 95% CI = 1.04 - 21.39).

Discussion

In this study, the different types of enamel defects were recorded separately to determine the time, type and severity of the lesion. It was concluded that almost half of the population presented these alterations, confirming studies conducted in similar communities of low socio-economic status (Chaves *et al*., 2007; Oliveira *et al*., 2006; Rugg-Gunn *et al*., 1998; Seow, 1997). As in this study, Li *et al*. (1995) found a higher prevalence of enamel defects in males. In contrast, Chaves *et al*. (2007), Oliveira *et al*. (2006), did not link enamel defects to gender.

Diffuse opacities were the most frequent type of enamel defect found in this sample, as shown in previous studies (Chaves *et al*., 2007; Oliveira *et al*., 2006; Rugg-Gunn *et al*., 1998). It seems clear that a higher prevalence of opacity is associated with injuries during calcification and maturation stages, resulting in qualitative changes. The buccal surface was the most affected site, also reported by Chaves *et al*., 2007; Drummond *et al*., 1992; Li *et al*., 1995; Oliveira *et al*., 2006. Also shown in this study, is the position of the defect on the tooth crown, which could provide some answers about the time the aggression occurred (Needleman *et al*., 1992). The incisal half was the most frequent position of the defects, confirming previous findings (Drummond *et al*., 1992; Pimlott *et al*., 1985). This could be explained by the high percentage of premature children (41%), regarding the reduction of gestational weeks related to the neonatal line and its position on the incisal third of the tooth. (Ranggård *et al*., 1995). Furthermore, the

Table 2. Evaluation of enamel defect occurrence according to the mother's variables.

Variable	*Enamel Defects*							
	Presence		*Absence*		*TOTAL*		*P value*	*OR and CI 95.0%*
	n	*%*	*n*	*%*	*n*	*%*		
Mother's education level								
Elementary school	45	57.7	33	42.3	78	100.0	0.0130	2.72 (1.22 - 6.09)
High school/College	13	33.3	26	66.7	39	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Per capita income (Reals)								
Below poverty line /Poverty line	49	53.3	43	46.7	92	100.0	0.1259	2.02 (0.8 - 5.05)
Above poverty line	9	36.0	16	64.0	25	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Mother's age (years)								
< 20 or > 35	9	31.0	20	69.0	29	100.0	0.0213	1.00
20 - 34	49	55.7	39	44.3	88	100.0		2.79 (1.44 - 6.81)
TOTAL	58	49.6	59	50.4	117	100.0		
Number of prenatal consultations								
Up to 3	13	56.5	10	43.5	23	100.0	0.4571	1.41 (0.56 - 3.55)
4 or more	45	47.9	49	52.1	94	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Drug use								
Yes	10	52.6	9	47.4	19	100.0	0.7708	1.16 (0.43 - 3.09)
No	48	49.0	50	51.0	98	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Hypertension								
Yes	12	63.2	7	36.8	19	100.0	0.1956	1.94 (0.70 - 5.34)
No	46	46.9	52	53.1	98	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Gestational infections								
Yes	7	63.6	4	36.4	11	100.0	0.3270	1.89 (0.52 - 6.83)
No	51	48.1	55	51.9	106	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Delivery type								
Cesarean section	28	58.3	20	41.7	48	100.0	0.1139	1.82 (0.86 - 3.84)
Natural childbirth	30	43.5	39	56.5	69	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
High-risky pregnancy								
Yes	32	59.3	22	40.7	54	100.0	0.0524	2.07 (0.99 - 4..33)
No	26	41.3	37	58.7	63	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		

(*) - Significantly associated - $p < 0.05$

Table 3. Evaluation of enamel defect occurrence according to pre-, peri- and postnatal variables of newborns.

Variables	*Enamel defect*								
	Presence		*Absence*		*TOTAL*		*P value*	*OR and CI 95.0%*
	n	*%*	*n*	*%*	*n*	*%*		
Weight (delivery)								
Low birth weight/very low birth weight	40	66.7	20	33.3	60	100.0	< 0.0001* (2)	4.33 (1.99 - 9.40)
Appropriate birth weight	18	31.6	39	68.4	57	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Prematurity								
Preterm	32	66.7	16	33.3	48	100.0	0.0020* (2)	3.31 (1.53 - 7.16)
Full term	26	37.7	43	62.3	69	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Intrauterine growth retardation (IUGR)								
SGA	25	75.8	8	24.2	33	100.0	0.0004*	4,83 (1.95 - 11.98)
AGA	33	39.3	51	60.7	84	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Groups								
SGA /PT	10	100,0	-	-	10	100.0	< 0.0001*(2)	**
SGA /FT	15	65.2	8	34.8	23	100.0		**
AGA /PT	22	57.9	16	42.1	38	100.0		**
AGA /FT	11	23.9	35	76.1	46	100.0		**
TOTAL	58	49.6	59	50.4	117	100.0		
*APGAR****								
Normal	51	51.0	49	49.0	100	100.0	0.4539 (2)	1.47 (0.52 - 4.22)
Asphyxia Light/moderate/severe	7	41.2	10	58.8	17	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Neonatal infections								
Present	2	66.7	1	33.3	3	100.0	0.6185 (1)	**
Absent	56	49.1	58	50.9	114	100.0		
TOTAL	58	49.6	59	50.4	117	100.0		
Postnatal infections (2 - 6 months)								
Present	15	60.0	10	40.0	25	100.0	0.2396 (2)	1.71 (0.69 - 4.20)
Absent	43	46.7	49	53.3	92	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Breastfeeding								
Present	13	72.2	5	27.8	18	100.0	0.0367*(2)	3.12 (1.03 - 9.42)
Absent	45	45.5	54	54.5	99	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Age of weaning (month)								
Absent / Up to 2 months	23	57.5	17	42.5	40	100.0	0.2164 (2)	1.62 (0.35 - 3.51)
3 or more	35	45.4	42	44.6	77	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		
Nutritional status (on examination)								
Malnourished	37	66.1	19	33.9	56	100.0	0.0006*(2)	3.70 (1.73 - 7.97)
Eutrophic	21	34.4	40	65.6	61	100.0		1.00
TOTAL	58	49.6	59	50.4	117	100.0		

(*) Significantly associated - $p < 0.05$. (**) p value not determined – (null or very low frequencies).
(***) Health assessment of newborn
(1) p values obtained by Fisher's Exact test. (2) p values obtained by chi-square test

Table 4. Logistic regression results in relation to children with enamel defects.

Variables included in the model	*Variables selected by the model*	*OR and CI 95% value*	*P value*
Mother's age (years)	*Mother's age (years)*		
	< 20 or > 35	1.00	0.009*
	20 - 34	5.09 (1.50 - 17.29)	
Mother's educational level	*Mother's educational level*		
	Up to elementary school	5.16 (1.63 - 16.37)	0.005*
	High school /College	1.00	
per capta income (Reals)	*Per capta income (Reals)*		
	Below poverty line/poverty line	3.46 (0.96 - 12.51)	0.058
	Above poverty line	1.00	
Hypertension			
High-risky pregnancy			
Type of delivery			
Gender	*Gender*		
	Boy	4.94 (1.79 - 13.63)	0.002*
	Girl	1.00	
Weight at deliver			
Ggestational age	*Ggestational age*		
	Preterm	7.23 (2.35 - 22.35)	< 0.001*
	Full term	1.00	
Intrauterine growth retardation (IUGR)	*Intrauterine growth retardation (IUGR)*		
	SGA	6.59 (2.01 - 21.54)	0.002*
	AGA	1.00	
Breastfeeding	*Breast Feeding*		
	Absent	4.71 (1.04 - 21.39)	0.045*
	Present	1.00	
Nutritional status (on examination)			

(*) - Significantly associated - $p < 0.05$

primary incisors present a final maturation in the neonatal period. Disruptions occurring soon after birth could develop hypomaturation on the incisal edge of the tooth (Robinson *et al*., 1981).

In the present study it was also found that enamel alterations occurred mainly on the upper central incisors, which was confirmed by several studies (Rugg-Gunn *et al.*, 1998).

Needleman *et al*. (1992) showed that children of low-income families were likely to be at increased risk of developing enamel defects in the primary dentition. The population in this study was considered to have a low socio-economic status, as more than half of the population lived below the poverty line. This could also be confirmed by visiting their homes (overcrowding, no piped water and poor housing conditions). Only educational level presented a significant correlation with the alterations, since most defects were observed in children whose mothers had only a basic education. Data could suggest that social inequalities may have an important impact on the quality of life within this community. Education comes secondary, as the people want to improve their income, by working.

According to the bivariate analysis used in this study, the enamel defects of the primary incisors were significantly associated with premature children, low birth weight children, intrauterine growth retardation children, non-breastfed children and children presenting some nutritional dysfunction when they were very young. When the four sample groups were combined, an increased risk of developing defects was observed especially when combining risk factors – children small for their gestational age and premature children. No correlation was identified concerning pregnancy risk variables for mothers.

This strong association between enamel defects and the previous variables confirms the results of several other studies related to low birth weight, prematurity (Drummond *et al*., 1992; Needleman *et al*., 1992; Pimlott *et al*., 1985) and intrauterine malnutrition (Agarwal *et al*. 2003). When a combination of factors occurs, it may potentially increase development of the defects. All the teeth, from the children in SGA/PT group had enamel defects, as suggested in this study.

The variables selected for inclusion in the multivariate analysis were in accordance to Pimlott *et al.* (1985) who included, among other factors, birth weight and gestational age and its association with hypoplasia. Li *et al*., (1995) found a relationship between enamel defects and gender, low birth weight and prematurity.

The association between enamel defects and the etiologic factors shown in this study suggest the existence of social influences regarding oral health and teeth development.

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