CROSS-SECTIONAL STUDY

Demarcated Primary Second Molar Hypomineralization: Prevalence Data and Associated Sociodemographic Determinants from Indiana

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Abstract: ***Purpose:*** *Demarcated primary second molar hypomineralization (DMH-Es) is a common developmental defect of enamel, with prevalence estimates between five percent and 20 percent. From the Americas, studies exploring the problem of DMH-Es and explicitly using the European Academy of Pediatric Dentistry diagnostic criteria were limited to some South American countries, but no similar studies were available from any of the North American countries including the United States. The purpose of this study was to investigate the prevalence and sociodemographic determinants of DMH-Es among schoolchildren in Indiana, USA.* ***Methods:*** *Four hundred twenty-three schoolchildren (average age equals 7.6 [±2.2 standard deviation] years) were examined by a calibrated pediatric dentist. Sociodemographic data were collected from patients' questionnaires and electronic dental records.* ***Results:*** *DMH-Es had a prevalence estimate of six percent versus 40 percent overall of any enamel defect (AED) of the primary second molars (PSMs) and/or the permanent first molars (PFMs). Race/ethnicity was significantly associated with a higher overall prevalence of AED of PSMs but not with the prevalence estimate of DMH-Es. Older age group (10 years or older), living in central Indiana, and water fluoridation were significantly associated with a higher overall prevalence of AEDs (P<0.01) but not with the prevalence of DMH-Es. Caries experience was significantly higher in children with demarcated molar hypomineralization (DMH) of PFMs and/or PSMs than in the group without.* ***Conclusions:*** *DMH-Es prevalence estimate was similar to the global figures. Certain demographic characteristics were significantly associated with the overall prevalence of the enamel defects of the examined teeth.* *(Pediatr Dent 2021;43(6):443-50) Received December 4, 2020 I Last Revision July 21, 2021 I Accepted July 26, 2021*

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Demarcated molar hypomineralization (**DMH**) is a qualitative developmental enamel defect presenting as a continuum affecting molars of any type, commonly the permanent first molars (**PFMs**) and the primary second molars (**PSMs**). Demarcated molar hypomineralization of primary second molars (**DMH-Es**) has been presumably related to post-secretory disturbance of amelogenesis basically around the intrauterine period and up to 12 months postnatally.[1] Primary second molars commence enamel mineralization somewhat earlier than permanent first molars but generally at very analogous time frames.[2] The exact etiology of DMH-Es lacks supporting evidence,[3] but environmental insults rather than genetic influences have been strongly implicated in the etiology of DMH-Es.[4]

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DMH-Es and the DMH-6s share numerous connotations, as both defects share comparable variations in prevalence estimates from different parts of the world (DMH-Es equals five percent to 20 percent).[4-7] However, the burden of DMH-Es is less investigated and appears less conspicuous than that of DMH-6s.

In general, DMH is not a recent manifestation. In the early 2000s, the literature described demarcated opacities of molars and their concomitant clinical consequences as post-eruptive breakdown and atypical restorations utilizing the European Academy of Pediatric Dentistry (**EAPD**) diagnostic criteria.[8] The earliest studies exploring the prevalence of DMH-Es using these diagnostic criteria were from the Netherlands.[5,9] From the Americas, studies exploring the problem were limited to two South American countries: Brazil and Chile.[7,10]Although no similar epidemiological studies employ the EAPD diagnostic criteria from any of the North American countries, the early literature from the United States (**U.S.**) reported on demarcated opacities of primary teeth in Iowan[11] and Californian[12] children, mostly using the established modified developmental defect of enamel (**mDDE**) index.

Children with DMH-Es have extensive dental treatment needs posing substantial psychological burdens for this population and emphasizing the need for early recognition and intervention by pediatric dentists to prevent premature loss of these teeth. Together with the dearth of prevalence data of DMH-Es from the U.S., and the fact that the earlier reports from the U.S.[11,12] have used indices that disregarded progressive clinical manifestations of the defects, it is imperative to have epidemiological data elaborating on the substantial burden of the defect among U.S. children.

Therefore, the purpose of this report was to determine the prevalence of demarcated molar hypomineralization of the primary second molars and describe associated sociodemographic risk determinants in a group of U.S. school children and preschool children in the state of Indiana.

Methods

Ethical approval. The study received appropriate approval from the Institution Review Board (exempt 1907102161 and expedited 1703753377R001 approvals) of Indiana University, Indianapolis, Indiana, USA.

Subjects' recruitment. The study was conducted as part of a larger project examining molar hypomineralization in schoolchildren in Indiana. Study subjects were preschool children from Head Start programs and schoolchildren from selected public elementary schools seen as part of a school-based dental program within the state of Indiana. Head Start programs are U.S. federally funded preschool programs that incorporate children younger than five years mainly from low-income families. The recruitment methodology is explained in detail in another paper.[13] In brief, recruitment was either conducted as part of an outreach dental sealant program or independently. Eligibility for participation included the following: children three years and older, residents of the state of Indiana, had at least one PSM for evaluation, and had returned a signed informed consent.

Examiner calibration and diagnostic criteria. Details on the calibration and Kappa coefficients for the intraexaminer and interexaminer agreements are detailed elsewhere.[13] Demarcated opacities of molars were recorded when a white/creamy or yellow/brown change of enamel translucency was observed. Demarcated opacities with associated disintegration of enamel with demarcated irregular enamel borders were recorded as post-eruptive breakdown. Hypoplasia was differentiated by the presence of pits, grooves, or linear deficiency of enamel thickness, mostly with smooth borders of enamel.[14] Additionally, buccal/facial, lingual/palatal, and occlusal surfaces of all teeth present at the time of examination were evaluated for dental caries using the International Caries Detection and Assessment (**ICDAS**) criteria.

Examination procedures and data collection. All examinations were conducted during the regular school day within the school premises. Each child was seated on a portable dental chair for examination. Together with the classroom lighting, a portable head light (Zeon Endeavour portable LED headlight system, light intensity 34-68 lumens, Orascoptic, Wis., USA) was used. Examinations were carried out with a regular dental mirror and a blunt dental explorer on wet teeth surfaces. Before the dental exam, each subject was given a toothbrush and instructed to brush their teeth for at least one minute. Large debris that were still retained on the tooth surface were removed with a cotton roll or a gauze.

Sociodemographic data were collected from patients' questionnaire and electronic dental records. Residence and zip code information were allocated from informed consents. Water fluoridation data of each subject were extracted by exploiting the subject's zip code information matched to the data from the survey of public water supply service areas in Indiana (report available from the Indiana State Department of Health, 1981). Then, the fluoride level of the specific water supply system was consequently retrieved from the Centers for Disease Control and Prevention My Water's Fluoride database.[15] Subjects who had arrived within one year in the United States were excluded from the water fluoride analysis.

Statistical analysis. Data were analyzed using SAS 9.4 software (SAS Institute Inc., Cary, N.C., USA). Descriptive statistics and exact 95 percent confidence intervals (**95% CIs**) were alculated for the prevalence estimates of DMH-Es. Chi-square tests were used to evaluate associations of subject characteristics with the prevalence estimates of DMH-Es. Generalized linear mixed models for ordinal outcomes were used to evaluate the associations of age, number of affected surfaces, and the number of affected teeth with defect severity and extension; these analyses were limited to surfaces with the demarcated hypomineralization defects. Post-study power calculations, assuming a five percent significance level, showed that the study had 80 percent power to detect a 16 percent difference in DMH-Es between White and Black subjects and a 10 percent difference between White and Hispanic subjects.

Table 1. DESCRIPTIVE RESULTS OF THE STUDY POPULATION*

Variable	N (%)
Demographics	
Age (years)**	Mean±SD=7.6±2.2, range=3.0-12.7 3-5 years=104 (24.6); 6-9 years=254 (60.0); ≥10 years=63 (14.8)
Participants' gender	Female=208 (49.2); Male=215 (50.8)
Race/ethnicity	White=286 (67.6); Hispanic/Latino=84 (19.9); Black=28 (6.6); other (including multiracial)= 24 (5.7)
Insurance status	
Medicaid	257 (60.8)
No Medicaid	129 (30.5)
Private insurance	15 (3.5)
Insurance data not available	22 (5.2)
Geographical distribution	
Indiana county	Bartholomew=56 (13.2); Boone=42 (9.9); Brown=23 (5.4); Crawford=18 (4.3); De Kalb=16 (3.8); Greene=18 (4.3); Gibson=11 (2.6); Johnson=33 (7.8); Marion=23 (5.4); Marshall=73 (17.3); Monroe=21 (5.0); Montgomery=25 (5.9); Shelby=18 (4.3); Wayne=46 (10.9)
Urbanization	Rural mixed=294 (69.5); urban=77 (18.2); rural=52 (12.3)
Water fluoridation	
0.7 ppm	368 (86.9)
>0.7 ppm	24 (5.7)
<0.7 ppm	14 (3.3)
Caries status	
Any caries	338 (79.9)
Enamel caries (ICDAS II code 2-3)	266 (62.9)
Dentin caries (ICDAS II** code 4-6)	190 (44.9)
DMFS+dmfs ≥1	338 (79.9)

* Abbreviations used in this table: SD=standard deviation; ICDAS= International Caries Detection and Assessment; DMFS/dmfs=decayed, missing, and filled permanent surfaces/primary surfaces.

** Two subjects missing age.

Results

Response rate. Of the total 654 schoolers and preschoolers seen as part of the school-based dental program during the school year 2018 to 2019, 392 subjects (60 percent) met all inclusion criteria and agreed to be part of the study. For the independent school recruitment, 45 subjects (4.5 percent) of the 990 invited subjects completed the consenting process and 31 subjects (three percent) were available for the examination, making a total sample of 423 subjects.

Description of the sample. Four hundred and twenty-three subjects were included in the exams conducted between April 2018 and May 2019 across public elementary schools and preschools as part of an outreach dental school sealant program in the state of Indiana, USA. The mean age was 7.6 (±2.2 standard deviation) years, and more than half of the study subjects (N equals 254, 60.0 percent) were in the age group six to nine years old. The study had almost equal percentages of male and female participants (females N equals 208, 49.2 percent), and the majority self-identified as non-Hispanic Whites (N equals 286, 67.6 percent). All the schools involved in the study were identified as Title I schools, where there is a high concentration of low-income students. One-third of the sample (N equals 129, 30.5 percent) had no medical/dental coverage, and more than 60 percent of the total sample were covered by Medicaid (N equals 257, 60.8 percent).

The study population was recruited from equal numbers of counties in Central Indiana (six counties, N equals 187, 44.2 percent) and Southern Indiana (six counties, N equals 147, 34.7 percent) with a smaller portion from Northern Indiana (two counties, N equals 89, 21 percent). Most of the subjects lived in rural/mixed Indiana (N equals 235, 69.7 percent), had optimal water fluoridation (N equals 368, 86.9 percent), and had enamel or dentin caries (N equals 338, 80 percent). Table 1 illustrates the descriptive characteristics of the study population.

Table 2. PREVALENCE ESTIMATES OF DEMARCATED PRIMARY SECOND MOLAR HYPOMINERALIZATION (DMH-Es) AND OTHER ENAMEL DEFECTS (AEDs) OF PRIMARY SECOND MOLARS (PSMs) AS PERCENTAGE DISTRIBUTION*

		N (%, 95% confidence interval for %)			
		DMH-Es	*P*-value†	AEDs of PSMs**	*P*-value†
Overall		25 (6%, 4%-9%)		32 (8%, 5%-11%)	
Demographics					
Age group	3-5	9 (9%, 4%-16%)	0.45	11 (11%, 5%-18%)	0.42
	6-9	13 (5%, 3%-9%)		17 (7%, 4%-10%)	
	≥10	3 (5%, 1%-13%)		4 (6%, 2%-15%)	
Gender	F	15 (7%, 4%-12%)	0.31	17 (8%, 5%-13%)	0.71
	M	10 (5%, 2%-8%)		15 (7%, 4%-11%)	
Race/ethnicity	White	15 (5%, 3%-9%)	0.11	18 (6%, 4%-10%)	**0.01**
	Hispanic/Latino	3 (4%, 1%-10%)		4 (5%, 1%-12%)	
	Black	3 (11%, 2%-28%)		4 (14%, 4%-33%)	
	Other (including multiracial)	4 (17%, 5%-37%)		6 (25%, 10%-47%)	
Insurance status					
	Medicaid	15 (6%, 3%-9%)	0.14	19 (7%, 5%-11%)	0.22
	No Medicaid	7 (5%, 2%-11%)		10 (8%, 4%-14%)	
	Private	1 (7%, 0%-32%)		1 (7%, 0%-32%)	
Geographical distribution					
Urbanization	Rural mixed	17 (6%, 3%-9%)	0.81	22 (7%, 5%-11%)	1.00
	Urban	4 (5%, 1%-13%)		6 (8%, 3%-16%)	
	Rural	4 (8%, 2%-19%)		4 (8%, 2%-19%)	
Region	North	6 (7%, 3%-14%)	0.60	7 (8%, 3%-16%)	0.27
	Central	9 (6%, 3%-12%)		14 (10%, 6%-16%)	
	South	5 (4%, 1%-9%)		6 (5%, 2%-10%)	
Water fluoridation					
	0.7 ppm	23 (6%, 4%-9%)	1.00	28 (8%, 5%-11%)	0.40
	>0.7 ppm	1 (4%, 0%-21%)		3 (13%, 3%-32%)	
	<0.7 ppm	0 (0%, 0%-23%)		0 (0%, 0%-23%)	
Caries status					
	Any caries	22 (7%, 4%-10%)	0.44	27 (8%, 5%-11%)	0.65
	Enamel caries (ICDAS II code 2-3)	17 (6%, 4%-10%)	0.67	21 (8%, 5%-12%)	0.85
	Dentine caries (ICDAS II code 4-6)	16 (8%, 5%-13%)	0.06	18 (9%, 6%-15%)	0.20
	DMFS+dmfs ≥1	22 (7%, 4%-10%)	0.44	27 (8%, 5%-11%)	0.65

* Abbreviations used in this table: ICDAS=International Caries Detection and Assessment; DMFS/dmfs= decayed, missing, and filled permanent surfaces/primary surfaces.

** Any enamel defect of primary second molars includes demarcated opacities of the PSMs and/or any other enamel defects (diffuse opacities and hypoplasia) of the PSMs.

† Level of significance for *P*-value is considered statistically significant when $P<0.05$ (**bold values**) using chi-square test.

Prevalence of DMH-Es and other enamel defects of the PSMs: overall and per demographics, geographic location, water fluoridation, and caries status. The DMH-Es group included any subject with at least one PSM with demarcated opacity or its clinical consequences (clinical status criteria score equals two to six). Of the whole study population, 25 subjects had at least one PSM affected (DMH-Es equals six percent, 95% CI equals four percent to nine percent). Any enamel defect of the primary second molar (**AED** of the PSM) group combines subjects with demarcated opacities and/or any other enamel defects (diffuse opacities and hypoplasia) of at least one PSM (clinical status criteria score equals one to six). Additionally, seven subjects had other enamel defects of at least one PSM with an overall prevalence of eight percent (95% CI equals five percent to 11 percent) of the PSMs. Of all the sociodemographic determinants tested, chi-square analyses revealed that race/ethnicity (being other than White, Black, or Hispanic/Latino) was significantly associated with higher prevalence estimates of AED of PSMs but not with the prevalence estimates of DMH-Es ($P<0.05$; odds ratios [**OR**] equal 2.0 [0.5 to 8.2] for others versus Black, 6.7 [1.7 to 26.1] for others versus Hispanic, 5.0 [1.8 to 14.0] for others versus White, 3.3 [0.8 to 14.3] for Black versus Hispanic, 2.5 [0.8 to 7.9] for Black versus White, and 1.3 [0.4 to 4.2] White versus Hispanic). Table 2 illustrates the prevalence of DMH-Es and the overall prevalence of enamel defects of the PSMs and their associated sociodemographic determinants.

Prevalence of enamel defects of the index teeth (PSM and PFM): overall and per demographics, geographic location, water fluoridation, and caries status. When examining the combination of demarcated opacity or its clinical consequences of the PSMs and/or the PFMs/PIs (DMH-Es±DMH-6s group) in this study population, 63 subjects (15 percent, 95% CI equals 12 percent to 19 percent) had at least one PSM and/or one PFM with a score of two to six on the mDDE-EAPD diagnostic index. The AED group includes any subject with DMH-Es, DMH-6s, diffuse opacities of PSM, PFM/PI, and/or other enamel defect of the index teeth (PSM, PFM/PI). A total of 169 among the study population (40 percent, 95% CI equals 35 percent to 45 percent) belonged to the AED group. Neither age group, gender, nor race/ethnicity or any geographical or water fluoridation confounders were significantly related to the prevalence estimates of DMH-Es±DMH-6s. However, dentin caries experience (ICDAS score equals four to six) was significantly higher in the DMH-Es±DMH-6s group than in the group without DMH-Es±DMH-6s ($P=0.02$, OR equals 1.9 [95% CI equals 1.2 to 3.3]). Children in the oldest age group (at least 10 years old) were more likely to have higher prevalence estimates of AED of the PFM/PI and PSM than children in the younger age groups ($P<0.01$; OR equals 6.6 [95% CI equals 3.1 to 14.0] equal to or greater than 10 years versus three to five years, 1.1 [95% CI equals 0.6 to 1.9] equal to or greater than 10 years versus six to nine years, and 5.9 [95% CI equals 3.2 to 11.0] sixto nine years versus three to five years).

Table 3. PREVALENCE ESTIMATES OF DMH-6S±DMH-ES AND OTHER ENAMEL DEFECTS OF THE INDEX TEETH (PSMs AND PFMs/PIs) AS PERCENTAGE DISTRIBUTION AND 95% CONFIDENCE INTERVAL (CI)*

		N (%, 95% CI for %)			
		DMH-6s±DMH-Es	*P*-value†	AED	*P*-value†
Overall		63 (15%, 12%-19%)	–	169 (40%, 35%-45%)	–
Demographics					
Age group	3-5	12 (12%, 6%-19%)	0.15	14 (13%, 8%-22%)	**<0.01**
	6-9	45 (18%, 13%-23%)		122 (48%, 42%-54%)	
	≥10	6 (10%, 4%-20%)		32 (51%, 38%-64%)	
Gender	F	38 (18%, 13%-24%)	0.06	91 (44%, 37%-51%)	0.14
	M	25 (12%, 8%-17%)		78 (3 6%, 30%-43%)	
Race/ethnicity	White	47 (16%, 12%-21%)	0.64	106 (37%, 31%-43%)	0.08
	Hispanic/Latino	9 (11%, 5%-19%)		34 (40%, 30%-52%)	
	Black	3 (11%, 2%-28%)		17 (61%, 41%-78%)	
	Other (including multiracial)	4 (17%, 5%-37%)		12 (50%, 29%-71%)	
Insurance status					
	Medicaid	33 (13%, 9%-18%)	0.27	93 (36%, 30%-42%)	0.38
	No Medicaid	24 (19%, 12%-26%)		57 (44%, 35%-53%)	
	Private	3 (20%, 4%-48%)		7 (47%, 21%-73%)	
Geographical distribution					
Urbanization	Rural mixed	44 (15%, 11%-20%)	0.76	115 (39%, 34%-45%)	0.52
	Urban	10 (13%, 6%-23%)		35 (45%, 34%-57%)	
	Rural	9 (17%, 8%-30%)		19 (37%, 24%-51%)	
Region	North	15 (17%, 10%-26%)	0.80	31 (35%, 25%-46%)	**0.03**
	Central	24 (17%, 11%-24%)		74 (52%, 44%-61%)	
	South	18 (14%, 9%-22%)		57 (45%, 36%-54%)	
Water fluoridation					
	0.7 ppm	53 (14%, 11%-18%)	0.29	144 (39%, 34%-44%)	**<0.01**
	>0.7 ppm	6 (25%, 10%-47%)		17 (71%, 49%-87%)	
	<0.7 ppm	1 (7%, 0%-34%)		3 (21%, 5%-51%)	
Caries status					
	Any caries	55 (16%, 12%-21%)	0.13	142 (42%, 37%-47%)	0.11
	Enamel caries (ICDAS II code 2-3)	40 (15%, 11%-20%)	1.00	109 (41%, 35%-47%)	0.61
	Dentin caries (ICDAS II code 4-6)	37 (19%, 14%-26%)	**0.02**	80 (42%, 35%-49%)	0.43
	DMFS+dmfs equal or > than 1	55 (16%, 12%-21%)	0.13	142 (42%, 37%-47%)	0.11

* Abbreviations used in this table: DMH-6s=demarcated molar hypomineralization of permanent first molars; DMH-Es=demarcated molar hypomineralization of primary second molars; PSMs=primary second molars; PFMs=permanent first molars; PI=permanent incisor; any enamel defect (AED) includes any subject with DMH-Es, DMH-6s, diffuse opacities (DO), or other enamel defect of the index teeth (PSMs and PFMs/PIs).

† Level of significance for *P*-value is considered statistically significant when $P<0.05$ (**bold values**) using chi-square test.

Subjects who were residents of the central Indiana region had significantly higher prevalence of AED of PFMs and PSMs than subjects living in other regions of Indiana (*P*=0.03; OR equals 2.1 [95% CI equals 1.2 to 3.6] Central versus South, 1.3 [95% CI equals 0.8 to 2.2] Central versus North, and 1.5 [95% CI equals 0.9 to 2.7] South versus North). Living in areas with water fluoridation more than 0.7 ppm was significantly associated with higher prevalence estimates of AED of index teeth than children living in areas with optimal or suboptimal water fluoridation (*P*<0.01; OR equals 3.8 [95% CI equals 1.5 to 9.3] greater than 0.7 versus 0.7 ppm, 8.9 [95% CI equals 1.9 to 42.0] greater than 0.7 ppm versus less than 0.7, 2.4 [95% CI equals 0.6 to 8.6] 0.7 ppm versus less than 0.7 ppm). The mean decayed, missing, and filled permanent surfaces/primary surfaces (DMFS/dmfs) were not different for subjects with DMH-Es and those without DMH-Es (6.76±6.04 and 5.99±6.33, respectively). Table 3 shows the prevalence estimate of demarcated opacities of the PSMs and/or PFMs (DMH-Es ±DMH-6s) and the overall enamel defect prevalence of index teeth and their associated demographics.

DMH-Es: defect severity, distribution, and extension. Overall, 106 PSMs were identified as DMH-Es. Maxillary molars (N equals 55 out of 106, 51.9 percent) were more affected than mandibular molars (51 out of 106, 48.1 percent). All in all, demarcated opacities (score two) were the most prevalent defect severity of the affected PSMs (36 out of 106, 34 percent), followed by atypical caries (score five) as the second most common defect severity (N equals 27 out of 106, 25 percent). Twenty (19 percent) and 17 (16 percent) PSMs had posteruptive enamel breakdown and atypical restorations, respectively. Six mandibular PSMs (six percent) were extracted due to the defect. Occlusal surfaces of the PSMs were the most affected surfaces (N equals 42 out of 106, 37 percent), followed by the palatal surfaces (33 out of 106, 31 percent). However, no significant differences were found between defect severity of affected surfaces (*P*=0.15 occlusal versus buccal; *P*=0.92 occlusal versus palatal; *P*=0.29 buccal versus palatal) or maxillary and mandibular PSMs (*P*=0.91). Figures 1 and 2 show the distribution of PSM defect severity per tooth type (maxillary or mandibular PSM) and tooth surface (occlusal, buccal, or lingual). Figure 3 demonstrates the extension of the PSM defect per each category of defect severity (demarcated opacity, enamel breakdown, atypical restoration, and missing due to DMH-Es).

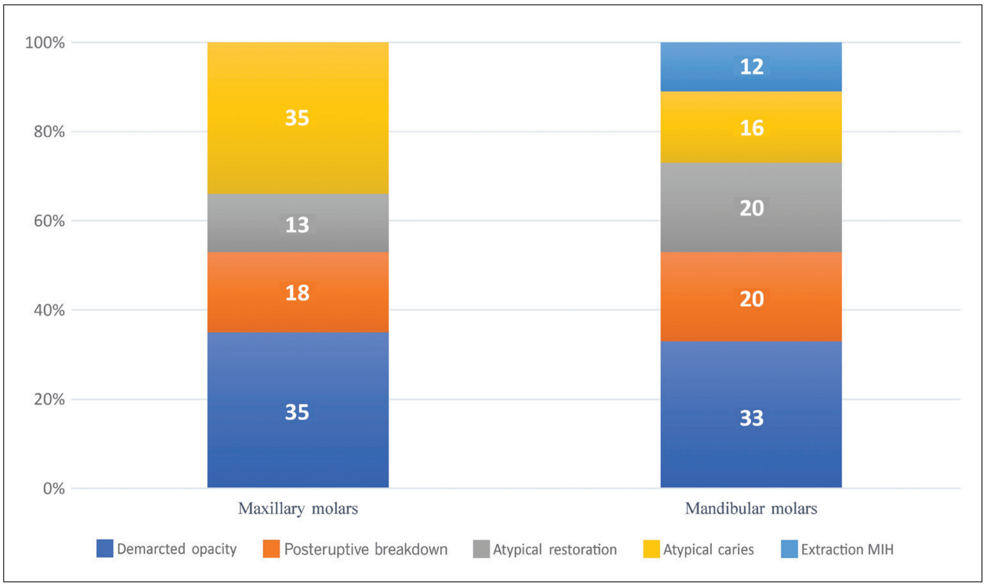

Figure 1. Defect severity percentage distribution of maxillary and mandibular primary second molars (PSMs). There is no difference in defect severity distribution between maxillary and mandibular PSMs (Wilcoxon rank-sum tests, *P*>0.05). Abbreviation in this figure: MIH=molar incisor hypomineralisation.

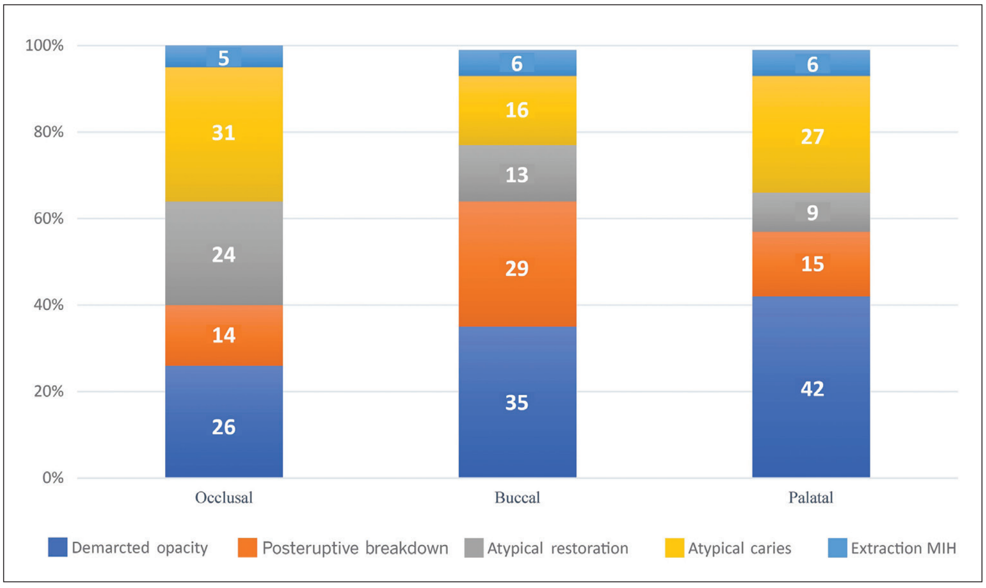

Figure 2. Defect severity percentage distribution per primary second molar (PSM) surfaces. There is no difference in defect severity distribution between the different PSM surfaces (Wilcoxon rank-sum tests, *P*>0.05).

Association of PSM defect severity and extension with age/age group, number of affected PSM surfaces, and number of affected teeth. Age was not associated with defect severity nor with the defect extension (*P*>0.05). A higher number of affected surfaces or teeth was associated with having severity scores above score two–demarcated opacity (*P*<0.05). A higher number of affected surfaces or teeth was associated with having at least one-third of the surface affected or missing due to defect (*P*<0.05; Table 4).

Discussion

This study is important to pediatric dentists because it recognizes and draws attention to a significant dental problem affecting the most enduring and perhaps important teeth of the primary dentition (PSMs) in terms of mastication and space maintenance.

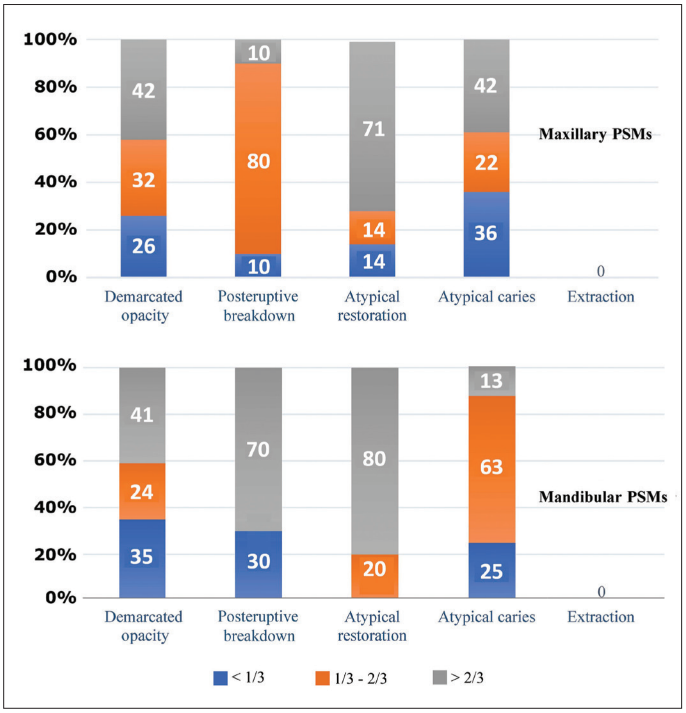

Figure 3. Percentage distribution of the defect extension (less than 1/3, 1/3-2/3 or more than 2/3 of tooth surfaces) in each of the severity categories in primary second molars. The most advanced extent of the defect (>2/3) was mostly seen in association with the "atypical restoration" severity category of maxillary and mandibular primary second molar (PSMs).

Understanding how frequent the problem of DMH-Es is, the pediatric dentist will be able to identify and track cases and, consequently, tailor long-term preventive and restorative management plans to help avoid unfavorable consequences such as the premature loss of these teeth.

In reviewing the literature, this is the first report from the USA on hypomineralized PSMs employing the EAPD diagnostic criteria as described by Weerheijm.[8] The diagnostic index used in this study documents not only the prevalence estimates of DMH-Es but expands to include other enamel defects of PFMs when available for evaluation. This study also contributes to the understanding not only of the occurrence but the associated sociodemographic characteristics of DMH-Es in a group of U.S. preschool (three to five years old) and schoolchildren (six to 12 years old).

Examining the prevalence estimate of DMH-Es reported by the present study and considering the unavailability of other U.S. reports investigating the prevalence of DMH-Es strictly following the Weerheijm criteria[8] makes running any comparison with U.S. studies unfeasible. The earlier U.S. study by Nation et al.[12] reported estimates of enamel opacities of 12 percent in California children attending Loma Linda pediatric dental clinics. Other than the different diagnostic criteria employed in the study, the younger age cohort (three to six years old), the hospital-based recruitment, and inclusion of all primary teeth rather than only the PSMs might have contributed to overemphasizing the prevalence of enamel opacities in that cohort of U.S. children. Slayton and co-investigators[11] have also reported a high prevalence of isolated enamel opacities (27 percent) in Iowa. Similar to the deviations of the present study and the Californian study (the different diagnostic index and inclusion of all primary teeth), the Iowan study sample incorporated a different socioeconomic population of relatively high socioeconomic status, which would warrant careful exploration of their findings to the results of the present study.

Nevertheless, when examining the global estimate of the DMH-Es problem, the present study's prevalence estimate is analogous to the figures obtained from the only two South American studies (Brazil equals six percent[10] and Chile equals five percent[7]). The present study's findings also showed comparable prevalence estimates of DMH-Es to those reported among Dutch,[5] German,[16] Iraqi,[17] and Nigerian[6] cohorts of children.

Considering the race/ethnicity issue, the present study was not able to identify differences between ethnic groups when comparison was limited to the prevalence of DMH-Es. Out of the negligible number of studies that have explored DMH-Es ethnic risk factors, a single prospective cohort was able to identify Dutch ethnicity as a risk determinant of DMH-Es.[5] It must be emphasized that, within the American perspective where people are descendants of diverse multiethnic immigrant groups, the authors were only able to extract the race/ethnicity variable based on the parents' self-identification rather than based on the country of birth of the mothers, as in the Dutch study.[5] Along the same line of examining the role of race/

Table 4. MEDIAN (25TH PERCENTILE TO 75TH PERCENTILE) OF AGE, NUMBER OF DEMARCATED MOLAR HYPOMINERALIZATION OF THE PRIMARY SECOND MOLAR (DMH-ES) AT SURFACE-LEVEL AND TOOTH-LEVEL IN RELATION TO DEFECT SEVERITY AND EXTENT*

	Defect severity					
	Demarcated opacities	Posteruptive breakdown	Atypical restoration	Atypical caries	Missing due to DMH-Es	*P*-value†
Age (years)	5 (4.6-6.6)	9 (9-9)	8.8 (8.8-8.8)	7.5 (5.6-8.1)	7.5 (7.5-7.5)	0.12
#DMH-Es-(surface-level)	4 (2-6)	12 (4-12)	11 (7-11)	6 (3-6)	8 (8-8)	**0.038**
#DMH-Es-(tooth-level)	2 (2-4)	4 (2.5-4)	4 (4-4)	2 (2-4)	4 (4-4)	**0.038**
	Defect extent					
	<1/3 affected	≥1/3 but <2/3	≥2/3 affected	Missing due to DMH-Es	*P*-value	
Age	7 (5.5-9.7)	8.1 (4.7-9)	7.2 (4.9-8.8)	7.5 (7.5-7.5)	0.71	
#DMH-Es-(surface-level)	2.5 (2-3)	6 (4-7)	6 (6-11)	8 (8-8)	**0.002**	
#DMH-Es-(tooth-level)	2 (2-2)	4 (2-4)	4 (2-4)	4 (4-4)	**0.003**	

* Abbreviation used in this table: DMH-Es=demarcated molar hypomineralization of primary second molars.
† Level of significance for *P*-value is considered statistically significant when *P*<0.05 (**bold values**) using generalized linear mixed models for ordinal outcomes.

ethnicity as a risk determinant, extending the comparison to include all enamel defects of the PSMs, children who were self-identified as other than any of the three ethnic groups (non-Hispanic White, non-Hispanic Black/African American, or Hispanic/Latino) were significantly at risk of having higher enamel defects of the PSMs than those from other ethnic backgrounds. These findings contrast with earlier findings where Black/African American children were reported to be at higher risk of having enamel defects of primary teeth when compared to Caucasians and Latinos.[12] However, the appraisal of these findings remains hampered by the different goal and methodology of the previous report and entail the imperative need for further inquiry into the role of race/ethnicity as a risk factor of DMH-Es in large multiethnic cohorts.

Age was not a risk determinant of having DMH-Es in the present study's population nor was it positively correlated with the severity or the extension of these defects. This could point to one of the limitations of this study, where the wide age range may have attenuated the effect of age. Yet, the age effect as a risk determinant was evident when examining the overall prevalence estimate of enamel defects, as the older age groups had a significantly higher prevalence of enamel defects (more than 50 percent in the age group of 10 years or older had enamel defects of at least one index tooth). This is fairly logical, as nearly one-third of the study population had at least one permanent index tooth with fluorosis. These defects would be recorded in the older age groups (six years and older) when permanent index teeth (PFMs/PIs) were present for evaluation.

The present study was also incapable of identifying discrepancies in the prevalence estimates of DMH-Es based on geographical variables (residence zip code, residence county, and region). On the other hand, living in Central Indiana but not in Northern or Southern Indiana was associated with higher odds of having an overall prevalence of enamel defects in the study population. The scarcity of U.S. data on enamel defects from Indiana or any of the Midwestern U.S. states creates inadequate room for comparison based on regional variances. However, it has been demonstrated that U.S. counties have declining fluoridation rates from the most urban to the most rural, implying that children living in the most urbanized counties have higher access to community water fluoridation than those living in less-urbanized counties[18] and, according to the index of Relative Rurality (**RR**) of U.S. counties (zero equals most urban, and one equals most rural),[19] more counties with a lower index of RR were represented within the Central Indiana region than within Northern or Southern Indiana, which might be a valid explanation as to why more children in the Central Indiana region had a higher overall prevalence of enamel defects. To further augment the authors' previous assumption, children within the study population living in areas with higher-than-optimal fluoride in drinking water were also notably more likely to have a higher overall prevalence of enamel defects than those living in areas with optimal or less-than-optimal water fluoridation.

The outcome of the present report should be assessed with caution, as it might not represent the actual estimation of DMH-Es, considering the wide age range and the overrepresentation of Indiana schoolchildren with a lower socioeconomic background. In addition, the generalizability aspects of the present study's sample might be compromised by the limited sample size and the socioeconomic profile typical of school sealant programs. However, the sample socioeconomic profile might also explain the high prevalence of dental caries within the study, where 80 percent of the children had enamel or dentin caries. When examining the difference in dentin caries experience of children with DMH-Es and/or DMH-6s, the conspicuous difference in dental caries was only evident in the group of children with demarcated hypomineralization of molars (DMH-Es±DMH-6s) than those without DMH-Es and/or DMH-6s. This finding indirectly emphasizes the key role of the pediatric dentist to explain and raise awareness about DMH to parents and families and how these defects would change their child's caries risk.

This association disappeared when the collective enamel defects (including diffused opacities) were analyzed for the prevalence of caries. The trend of associating demarcated opacities (including DMH-Es and DMH-6s) and higher prevalence of dental caries has been well documented in permanent teeth[20] as well as in primary teeth.[21] The reverse trend, where no correlation was evident between the overall enamel defects and dental caries, as apparent in the present study, might have been enhanced by the high prevalence of diffuse opacities/fluorosis (nearly one-third of the study population showed signs suggestive of fluorosis in permanent teeth) and the very low prevalence of other nondemarcated opacities and enamel hypoplasia. While these particular findings were in contrast to the outcome of a meta-analysis, where all enamel defects, regardless of the type, have been positively associated with dental caries,[22] it is important to acknowledge that more than 85 percent of this study cohort lived in areas with optimal water fluoridation and most of the diffuse opacities defects observed in this cohort was within the very mild to mild levels of fluorosis severity, which are recognized to grant resistance to dental caries.

In addition to the high caries experience of the present study's population, the subjects examined in this study had advanced severity of the defects, with more than 60 percent of the affected PSMs showing a severity score higher than demarcated opacity, including six extracted mandibular molars due to the hypomineralization defect. While the inclusion of older children in this study might have attenuated the influence of age on the defect severity, this was not the case when defect severity, number of teeth affected, and extension of the defects were scrutinized. The present study was able to reveal a positive relationship between the advanced severity with the number of teeth affected as well as with the extension of the defect. This trend of a positive association between the defect severity, the number of teeth affected, and the defect size has also been established in younger Melbourne preschool children with an overall low caries experience.[23]

Conclusions

Based on the findings of this study, the following conclusions can be made:

1. In this population of U.S. schoolchildren, demarcated molar hypomineralization of primary second molars had a very low prevalence estimate versus the overall enamel defect prevalence (six percent and 40 percent, respectively). However, pediatric dentists should offer thorough consideration for children with demarcated molar hypomineralization as dentin caries experience was almost two times higher in the group with DMH (DMH-Es± DMH-6s) than in the group without DMH.

Conclusions continued on the next page.

2. A child's demographic factors, such as region of residence, water fluoridation, and age, were not associated with DMH-Es prevalence estimate as opposed to the overall prevalence estimate of enamel defects of the examined index teeth.

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