Prevalence and Associated Factors to Developmental Defects of Enamel in Primary and Permanent Dentition

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Abstract

1.1 Background: The disturbances during enamel formation manifesting as Developmental Defects of Enamel (DDE) present important clinical significance since they are responsible for aesthetic problems, dental sensitivity and may act as predisposing factor for dental caries. The aim of the present study was to examine the prevalence of DDE and associated etiological factors.

1.2 Materials and Methods: A total of 1550 children was examined, using a mouth mirror and a CPI probe. Diagnosis of DDE was established according to the modified DDE index. Relationships between DDE and body mass index (BMI), socioeconomic status (SES), childhood illness and birth weight were assessed using the multivariable logistic regression. Difference in proportion was tested using Kruskal-Wallis H, followed by Mann-Whitney U test for inter group comparison, and Chi-Square tests.

1.3 Results: The prevalence of DDE was 42.19%. The logistic regression model showed that there was a significant association of DDE with age ($p<0.05$), gender ($p<0.05$), low SES ($p<0.05$) and obesity ($p<0.001$). Demarcated opacity was the most frequent type of DDE both in primary and permanent dentition. Prevalence was more frequent in permanent dentition compared to primary dentition, with the permanent maxillary central incisor and primary maxillary second molars being the teeth affected most commonly.

1.4 Conclusions: Prevalence of DDE was more in permanent teeth compared to primary teeth. A significant association of DDE with gender, low SES and BMI was demonstrated in the present study.

Key words: Body mass index, Dental enamel hypoplasia, Dentition, Permanent, Dentition, primary, Social class.

Introduction

Developmental enamel defects are disturbances during enamel formation and may be manifested as enamel hypoplasia or opacities. Opacity is a hypo-mineralization defect involving alteration in the translucency of enamel and these opacities are white, cream, yellow, or brown in color. Hypoplasia is a quantitative defect associated with a reduced or altered amount of enamel and appears as grooves and pits or else a partial or total lack of surface enamel [1-3]. Developmental Defects of Enamel (DDE) may result from systemic, genetic, or environmental factors such as birth prematurity, low birth weight, infections, malnutrition, or metabolic disorders–many of which have a higher incidence in low socioeconomic families [1-11]. Although the precise cause and effect mechanism has not been clearly elucidated, these defects present important clinical significance since they are responsible for aesthetic problems, dental sensitivity, dentofacial anomalies, as well as for a predisposition to dental caries [1,2].

Most epidemiological studies show that the frequency of appearance of these defects is on the rise in practically all populations, underlining their clinical significance and relevance for public health initiatives [2-5]. The prevalence rates of DDE in primary dentition range from 23% to 52% [2,5,7,9,10,12-17] depending on the population studied, teeth examined and diagnostic criteria used and the results of the few published studies have shown that the prevalence of enamel defects in permanent dentition varies from 20 to 77% [2,4,6,8,11,17-19]. Though there are numerous studies in the literature on DDE in children from developed countries [2-4,7,11,13,16,18,19], but little information is available about similar studies on children of developing countries, including India [20].

The purpose of the present study was to determine the prevalence and distribution of DDE in primary and permanent dentition of children aged 6- and 13- years old from Davangere city, India, and to explore the association of enamel defects with some possible etiologic factors.

Materials and Methods

Study population and sampling procedure

The sample of children included were drawn from school children aged 6 – and 13 –years, lifetime residents of the Davangere city (area of 68.63 km^2 and an approximate population of 3,64,523), Karnataka State (India). A pilot study was conducted before the main study to check the feasibility and validity of the study. By standardizing all the materials and methods, the study was conducted by considering a total of 50 children. Pilot study assessments were utilized for proper planning and execution of the main study. These 50 children who participated in the pilot study were not included in the main study. Based on previous study [20] and with the pilot study, at least 50 percent of the population was expected to have indicators of enamel defects. With this anticipated population proportion of 0.05 and a power of 80 percent, a sample of 1,550 children was needed to be recruited for this study from 61 public and 105 private schools in the area (2010-2011 data). Approximately 10% of schools (6 public and 10 private schools) were selected by lottery method to meet the sample size of 1,550. Two-stage random sampling method was followed by school as primary sampling unit

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and individual children as the unit of inquiry. Children were selected proportionate to the number of children in each school by systematic random sampling. All the participants were residents of communities with low natural fluoride content (<0.3 mg/l) in the drinking water. Children with some physical or mental handicap, a history of serious illness or a chronic medical condition such as cardiac disease, or who had lived in a fluoridated community in the past were excluded from the study. Furthermore, teeth with more than two-thirds of the surface restored (including stainless steel crowns), badly decayed or fractured, were excluded, as were teeth with braces. Ethical clearance was obtained from the institutional ethical committee before dental examination of participants and written informed consent was procured from parents of the study subjects.

Questionnaires

All children received a semi-structured questionnaire to be answered by their parents. Questionnaires were utilized to obtain demographic data, to collect information about maternal health during pregnancy, the child's overall pre-and postnatal health, birth weight and parental income. The reliability of the questionnaire was assessed by asking 20 parents to complete it through face to face interview. Cronbach alpha was used as a measure of reliability ($\alpha = 0.75$).

Socioeconomic Status (SES) was assessed according to Prasad classification [21] using per capita family income; children were classified into one of the three clusters: upper class, middle class and lower class.

Anthropometric Measurements

A Pre calibrated platform scale was employed to weigh the children. Weight was considered to the nearest 100 g. Height was measured via a stadiometer. Body mass index (BMI; weight/height in kg/m^2) was calculated. Children were classified into four categories using age- and gender-specific criteria recommended by the Indian Association of Pediatrics [22]: underweight – less than 5th percentile; normal weight – 5th percentile to less than 85th percentile; overweight – 85th to less than 95th percentile; and obese – equal to or greater than the 95th percentile.

Oral examination

Oral examination of school children was carried out visually by a single dentist under natural light using plane mouth mirrors and CPI probes. Diagnosis of DDE was established according to the modified DDE index as explained in Oral Health Survey Basic Methods manual of the WHO [23]. Visible surfaces of all primary and permanent teeth were assessed for the presence or absence of DDE. Color photographs showing typical examples of the different types of enamel defects are presented in the WHO manual [23]. These photographs were used as a guide in scoring the teeth for DDE. Each child was examined in a classroom. The child was seated on a classroom chair facing the examiner and a window to make the maximal use of natural light. All the surfaces were inspected visually for defects and, if there was any doubt, areas such as hypo plastic pits were checked with the periodontal probe to confirm the diagnosis. Any gross plaque or food deposits were removed and the teeth were examined in a wet condition. The child was recorded as DDE present if he/she had at least one tooth with any type of enamel defect.

Statistical analysis

Descriptive summary statistics were obtained for all demographic and outcome variables. Difference in proportion was tested using Kruskal-Wallis H, followed by Mann-Whitney U test for inter group comparison, and Chi-Square tests. Relationships between DDE and associated factors were assessed using multivariable logistic regression. Adjusted odds ratios (ORs) and their 95 percent Confidence Intervals (CI) were calculated. Multivariate regression included age, gender, use of fluoridated dentifrice, BMI, childhood illness, birth weight, and SES as predictors and DDE as an outcome. The prevalence of enamel defects was calculated with respect to the distribution of the defect by arch, teeth and type of defect. Analysis was performed using the Statistical Package for Social Science version 17 (SPSS INC Chicago link). All statistical tests were two-sided, and the significance level was set at $p<0.05$.

Results

Among a total of 1550 children examined, 765 belonged to 6-year-old and 785 to 13- years-old. The overall prevalence of DDE was 42.19%. Of the total sample, the mean BMI was 16.56± 2.80, with 18.1% of children overweight for their age and 7.5% of children falling under obese. The majority (52.65%) of the children belonged to lower SES. Six percent of children presented with childhood illness and 4.58% of children presented with low birth weight. The intra examiner calibration was performed with respect to the diagnostic criteria of DDE. There was a significant correlation with Kappa value of 0.83, $p<0.05$ for DDE.

A statistically significant difference was seen between DDE prevalence and age, gender, SES, and BMI ($p<0.05$) (*Table 1*).

Table 2 provides unadjusted and adjusted ORs of DDE and associated factors. Child's age (13-year-old: Adjusted OR 1.01; 95% CI = 0.33-3.26), gender (Boys: Adjusted OR 1.32; 95% CI = 0.97-3.11), SES (Low SES: Adjusted OR 1.33; 95% CI = 0.72-3.57), and BMI (Obesity: Adjusted OR 1.95; 95% CI = 0.82-4.53) were statistically significant factors for the occurrence of DDE.

Table 3 presents the mean number of teeth with DDE types in 6- and 13-year-old. Statistically significant difference was seen with demarcated opacity ($p = 0.02$).

Defects were most prevalent in: maxillary central incisors and maxillary second molars in primary dentition ($p<0.05$, chi-squared test) (*Table 4*); and maxillary central incisors and maxillary first molars in permanent dentition ($p<0.05$, chi-squared test) (*Table 5*).

Discussion

Numerous studies have been conducted and reported since last three decades in different populations regarding the developmental defects of dental enamel [2-20,24,25]. Several indices were used, either based on the presumed etiology or based solely on simple description of the clinical appearance of the lesion. Thus, direct comparisons of these results are difficult. In this study, the observer was trained using photographs, as other authors have described [2,3], because this is thought to enable defects within the dental structure to

Table 1. *DDE categories according to the characteristics of children aged 6- and 13 –years.*

Variable	DDE categories									p value
	Normal	Demarcated opacity	Diffuse opacity	Hypoplasia	Demarcated and diffuse opacity	Demarcated opacity and hypoplasia	Diffuse opacity and hypoplasia	All three conditions together	Other defects	
Age in years†										
6-years (n=765)	469 (61.31)	107 (13.99)	52 (6.8)	36 (4.71)	23 (3.01)	20 (2.61)	19 (2.48)	12 (1.57)	27 (3.53)	p = 0.04
13 -years (n=785)	427 (54.39)	129 (16.43)	61 (7.77)	43 (5.48)	28 (3.57)	25 (3.18)	23 (2.93)	17 (2.17)	32 (4.08)	
Gender †										
Boys (n=798)	400 (50.13)	142 (17.79)	74 (9.27)	39 (4.89)	36 (4.51)	17 (2.13)	28 (3.51)	21 (2.63)	41 (5.14)	p = 0.03
Girls (n=752)	496 (65.96)	94 (12.50)	39 (5.19)	40 (5.32)	15 (1.99)	28 (3.72)	14 (1.86)	8 (1.06)	18 (2.39)	
Fluoridated dentifrice†										
Yes (n=1009)	575 (56.99)	173 (17.15)	76 (7.53)	43 (4.26)	37 (3.67)	31 (3.07)	29 (2.87)	14 (1.39)	31 (3.07)	p = 0.06
No (n=541)	321 (59.33)	63 (11.65)	37 (6.84)	36 (6.65)	14 (2.59)	14 (2.59)	13 (2.40)	15 (2.77)	28 (5.18)	
SES*										
1. Upper class (n=226)	167 (73.89)	11 (4.87)	10 (4.42)	13 (5.75)	6 (2.65)	3 (1.33)	4 (1.77)	3 (1.33)	9 (3.98)	p = 0.04
2. Middle class (n=508)	315 (62.01)	61 (12.01)	38 (7.48)	24 (4.72)	10 (1.97)	15 (2.95)	15 (2.95)	6 (1.18)	24 (4.72)	
3. Lower class (n=816)	414 (50.74)	164 (20.10)	65 (7.97)	42 (5.15)	35 (4.29)	27 (3.31)	23 (2.82)	20 (2.45)	26 (3.19)	
Mann-Whitney U test	3>2, 1									
BMI*										
1.Underweight (n=172)	125 (72.67)	11 (6.40)	7 (4.07)	4 (2.33)	0	9 (5.23)	5 (2.91)	5 (2.91)	6 (3.49)	p = 0.03
2. Normal weight (n=982)	566 (57.64)	171 (17.41)	75 (7.64)	43 (4.38)	38 (3.87)	20 (2.04)	25 (2.55)	13 (1.32)	31 (3.16)	
3.Overweight (n=280)	161 (57.5)	31 (11.07)	18 (6.43)	25 (8.93)	10 (3.57)	7 (2.50)	7 (2.50)	6 (2.14)	15 (5.36)	
4. Obese (n=116)	44 (37.93)	23 (19.83)	13 (11.21)	7 (6.03)	3 (2.59)	9 (7.76)	5 (4.31)	5 (4.31)	7 (6.03)	
Mann-Whitney U test	4>3, 2, 1									
Childhood illness†										
Yes (n=93)	62 (66.67)	7 (7.53)	5 (5.38)	3 (3.23)	0	4 (4.30)	4 (4.30)	3 (3.23)	5 (5.38)	p = 0.06
No (n=1457)	834 (57.24)	229 (15.72)	108 (7.41)	76 (5.22)	51 (3.50)	41 (2.81)	38 (2.61)	26 (1.78)	54 (3.71)	
Birth weight*										
1. < 2.5 kg (n=71)	48 (67.61)	9 (12.68)	4 (5.63)	3 (4.22)	2 (2.82)	2 (2.82)	0	2 (2.82)	1 (1.41)	p = 0.31
2. ≥ 2.5kg (n=1397)	773 (55.33)	225 (16.11)	107 (7.66)	75 (5.37)	49 (3.51)	42 (3.01)	42 (3.01)	26 (1.86)	58 (4.15)	
3. Don't know (n=82)	75 (91.46)	2 (2.44)	2 (2.44)	1 (1.23)	0	1 (1.23)	0	1 (1.23)	0	

† = Chi-Square test

*=Kruskal-Wallis H test, values in parenthesis represents percent.

be recognized and differentiated. The results of the present study show that the prevalence of DDE in children from a non-fluoridated community in India fall within the range previously reported for children in other developing countries [12,24,25].

Prevalence of DDE was found to be more in boys than in girls in the present study. Similar results have been reported by Li et al. [12] in an Asian population and Farsi [15] in an Arab population. Definitive reason for this finding is not documented but suggested to be because of greater intra uterine nutritional demands in boys than in girls, since boys weigh more, have more muscle mass, and are developmentally

Table 2. *Results of the Association between Age, Gender, BMI, SES, use of fluoridated dentifrice, Childhood illness, birth weight, and the Dependent Variable DDE in 1550 children.*

Variable	DDE yes/no	% yes/no	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)[+]	p value
Age						
6-years ÷	296/469	38.69/61.31				
13-years	358/427	45.61/54.39	0.98 (0.21-1.78)	0.05	1.01 (0.33-3.26)	0.04
Gender				0.03		
Boys	398/400	49.87/50.13	1.07 (0.73-2.44)		1.32 (0.97-3.11)	0.04
Girls ÷	256/496	34.04/65.96				
BMI						
Under weight (yes)	47/125	27.33/72.67	0.82 (0.30-1.41)	0.27	0.87 (0.41-1.52)	0.32
Under weight (no)÷	607/771	44.05/55.95				
Normal weight (yes) ÷	416/566	42.36/57.64				
Normal weight (no)	238/330	41.90/58.10	0.92 (0.25-1.86)	0.21	0.94 (0.27-1.92)	0.23
Overweight (yes)	119/161	42.5/57.5	0.71 (0.10-1.23)	0.36	0.77 (0.12-1.25)	0.42
Overweight (no) ÷	535/735	42.13/57.87				
Obese (yes)	72/44	62.07/37.93	1.92 (0.81-2.55)	0.001	1.95 (0.82-4.53)	0.001
Obese (no) ÷	582/852	40.59/59.41				
SES						
Upper class yes	59/167	26.11/73.89	0.98 (0.24-1.37)	0.32	0.99 (0.27-1.43)	0.47
Upper class no÷	595/729	44.94/55.06				
Middle class yes	193/315	37.99/62.01	0.93 (0.21-1.27)	0.07	0.96 (0.35-1.36)	0.08
Middle class no÷	461/581	44.24/55.76				
Lower class yes	402/414	49.26/50.74	1.21 (0.68-1.93)	0.04	1.33 (0.72-3.57)	0.04
Lower class no ÷	252/482	34.33/65.67				
Fluoridated dentifrice						
Yes	434/575	43.01/56.99	0.83 (0.11-1.39)	0.27	0.87 (0.12-1.54)	0.22
No ÷	220/321	40.67/59.33				
Childhood illness						
Yes	31/62	33.33/66.67	0.65 (0.10-0.97)	0.42	0.71 (0.13-1.02)	0.46
No ÷	623/834	42.76/57.24				
Birth weight						
< 2.5 kg	23/48	32.39/67.61				
≥ 2.5kg ÷	624/773	44.67/55.33	0.84 (0.20-1.11)	0.08	0.87 (0.21-1.21)	0.08
Don't know	7/75	8.54/91.46				

[+] adjusted for Age, Gender, BMI, SES, use of fluoridated dentifrice, Childhood illness, Birth weight, ÷ ; Reference category.

Table 3. *DDE types in 6- and13-year-old. (Mean ± SD).*

DDE types	6-year-old (n = 765)	13-year-old (n= 785)	Total (n = 1550)	p value[≠]
Demarcated opacity	0.92 ± 1.79	1.01 ± 1.97	0.96 ± 1.88	0.02
Diffuse opacity	0.55± 1.08	0.66 ±1.29	0.61 ± 1.19	0.05
Hypoplasia	0.11 ± 0.22	0.17 ± 0.33	0.14 ± 0.28	0.06
Other defects	0.07 ± 0.13	0.08 ± 0.16	0.08 ± 0.16	0.16
Demarcated and diffuse opacities	0.08 ± 0.16	0.06 ± 0.11	0.07 ± 0.14	0.21
Demarcated opacity and Hypoplasia	0.08 ± 0.16	0.04 ± 0.08	0.06 ± 0.12	0.27
Diffuse opacity and Hypoplasia	0.07 ± 0.14	0.05 ± 0.11	0.06 ± 0.12	0.08
All three conditions.	0.04 ± 0.07	0.03 ± 0.06	0.03 ± 0.07	0.19

[≠] 6-year-old vs 13-year-old; t test

delayed both in the uterus and at birth [26]. Greater nutritional requirements of boys due to more rapid growth make them more susceptible than girls to the formation of enamel defects [12]. In contrast to this, the study conducted by Tapias-Ledesma et al. [8], showed nearly 3-fold increase in risk of girl child suffering DDE than boys. No radical explanation was given to this finding.

Developmental defects of enamel were strongly associated with low SES in the present study. Unequal distribution of children among different social strata in the present study may be a contributory factor for the high prevalence of DDE among children of low SES. This finding is supported by previous reports suggesting that in economically disadvantaged communities in developing countries and indigenous groups have high prevalence of DDE [4,6,12,27]. Underprivileged low socio economic child population may suffer from increase frequency of childhood illness and adverse health behaviors, which act as risk factors in the etiology of DDE [28,29]. However, the results of the present study cannot be compared with those of the above mentioned ones [4,6,12,27] as the method of evaluating SES used by those authors was different from the analysis carried out in the present study, which used

Table 4. *Prevalence of DDE by primary tooth type.*

Teeth affected FDI numbers	DDE types								
	Normal (n=12802)	Demarcated opacity (n= 668)	Diffuse opacity (n= 403)	Hypoplasia (n =69)	Other defects (n=56)	Demarcated and diffuse opacities (n=60)	Demarcated opacity and hypoplasia (n=58)	Diffuse opacity and hypoplasia (n=53)	All three condition (n=28)
51, 61	1276	83	69	14	7	10	6	12	5
52, 62	1385	47	28	9	11	6	5	4	3
53, 63	1422	22	17	2	2	6	8	9	2
54, 64	1118	94	58	6	8	9	6	5	4
55, 65	986	117	73	12	9	7	5	6	4
81, 71	1322		33	4	7	4	6	5	3
82, 72	1435	39	21	5	6	7	9	6	2
83, 73	1490	20	10	5	0	3	2	1	0
84, 74	1248	82	41	5	3	2	4	0	3
85, 75	1120	96	53	7	3	6	7	5	2

Table 5. *Prevalence of DDE by permanent tooth type.*

Teeth affected FDI numbers	DDE types								
	Normal (n=19630)	Demarcated opacity (n= 825)	Diffuse opacity (n= 538)	Hypoplasia (n =150)	Other defects n=70)	Demarcated and diffuse opacities (n=51)	Demarcated opacity and hypoplasia (n=33)	Diffuse opacity and hypoplasia (n=43)	All three condition (n=24)
11, 21	1375	112	73	10	3	4	2	2	2
12, 22	1422	63	22	11	7	0	0	4	1
13, 23	1479	31	17	4	0	0	0	2	0
14, 24	1462	33	52	16	6	3	3	1	2
15, 25	1508	42	39	13	11	6	2	0	1
16, 26	1233	123	66	20	9	11	4	3	2
17, 27	1311	62	49	11	12	5	2	7	3
41, 31	1417	59	41	6	2	2	1	5	0
42, 32	1429	36	33	9	0	1	5	3	2
43, 33	1458	20	19	0	0	0	0	0	0
44, 34	1389	51	30	7	5	5	2	2	3
45, 35	1411	63	41	11	3	9	7	7	5
46, 36	1326	81	39	19	9	3	3	3	2
47, 37	1410	49	17	13	3	2	2	4	1

the percapita family income criteria recommended by Prasad [21].

The association between nutritional status in various populations and prevalence of DDE has been extensively reported [9,12,30]. Many previous studies reported increased risk of linear hypoplasia in the primary dentition in malnourished children [9,12,30]. Surprisingly in the present study the children with obesity were 1.95 times more likely to have DDE than subjects without obesity. Further research is essential to substantiate this finding. It is definitely possible that an obese child may also suffer from deficiency of essential nutrient during critical phases of tooth development leading to development of DDE.

There is clear evidence to show that DDE in primary dentition is associated with low birth weight babies (< 2.5kg) [9,10,13,30,31] and childhood illness [2,35,7,9,12,16,30]. In contrast to this, the present study did not find any statistically significant association of DDE with either low birth weight nor childhood illness. This may be attributed to recall bias, as many parents were not able to recollect the birth weight of their babies. Moreover, in the present study, the information regarding the type of illness was not collected.

The prevalence of DDE was found to be more in permanent dentition compared to the primary dentition in the present study. Few past researchers have also reported lower prevalence of DDE in Primary teeth [2,5,7,12,13,15,19]. The period between births to 2 years of age is active phase of amelogenesis for permanent teeth so any common systemic conditions occurring during this critical period makes the teeth particularly vulnerable for formation of DDE [2]. Permanent maxillary first molars followed by maxillary central incisors were most affected teeth in present study as similar to recent reports [2,4,7]. Whereas for primary teeth the DDE involvement was most in maxillary second molars than followed by maxillary central incisors and mandibular second molars. Pervious researchers have reported primary maxillary second molars [2,5,14] and primary central incisors [12,13,15,16] to be most affected in their respective studies.

Most prevalent type of defect observed in both primary and permanent dentition was demarcated opacity followed by diffuse opacity and hypoplasia. Transient damage to ameloblasts during the maturation phase leads to formation of demarcated defects, but the cells are able to recover and resume their normal function [2,6,18]. Previous epidemiological investigations in primary and permanent dentition point to enamel hypoplasia as the least common DDE [2,4-19], as

does the present study. Although the association between fluoride and diffuse opacity has been demonstrated in a few studies within communities with fluoridated drinking water, [7,19,20] the subject involved in the present study had no natural or artificial fluoridation of drinking water.

As this study was cross-sectional in nature it was influenced by the problem of accurate recall of medical histories of individual children by respective parents. However, the study population was typical of many urban groups in developing countries; the results would definitely be applicable to the larger population.

To conclude,

1. Approximately 42% of the children studied presented with DDE.
2. Defects were more common among 13-years-old. There was statistically significant difference in prevalence with regard to sex, BMI, and SES.
3. Prevalence was more frequent in permanent dentition compared to primary dentition, with the permanent maxillary first molar, permanent maxillary central incisor and primary maxillary second molars being the tooth affected most commonly.
4. The present study results allow dentists/pediatric dentists to gain greater understanding of the prevalence and distribution of developmental defects of enamel with emphasis on associated factors which may influence the development of these defects.

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