DOI: 10.1111/j.1365-263X.2010.01097.x

Molar incisor hypomineralization: prevalence, severity and clinical consequences in Brazilian children

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International Journal of Paediatric Dentistry 2010; 20: 426–434

Background. The prevalence of molar incisor hypomineralization (MIH) varies considerably around the world; however, few studies have examined MIH in South American countries.
Objective. To evaluate the prevalence, severity, and clinical consequences of MIH in Brazilian children residing in rural and urban areas of the municipality of Botelhos, Minas Gerais, Brazil.
Methods. Children aged 6 to 12 years (n = 918) with all four-first permanent molars erupted had these teeth evaluated according to the European Academy of Paediatric Dentistry (EAPD) criteria. The examinations were conducted by two previously trained examiners, and the dental impact caused by MIH was evaluated with the Decayed, Missing and Filled Teeth (DMFT) index (WHO).
Results. Molar incisor hypomineralization was present in 19.8% of the 918 children, with a higher prevalence in rural areas. The majority of the defects presented were demarcated opacities without post-eruptive structural loss, which has been considered as mild defects. Children with MIH had higher DMFT values.
Conclusion. Despite the high prevalence of MIH, the severity of the defects was mild. The results indicate a positive association between MIH and the presence of dental caries.

Introduction

Molar incisor hypomineralization (MIH) refers to a hypomineralization of systemic origin, which affects 1–4 first permanent molars and is frequently associated with permanent incisors[1]. MIH differs from hypoplasia or quantitative defects because it is a qualitative defect of the enamel that is clinically visualised as a demarcated opacity with clear and defined limits. Clinically, the severity of the MIH lesions may vary from demarcated opacities to structural loss that results in atypical restorations or crown destructions often followed by exodontia[2].

The teeth affected by MIH present with high sensitivity to temperature variations and to tooth brushing even when the enamel is clinically intact[1]. As a consequence, there may be difficulty in obtaining adequate anaesthesia[3], which causes affected children to exhibit behavioural problems, fear, and anxiety during dental treatment[4].

Despite the obscure aetiology of this Hypomineralization, it is suggested that it has a systemic cause[5–7]. Many factors have been related to MIH origin, such as problems during gestation; pre-term delivery; cyanosis; diseases of early childhood, such as chickenpox, otitis, urinary infections, and tonsillitis; high fever; gastrointestinal disorders, such celiac disease, and the frequent use of antibiotics[8–12]. The relevance of each event is difficult to establish as many of those events can happen more than once during early childhood[13].

The prevalence of MIH varies considerably throughout the world, ranging from 2.5% in China[14] to 37.3% in Denmark[15]. Soviero *et al.*[16] found a 40.2% prevalence of MIH in 7 to 13 years-old children in Rio de Janeiro,

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Brazil. This has been the highest prevalence reported in the literature and indicates the importance of better understanding the distribution and severity of the defect among the various regions of Brazil. Thus, the objective of this study was to assess the prevalence and severity of MIH as well as its clinical consequences in children aged 6 to 12 years-old who resided in 2008 in urban (UA) and rural areas (RA) of the municipality of Botelhos, state of Minas Gerais, Brazil.

Materials and methods

This study was performed after approval from the research ethics committee of the Faculdade de Odontologia de Araraquara (FOAr-UNESP) and informed consent term (ICT) from the children's guardians.

This study was performed with public school students who resided in UA and RA of the city of Botelhos in the state of Minas Gerais, Brazil. The city has slightly over 15,000 inhabitants and has a Human Development Index (HDI) of 0.7. The natural level of fluoride in the rural community water is below 0.1 ppm/F, and the ion concentration in the urban community water after fluoridation is 0.7 ppm/F.

The parents of 1315 six to twelve years old children received a letter about the investigation and were asked to give permission for participation of their child in this investigation. After obtaining the ICT from parents, children were examined in school environment according to the guidelines of the World Health Organisation (WHO) for epidemiologic studies in oral health[17]. The following were the inclusion criteria: children aged 6 to 12 years old whose parents agreed to their participation in the study and those with four fully erupted first permanent molars with the occlusal surfaces free of gingival tissue[18]. The exclusion criteria were children with syndromes connected to enamel malformations; those with dental fluorosis (DF), enamel hypoplasia (EH) or amelogenesis imperfecta (AI), and whose were currently under orthodontic treatment at the moment of the assessment.

The epidemiologic survey was performed by two calibrated dental surgeons in October, 2008. The oral health assessment was measured using the DMFT (Decayed, Missing and Filled Teeth) index[17]. For the diagnosis of MIH, the judgement criteria proposed by the European Academy of Paediatric Dentistry (EAPD)[2] was used (Table 1). The opacities were recorded according to colour shades of white, yellow and brown[19]. Only demarcated opacities larger than 1.0 mm of diameter were considered[17], and the differential diagnosis between these lesions and white spot lesions was based on the Seow[20] criteria. Prior to this practice, a calibration exercise was conducted between the two examiners using 37 clinical photographs of patients from Department of Paediatric Dentistry FOAr. All patients had enamel defects (15 with MIH). One month after this exercise the clinical photographs were re-examined independently by the two examiners[14] and the Kappa statistic was used to measure the concordance between them. The inter-examiner agreement for the variables dental decay and MIH was 0.91 and 0.93, respectively. The intra-examiners concordances were above 0.91 for both dental decay and MIH.

Regarding the severity of lesions, teeth presented demarcated opacities with no need of treatment were considered to have mild MIH; moderate MIH included lesions in teeth with rough and broken enamel. Severe defects included the presence of hypomineralized lesions associated to loss of dental structure affecting both enamel and dentin, atypical restorations replacing affected hard tissue and teeth extracted because of severe hypomineralization[21]. Each child individual hypomineralization grade was defined by the most severe defect seen in his/her permanent first molars or permanent incisors[21].

Data were tabulated, and the analysis was conducted with Statistical Package for Social Sciences 16.0 for Windows (SPSS Inc., Chicago, IL, USA). To test the association between the categorical variables, the non-parametric Chi-square test was used with a significance level of 0.05. Odds Ratio (OR) and confidence interval (CI) were calculated for each association. Logistic regression was used to test the association of MIH with demographics variables and DMFT in the two

Table 1. Judgedement criteria for molar incisor hypomineralization (Weerheijm *et al.*, 2003).

Observed condition	Description	Clinical features
1. Demarcated opacity	A demarcated defect involving an alteration in the translucency of the enamel, variable in degree. The defective enamel is of normal thickness with a smooth surface and can be white, yellow or brown in colour.	Example of permanent Incisor with enamel demarcated opacity (42). 
2. Posteruptive enamel breakdown	A defect that indicates deficiency of the surface after eruption of the tooth. Loss of initially formed surface enamel after tooth eruption. The loss is often associated with a pre-existing demarcated opacity.	Example of posteruptive enamel breakdown associated with demarcated opacity in palate and occlusal surfaces (26). Note the presence of enamel opacity around the lesion and the irregular sharp edges that can distinguish it from quantitative defects (hypoplasia). 
3. Atypical restoration	The size and shape of restorations are not conforming to the temporary caries picture. In most cases in molars there will be restorations extended to the buccal or palatal smooth surface. At the border of the restorations frequently opacity can be noticed. In incisors a buccal restoration can be noticed not related to trauma.	Example of atypical restoration (46). In this case, the atypical restoration is unsatisfactory, with loss of enamel margins and infiltration. 
4. Extracted molar due to MIH	Absence of a first permanent molar should be related to the other teeth of the dentition. Suspected for extraction due to MIH are: opacities or atypical restorations in the other first permanent molars combined with absence of a first permanent molar. Also the absence of first permanent molars in a sound dentition in combination with demarcated opacities on the incisors is suspected for MIH. It is not likely that incisors will be extracted due to MIH.	Example of absence of first permanent molar (36) related to other teeth of the dentition with enamel opacity and posteruptive breakdown (26). 
5. Unerupted	The first permanent molar or the incisor to be examined are not yet erupted.	Example of first permanent molar that is not yet erupted (36). 

residential areas. Adjusted Odds Ratio and CI were calculated for each, respectively. The result of logistic regression was accepted only if approved by Hosmer-Lemeshow goodness-of-fit statistic.

Results

The parents of 1315 children aged 6 to 12-year-old, received a letter about the investigation and were asked to give permission for participation of their child in this investigation. The assessment was performed in 1126 children 6 to 12 years-old who were present on the day of examination and whose guardians had filled out and signed the ICT (85.6% of the enrolled children). Among the assessed children, 208 were excluded for not meeting the inclusion criteria. Therefore, 918 children participated in this study, being 66.8% (613/918) from UA and 33.2% (305/918) from RA.

The percentage of children who had at least one-first permanent molar with MIH was 19.8% (182/918) overall. The prevalence of MIH was 17.6% (108/613) in the UA, and 24.3% (74/305) in the RA. The prevalence was significantly higher in the RA (Chi-square test, $P = 0.017$), even when the OR was adjusted by logistic regression (Table 2). There was no difference in MIH prevalence according to gender (Chi-square test, $P = 0.14$); however, there was a significant association between age and enamel defects, with a higher prevalence among children with 10 years old or older (Chi-square test, $P = 0.001$). Furthermore this significance was borderline when the OR was adjusted by logistic regression (Table 2).

The severity of the defects varied from demarcated enamel opacities to severe structural loss and atypical restorations. The mild defects were the most prevalent type of MIH lesion, with the white-yellowish opacities more frequent than the brownish opacities. It was observed that 66.2% (49/74) of the children in the RA and 73.1% (79/108) of the children in the UA had mild MIH, with no statistically significant difference between the areas (Table 3). Both prevalence and severity of MIH increased along with the age of children (Fig. 1).

It was observed that 9.0% (55/613) of the children in the UA and 12.1% (37/305) of the children in the RA presented MIH lesions on both permanent molars and incisors. Of the overall population, 24 children presented MIH lesions in the four-first permanent molars; they comprised 2.0% (12/613) of the children in the UA and 3.9% (12/305) of the children in the RA; however, 71 children presented with defects in only one permanent molar, and they comprised 6.7% (41/613) in the UA and 9.8% (30/305) in the RA. The risk of incisor involvement increased with the number of affected molars: 67.0% (16/24) of the children with all four molars affected also presented with defects in their permanent incisors, and only 31.0% (22/71) of the children with one affected molar also presented with defects in their permanent incisors [Chi-square test, $P = 0.004$; OR = 4.4; IC 95% (1.6–11.9)].

Table 2. Number of children with MIH by age, gender and residence areas. Botelhos, Minas Gerais, Brazil, 2008.

	MIH = 0		MIH > 0		Total				
Variables	***n***	**%**	***n***	**%**	***n***	**%**	***P*-value**	**OR[a] (CI 95%)**	**OR[b] (CI 95%)**
Gender									
Male	320	78	90	22	410	100	0.14	1.3 (0.9–1.8)	1.2 (0.9–1.7)
Female	416	81.9	92	18.2	508	100			
Age of years									
<10 years age	466	83.6	91	16.4	557	100	0.001*	1.7 (1.2–2.4)	1.1 (1.0–1.2)
≥10 years age	270	74.8	91	25.2	361	100			
Residence areas									
Rural Areas	231	75.7	74	24.3	305	100	0.017*	1.5 (1.1–2.1)	1.5 (1.1–2.1)
Urban Areas	505	82.4	108	17.6	613	100			

*Association statistically significant, Chi-square test, $\alpha = 0.05$; OR[a]: crude values; OR[b]: adjusted values.

Table 3. Molar incisor hypomineralization severity among children. Botelhos, Minas Gerais, Brazil, 2008.

Residential Area	Severity of the MIH: Mild defects: White opacities		Yellow opacities		Brown opacities		Moderate Defects		Severe Defects		Total		*P*-value	OR[a] (CI 95%)
	n	%	*n*	%	*n*	%	*n*	(%)	*n*	(%)	*n*	(%)		
Urban	31	28.7	35	32.4	13	12.0	14	13	15	13.9	108	100	0.4	1.3
Rural	15	20.3	22	29.7	12	16.2	9	12.2	16	21.6	74	100		(0.7–2.6)
Total	46	25.3	57	31.3	25	13.7	23	12.7	31	17.0	182	100		

P-value: descriptive level of the Chi-square test, $\alpha = 0.05$; OR[a]: crude values.

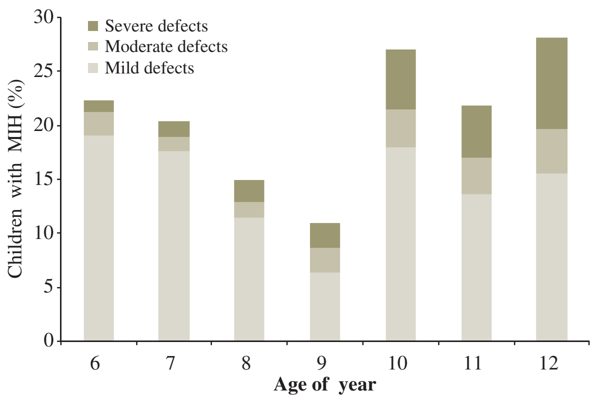

Fig. 1. Prevalence and severity of MIH among children in each year of age. Botelhos, Minas Gerais, Brazil, 2008.

When the individual tooth was considered as the unit of analysis, we observed that among the 3672 first permanent molars and 5508 permanent incisors, 478 (13.0%) and 136 (2.4%), respectively, were diagnosed with MIH. This implied that the same child had more than one tooth affected by the disease. There was no statistically significant diference in the prevalence of MIH between the upper and lower molars or between the upper and lower incisors (Chi-square test, $P > 0.05$) (Fig. 2).

Each tooth diagnosed with MIH had an average of 1.2 affected surfaces, and the surface with the most severe condition was chosen for analysis. Of all surfaces affected with MIH ($n = 763$), the vestibular surface was the most frequently affected, although the most severe defects, such as structural loss and atypical restorations, were more prevalent in the occlusal surface of the first permanent molars. Structural loss and atypical restorations were not found in incisors diagnosed with MIH.

The means of DMFT were 1.25 and 1.97 in UA and RA, respectively. Among the children with MIH, 33.3% (36/108) in the UA and 21.6% (16/74) in the RA were free from dental caries in permanent teeth (DMFT = 0). Among the children without MIH, 53.2% (269/505) in the UA and 36.3% (84/231) in the RA were free from caries in the permanent teeth. Thus, it was observed that in the two areas, the presence of the defect was associated with a greater prevalence of dental caries in the permanent teeth (Table 4). The affected first permanent molars were associated with dental caries, as evidenced from the previous history (i.e., restored tooth) or from its current status (i.e., decayed tooth) (Fig. 3).

Discussion

To determine the MIH diagnosis, we included only demarcated opacities of at least 1 mm in diameter[17], which occurred in 19.8% of subjects. The first study of MIH performed in Brazil revealed that more than 40% of 7 to 13 years old children from Rio de Janeiro showed the defect when an extension in a lesion was not considered as a criterion for diagnosis[16].

Similar to the study by Muratbegovic *et al.*[22] that observed varying MIH prevalences by geographic location, we also observed differences in MIH prevalence between the two residential areas. Brazil is a country with

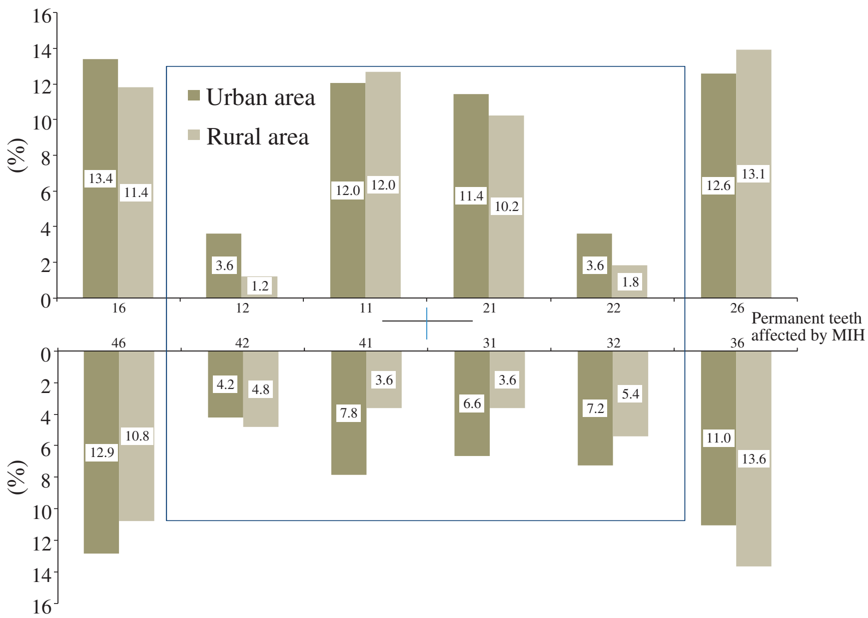

Fig. 2. Prevalence of MIH in First Permanent Molars and Permanent Incisors of children from Urban and Rural areas. Botelhos, Minas Gerais, Brazil, 2008.

Table 4. Prevalence and association of MIH with dental caries in permanent dentition of children from Urban and Rural areas. Botelhos, Minas Gerais, Brazil, 2008.

	Urban areas							Rural areas						
	MIH = 0		MIH > 0					MIH = 0		MIH > 0				
Caries history	*n*	%	*n*	%	*P*-value	OR[a] (CI 95%)	OR[b] (CI 95%)	*n*	%	*n*	%	*P*-value	OR[a] (CI 95%)	OR[b] (CI 95%)
DMFT = 0	269	43.9	36	5.9	<0.001*	2.3	2.0	84	27.5	16	5.2	0.02*	2.1	2.8
DMFT > 0	236	38.5	72	11.7		(1.5–3.5)	(1.2–3.1)	147	48.2	58	19.0		(1.1–3.8)	(1.4–5.6)
Total	505	82.4	108	17.6				231	75.7	74	24.3			

*Statistically significant, Chi-square test, $\alpha = 0.05$; OR[a]: crude values; OR[b]: values adjusted by year of age.

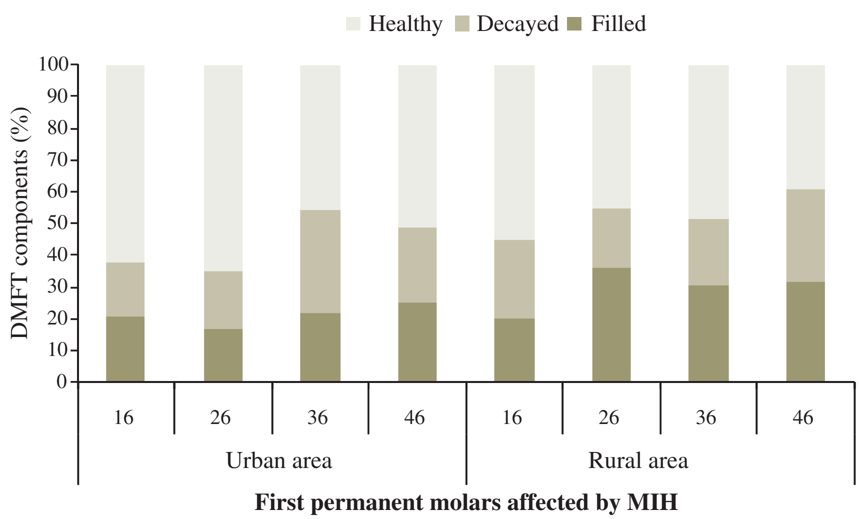

Fig. 3. Clinical conditions of first permanent molars affected by MIH according DMFT index. Botelhos, Minas Gerais, Brazil, 2008.

significant socioeconomic discrepancies, which results in an uneven distribution of oral diseases in its population[23]. Residents of the rural areas are at greater risk for the development and aggravation of oral diseases[24], and this may be due to either the greater concentration of public health services in the urban areas or to the more limited access of the rural population to public health interventions, such as community water fluoridation[25]. Similarly to the national trend, we observed that the prevalence of MIH was significantly greater in the RA. Other studies show higher prevalence of enamel defects in rural, socioeconomic disadvantaged and malnourished populations[26,27]. This reinforces the requirement for prospective studies that evaluate the interference of socioeconomics and environmental factors with the development of this enamel defect.

A higher prevalence of hypomineralization was found among children who were born in the 1970s when compared to those who were born in the 1960s[19]. Similar to study by Koch *et al.*[19], we found a higher prevalence of MIH among children with 10 years old or older than. Whereas the MIH aetiology is probably related to a systemic disturbance that occurred during the development of the dental enamel[19], it can also be hypothesised that a specific environmental factor may have been present during the development of the first permanent molars and incisors in the study group, although no attempt to determine the potential causes of MIH in this study population has been carried out. The severity of MIH increased along with the age of children, which could suggest that hypomineralized lesions are dynamic defects. As the child grows older the change in the oral environmental worsen those mild defects leading to clinical detection of structural loss or its consequences, like atypical restorations.

We observed that 8.9% (55/613) of the children in the UA and 12% (37/305) of the children in the RA presented MIH in permanent molars and incisors concomitantly, and these percentages were much lower than those reported in the literature[10,16]. This study evaluated 6 to 12 years old children with all the four-first permanent molars, but not necessarily all eight permanent incisors erupted. Although the presence of opacities in the incisors did not affect the prevalence of MIH, the severity of opacities could have been underestimated in the study population.

The demarcated opacities were the types of MIH alterations that were most frequently found in this study. In this study, it was observed that the lighter opacities (white and yellow) were the most prevalent types of MIH defects. Jalevik and Nòren[28] observed that darker opacities of MIH demonstrated greater porosity than the lighter (white-yellowish) opacities and the greater porosity of the hypomineralized tissue contributes to its smaller mechanical resistance, which facilitates structural loss[29]; however, due to the cross sectional characteristic of this study, the greater susceptibility of the darker opacities to structural loss could not be demonstrated.

The most severe MIH defects were present on the first permanent molars. The permanent incisors only showed demarcated opacities in their labial surfaces, implying that the incisors do not require treatment except for aesthetic reasons. Defects on the permanent incisors are probably not related to structural loss because of the absence of masticatory forces upon these surfaces[28]. It is important to note that, however the abrasion of the tissue due to tooth brushing is more evident on hypomineralized tissue than on mineralised enamel[30] and possible structural microscopic loss may occur on the surfaces of MIH lesions contributing to dental plaque accumulation.

Molar incisor hypomineralization is associated with many dental problems, such as hypersensitivity, quick development of carious lesions, and recurrent dental treatment needs[4,21,22]. Because of the MIH characteristics, such as higher porosity and smaller mechanical resistance,[29] this defect is referred to as a dental caries risk factor in populations with a low prevalence of dental caries[1,4,8,21]. In populations with high caries activity, the hypomineralized lesions could be disguised by carious lesions. However even in this study, where the majority of the children presented with carious lesions in their permanent teeth, the MIH lesions could be clearly diagnosed. In both residential areas a statistically significant difference was observed between the number of children without caries lesions between the groups with and without MIH, showing that MIH is associated with a greater prevalence of dental decay.

Conclusions

Special attention should be given to the enamel defects characterised as MIH. Although the majority of affected children present mild enamel defects, this study demonstrated the adverse impact of these defects on the development of the carious lesion in a population with high caries experience. The regional difference in the MIH prevalence deserves attention from health professionals and administrators, especially in a country with an uneven distribution of oral diseases, where the contextualization of health promotion and prevention actions are necessary.

What this paper adds

- This study is the first to provide information about the prevalence, severity, and clinical consequences of MIH in Brazilian children residing in the rural and urban areas of a municipality in the state of Minas Gerais, Brazil.

Why this paper is important to paediatric dentists

- Paediatric dentists must be aware of MIH and its clinical consequences; this study demonstrated that MIH is associated with a greater prevalence of dental decay.

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