Saudi Dental Journal (2022) 34, 36–44

King Saud University

Saudi Dental Journal

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ORIGINAL ARTICLE

Prevalence and possible aetiological factors of molar incisor hypomineralisation in Saudi children: A cross-sectional study

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Received 29 May 2021; revised 28 October 2021; accepted 31 October 2021
Available online 8 November 2021

KEYWORDS

Molar incisor hypomineralisation;
MIH;
Hypomineralised second primary molars;
Epidemiology;
Risk factors;
Enamel defect;
Short form

Abstract *Background:* A new charting system for molar incisor hypomineralisation (MIH) was recently published and is based on the European Academy of Paediatric Dentistry (EAPD) criteria. This charting system aims to standardise MIH data collection. Therefore, there is a need for new MIH prevalence studies using the currently recommended charting-form.

Aim: To investigate the prevalence and possible aetiological factors of MIH in randomly selected Saudi schoolchildren aged 8–12 years in Riyadh.

Design: A randomly selected sample of Saudi schoolchildren aged 8–12 years attending elementary schools in Riyadh was examined using the EAPD short-form charting, which was recently recommended for the standardised collection of epidemiological data on MIH. To investigate possible aetiological factors of MIH, we collected demographic, pregnancy, and medical history using a questionnaire.

Results: A total of 1,562 children participated in the study (48.8% girls, 51.2% boys). The prevalence of MIH was 15.2%, without a significant difference in the prevalence between the sexes. Among those with MIH, 79.4% had affected incisors and 55.9% had hypomineralised second primary molars. The most prevalent clinical defect was demarcated opacities, and the maxillary arch

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Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

https://doi.org/10.1016/j.sdentj.2021.10.004

was more affected. Permanent incisors were more affected in boys than in girls. Defects of the first permanent molars were more severe in terms of clinical status and lesion extent than defects of the permanent incisors. MIH was significantly more prevalent in children with a history of early childhood ear infections, respiratory distress, and tonsillitis.

Conclusions: MIH is common in Saudi schoolchildren living in Riyadh, with no gender predilection. Hypomineralised second primary molars can be used to predict MIH. MIH was significantly associated with childhood illness during the first three years of life, including ear infection, respiratory distress, and tonsillitis.

1. Introduction

The term molar incisor hypomineralisation (MIH) was first introduced by Weerheijm et al. (2001) and defined as 'hypomineralisation of systemic origin, affecting the enamel of one to four first permanent molars (FPMs) frequently associated with affected permanent incisors (PIs)'. More recently, the term hypomineralised second primary molars (HSPMs) was introduced to describe similar lesions affecting the second primary molars (SPMs) (Elfrink et al. 2008). There is a significant association between MIH and HSPMs (Ghanim et al. 2017). The mineralisation of FPMs, SPMs, and PIs occurs at approximately the same chronological time. Any systemic illnesses that occur during enamel development could disturb the mineralisation of these teeth (Crombie et al. 2009; Lygidakis et al. 2008). In the literature, multiple possible risk factors have been suggested, such as perinatal complications, dioxins, respiratory distress, hypoxia, low birthweight, frequent childhood illnesses, use of antibiotics, and prolonged breastfeeding (Almuallem, Busuttil-Naudi 2018). Recently, the multifactorial nature of the aetiology of MIH has been recognised. A genetic predisposition to MIH with the influence of epigenetic factors has also been proposed (Vieira, Manton 2019).

The clinical features of MIH are variable and include demarcated opacities, post-eruptive enamel breakdown (PEB), and atypical caries located on at least one FPM, with or without incisor involvement (Weerheijm 2004). Affected teeth are more prone to caries, PEB, and hypersensitivity. Aesthetics is also a concern when PIs are affected. As such, MIH may affect children psychologically (Large et al. 2019).

The reported global prevalence of MIH ranges from 2.8% to 40.2% (Ghanim et al. 2017). This wide variation may be due to a lack of standardised tools to record MIH (Elfrink et al. 2015). To address this limitation, Ghanim et al. (2015) developed a standardised charting system based on the European Academy of Paediatric Dentistry (EAPD) evaluation criteria, including a manual (Ghanim et al. 2017) to facilitate and standardise data collection for epidemiological studies. Two forms of the charting system have been proposed: a short form for simple screening surveys designed to grade only the index teeth (i.e. the FPMs, PIs, and SPMs) and a longer form that is designed to assess all present teeth at the surface level for more detailed community or clinic-based studies (Ghanim et al. 2015). This charting system is a valid and reliable tool for use in epidemiological studies (Ghanim et al. 2019).

Previous studies have assessed the prevalence of MIH in Saudi Arabia. All available studies used the EAPD criteria for the diagnosis of MIH (Weerheijm et al. 2003). The prevalence of MIH in these studies varied significantly. Allazzam et al. (2014) reported an MIH prevalence of 8.6% in a group of children attending dental clinics at King Abdulaziz University in Jeddah. In contrast, Al-Hammad et al. (2018) reported a 40.7% prevalence of MIH among schoolchildren in Riyadh. In another region of Saudi Arabia, Qassim, Rizk et al. (2018) found a 25.1% prevalence of MIH among schoolchildren. There is a need for new research using the recently developed charting system by Ghanim et al., which aimed to standardise data collection for MIH epidemiological studies. Updated information on the prevalence of MIH and the lesion characteristics using this charting system is warranted.

This study aimed to investigate the prevalence of MIH/HSPM and lesion characteristics among Saudi schoolchildren living in Riyadh using the MIH/HSPM short charting form. Our secondary aim was to investigate the possible aetiological factors of MIH in Saudi children.

2. Materials and methods

This was a cross-sectional survey conducted between March and April 2019, targeting 8–12-year-old Saudi schoolchildren in the third, fourth, fifth, and sixth grades attending public and private elementary schools in Riyadh.

A list of schools was obtained from the Ministry of Education. Riyadh is divided into five geographical areas (eastern, western, southern, northern, and central). Multiple schools were contacted from each area, and the schools that consented were included in the study. A paper leaflet describing the purpose and nature of the study, consent form, and questionnaire were sent to the parents.

All children whose parents provided consent were examined. The inclusion criteria were as follows: boys and girls aged 8–12 years; Saudi ethnic origin, and an eruption of at least one FPM. The exclusion criteria were as follows: children with orthodontic appliances and uncooperative children. According to the General Authority for Statistics in the Kingdom of Saudi Arabia, the total number of public and private elementary schools in Riyadh was 1,609, with almost equal numbers of schools for boys and girls. In the 8–12-year-old group, there were approximately 366,009 students. The sample size was calculated using Java Applets by Lenth (2006–9). The minimum sample size for this cross-sectional prevalence study, based on a prevalence of MIH of 41% and a prevalence estimation within 2.5% of the real value at a 95% confidence interval, was 1,481 participants.

Examinations were conducted individually using sterile mouth mirrors, probes, gauze, and dental gloves. Each child was asked to sit on a chair with the head resting at 45° to the horizontal. An oral examination was performed on wet teeth. Visible plaque, if present, was removed with gauze. All surfaces of the index teeth were examined, and each index tooth was scored according to the MIH/HSPM short charting form by Ghanim et al. (2015). The short form requires 16 index teeth (i.e., FPMs, PIs, and SPMs) to be evaluated for their eruption status, clinical status, and lesion extent.

Index teeth with < 1/3 of the clinical crown visible did not have enough visible surface for scoring and were scored with the letter (A). If the tooth had 1/3 or more of its clinical crown visible, it was scored according to the clinical status criteria. The clinical status of teeth was recorded as one of the following: no enamel defect, enamel defect but non-MIH/HSPM, demarcated opacity, PEB, atypical restoration, atypical caries, atypical extraction (missing due to MIH/HSPM), or cannot be scored. Any enamel lesion measuring 1 mm or less was considered to be sound. To assess lesion extent, the index teeth were divided into thirds and scored as follows: Code I, < 1/3 of the tooth surface affected; Code II, at least 1/3 but < 2/3 of the tooth surface affected; and Code III, at least 2/3 of the tooth surface affected. Finally, a diagnosis of MIH was made for any case that had at least one affected FPM.

A questionnaire was constructed to identify the possible aetiological factors of MIH/HSPM. The questions were developed after reviewing the literature to identify all possible aetiological factors. The questionnaire consisted of 17 questions and contained the following sections:

(i) demographic data
(ii) Maternal health during pregnancy
(iii) Method of delivery
(iv) Child's birth weight
(v) Average breastfeeding duration
(vi) The child's medical history during the first three years (asthma, respiratory distress, otitis media, fever, chickenpox, rubella, adenoid infection, digestive system diseases, kidney diseases, tonsillitis, and antibiotic intake)

The main examiner (ZA) was a paediatric dentist who completed an online training course with the establishment of the MIH index (AG) from The University of Melbourne, Australia. During training, 20 photographs including both MIH and other enamel defects were scored, and the test was repeated twice within one week. Using Kappa statistics, inter- and intra-rater reliabilities were almost perfect in terms of clinical status (0.84, and 0.89, respectively). For the lesion extent, the inter- and intra-rater reliabilities were substantial (0.76) and almost perfect (0.85), respectively. In turn, the ZA trained six general dental practitioners (GDPs) for diagnosing MIH/HSPM and the use of the short charting form. Their intra- and inter-rater reliabilities were tested, and based on the results, four GDPs were selected as examiners. The inter-rater reliability among examiners trained under ZA was almost perfect (0.83–0.89) for clinical status and substantial for the lesion extent (0.70–0.73), whereas the intra-rater reliability was almost perfect for the clinical status (0.8–0.97) and ranged from substantial to almost perfect for the lesion extent (0.7–0.97).

Data were analysed using IBM SPSS version 21 (IBM, Armonk, NY, USA). Associations between age and sex and the distribution and severity of MIH/HSPM were tested using chi-squared and Fisher's exact tests. The 95% confidence intervals were calculated for prevalence, and a p-value of ≤ 0.05, was considered statistically significant.

To investigate the possible aetiological factors, the sample was divided into the following: those diagnosed with MIH that affects at least one FPM and one PI referred to as 'MIH-affected group' and those who were 'non-MIH-affected' were considered the 'control' The influence of medical health variables on the presence of MIH was investigated using logistic regression analysis. The independent variable was every question (including age and gender) that was asked in the medical questionnaire, whereas the dependent variable was MIH. Differences were considered statistically significant at an alpha level ≤ 0.05.

3. Results

A total of 3,922 parents and their children were invited to participate in the study. Among them, 1,566 agreed to participate (response rate: 39.9%). Four children with orthodontic appliances were excluded, resulting in 1,562 participants. Demographic data and prevalence of enamel defects in the samples are shown in Table 1. MIH was diagnosed when there was at least one affected FPM. The prevalence of MIH in our sample was 15.2% (n = 238). Approximately 79.4% of the MIH-affected children had affected incisors (n = 189), and 55.9% had HSPMs (n = 133).

Table 1 Distribution of the sample according to demographic data and the prevalence of enamel defects.

	N	%
Gender		
Boys	800	51.2
Girls	762	48.8
School type		
Public	719	46
Private	843	54
Region		
North	631	40.4
South	236	15.1
East	295	18.9
West	158	10.1
Central	242	15.5
Age		
8 years	101	6.5
9 years	388	24.8
10 years	369	23.6
11 years	386	24.7
12 years	318	20.4
Prevalence of enamel defects		
Hypomineralised FPMs	238	15.2
Hypomineralised PIs	308	19.7
HSPMs	147	9.4
Hypomineralised FPMs and PIs	189	12.1
MIH with HSPMs	133	8.5
Fluorosis	185	11.8
Amelogenesis imperfecta	4	0.3
Chronological enamel hypoplasia	1	0.1

FPMs, first permanent molars; PIs, permanent incisors; HSPMs, hypomineralised second primary molars; MIH, molar incisor hypomineralisation

The maxillary PIs were more affected (n = 274, 17.5%) than the mandibular PIs (n = 100, 6.4%). There were more MIH lesions in the maxillary arch (Fig. 1). The number of affected FPMs and PIs per participant is shown in Table 2.

Demarcated opacities were the most common MIH lesions affecting the FPMs and PIs (Table 3). Approximately 1,163 SPMs could not be scored (18.6%). Atypical caries and atypical restorations were the most commonly identified clinical statuses among MIH-affected SPMs (Table 3). The extent of the MIH lesions is shown in Fig. 2**.**

The prevalence of hypomineralised FPMs and HSPMs was not significantly different between the age groups ($p = 0.9$ and $p = 0.7$, respectively). The distribution of MIH lesions in index teeth was also not significantly different according to age ($p > 0.05$).

The prevalence of FPM hypomineralisation and MIH/HSPM was not statistically different between boys and girls ($p = 0.9$). However, a statistically higher prevalence of affected PIs and HSPMs was detected among boys ($p < 0.001$ and $p = 004$, respectively). Boys also had a statistically higher prevalence of MIH involving both FPMs and PIs ($p = 0.008$), and a higher prevalence of hypomineralised FPMs with hypomineralised PIs in both upper quadrants ($p < 0.01$ and $p < 0.001$, respectively).

The severity of MIH lesions in FPMs and PIs was not significantly associated with age ($p = 0.4$ and $p = 0.6$, respectively). In contrast, the severity of HSPM lesions increased with age ($p < 0.001$). Interestingly, boys had more severe lesions in their PIs ($p < 0.001$) and SPMs ($p < 0.001$), whereas girls had more severe lesions in their FPMs ($p < 0.001$).

The likelihood of the influence of medical health variables on the presence of MIH was investigated by logistic regression analysis using health variables as predictors (Table 4). The results showed that all health predictors were statistically significant ($p \leq 0.05$). After controlling for the other independent variables included in the model, ear infection, respiratory distress, and tonsillitis were significant predictors of MIH ($p \leq 0.05$).

Table 2 Distribution pattern of the affected FPMs and PIs in participants.

	FPMs	
	N of participants	**%**
No FPM affected	1,326	84.9
One molar affected	18	1.2
Two molars affected	61	3.9
Three molars affected	44	2.8
Four molars affected	113	7.2
Total	1,562	100.0
	PIs	
	N of participants	**%**
No Incisor affected	1,230	78.7
One incisor affected	67	4.3
Two incisors affected	92	5.9
Three incisors affected	27	1.7
Four incisors affected	17	1.1
Five incisors affected	9	0.6
Six incisors affected	2	0.1
Eight incisors affected	1	0.1
Unerupted/partially erupted	117	7.5
Total	1,562	100.0

FPMs, first permanent molars; PIs, permanent incisors

4. Discussion

Measuring the prevalence of MIH in Saudi children is helpful for assessing the need to educate dentists and enhance community awareness of this condition. Increased awareness of MIH may lead to earlier detection and timely implementation of appropriate preventive measures to limit adverse outcomes.

In this study, we showed that the prevalence of MIH in a cohort of Saudi children was 15.2%. Our results are different from those of previous local studies (Al-Hammad et al. 2018; Rizk et al. 2018; Allazzam et al. 2014) but similar to the

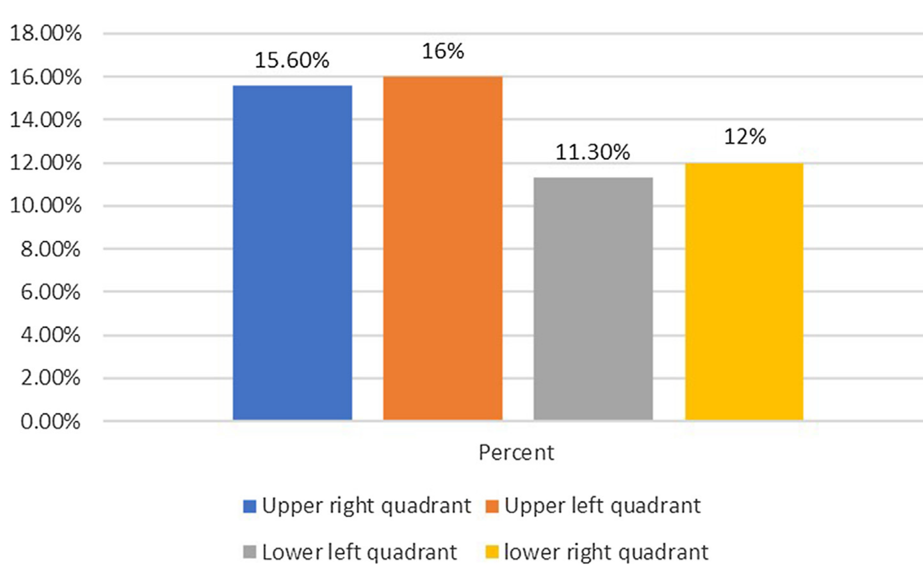

Fig. 1 Distribution of MIH lesions in participants' mouth quadrants.

Table 3 Distribution of MIH lesions in index teeth.

	First permanent molars		Permanent incisors		Second primary molars	
	N	%	*N*	%	*N*	%
Demarcated opacities	459	68.61	474	96.54	48	15.1
Post-eruptive enamel breakdown	36	5.38	17	3.46	16	5.03
Atypical restoration	101	15.1	0	0	97	30.5
Atypical caries	71	10.61	0	0	123	38.68
Atypical extraction	2	0.298	0	0	34	10.69
Total	669	100	491	100	318	100

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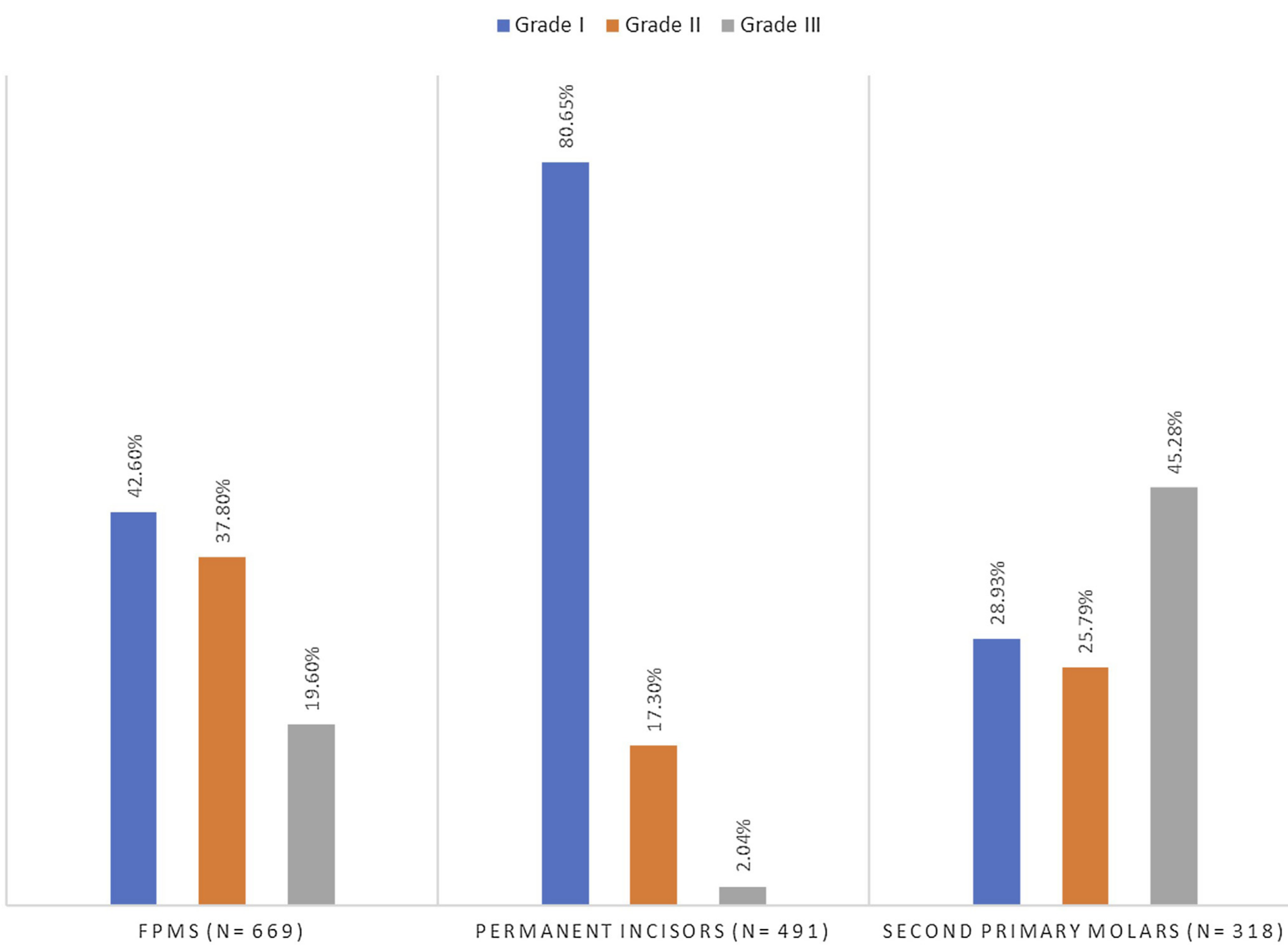

Fig. 2 Proportion of tooth surface affected by MIH lesion in index teeth (Grade I: < 1/3 of the tooth surface, Grade II: at least 1/3 but < 2/3 of the tooth surface, Grade III: at least 2/3 of tooth surface).

reported prevalence in other countries, such as the UK (15.9%) (Balmer et al. 2012), Argentina (15.9%) (Biondi et al. 2009) and Turkey (14.2%) (Koruyucu et al. 2018).

This is the first Saudi study to use the recently recommended criteria for assessing the prevalence of MIH (Ghanim et al. 2015). The advantage of this system is that in addition to MIH, other enamel defects may be recorded, and it yields an informative description of the severity of the MIH-affected teeth. Moreover, Ghanim's forms enable a standardised epidemiological data collection for MIH. In previous studies, participants with other enamel lesions were excluded, and it was unclear if atypical caries were reported as MIH lesions. These factors may lead to over- or underestimation of the prevalence of MIH. Moreover, the prevalence of fluorosis in the current study was 11.8%, which was considered high. Fluorotic and MIH lesions should be carefully distinguished, as misdiagnoses may lead to a significant increase in the reported prevalence of MIH. Although the sample size in the current study was the largest among the available Saudi studies, the response rate was low. This low response rate is a lim-

Table 4 Frequency distribution of MIH-affected and non-affected groups by health variables using binary logistic regression.

Variable	MIH-affected (N = 189) N (%)	Non-MIH-affected (N = 1,373) N (%)	Adjusted odds ratio	Confidence interval 95%	p-value
Pregnancy problems					
Yes (Reference)	21 (11.1)	124 (9.0)	1		
No	168 (88.9)	1,249 (91.0)	11.62	0.04–73.80	0.35
Delivery status					
Natural (Reference)	134 (70.9)	986 (71.8)	1		
Natural with complications	4 (2.1)	32 (2.3)	0.01	0.51–92.20	0.70
Caesarean	45 (23.8)	329 (24.0)			
Premature delivery	6 (3.2)	26 (1.9)			
Child's birth weight					
Normal (Reference)	177 (93.7)	1,251 (91.1)	1		
Underweight	10 (5.3)	105 (7.6)	2.3	0.20–25.85	0.49
Overweight	2 (1.1)	17 (1.2)			
Breastfeeding					
Yes (Reference)	105 (55.6)	884 (64.4)	1		
No	84 (44.4)	489 (35.6)	11.32	0.13–27.82	0.65
Duration of breastfeeding					
No BF (Reference)	84 (44.4)	495 (36.1)	1		0.63
< 6 months	49 (25.9)	415 (30.2)	9.87	0.86–39.00	
6 months to one year	36 (19.0)	292 (21.3)			
More than one year	20 (10.6)	171 (12.5)			
Presence of health issues					
Yes	28 (14.8)	190 (13.8)	3.27		0.82
No (Reference)	161 (85.2)	1,183 (86.2)	1	0.48–3.36	
History of allergies					
Yes (Reference)	22 (11.6)	146 (10.6)	1		0.23
No	167 (88.4)	1,227 (89.4)	12.69	0.14–84.10	
History of asthma					
Yes (Reference)	19 (10.1)	117 (8.5)	1		0.48
No	170 (89.9)	1,256 (91.5)	0.75	0.40–7.90	
History of ear infection					
Yes (Reference)	138 (8.8)	43 (2.8)	1	7.32–16.54	0.05
No	352 (22.5)	1,029 (65.9)	6.23		
History of respiratory distress					
Yes (Reference)	34 (18.0)	166 (12.1)	1		0.05
No	155 (82.0)	1,207 (87.9)	5.98	9.34–20.16	
History of fever					
Yes (Reference)	66 (34.9)	491 (35.8)	1		0.08
No	123 (65.1)	882 (64.2)	3.41	0.55–12.45	
History of chickenpox					
Yes (Reference)	0 (0.0)	6 (0.4)	1		0.23
No	189 (100.0)	1,367 (99.6)	0.02	0.04–2.01	
History of measles					
Yes (Reference)	0 (0.0)	2 (0.1)	1		
No	189 (100.0)	1,371 (99.9)	0.25	0.56–6.84	0.90
History of adenoidectomy					
Yes (Reference)	16 (8.5)	96 (7.0)	1		0.76
No	173 (91.5)	1,277 (93.0)	0.27	0.56–15.46	
History of gastritis					
Yes (Reference)	7 (3.7)	37 (2.7)	1		
No	182 (96.3)	1,336 (97.3)	1.24	0.45–21.76	0.81
History of renal problems					
Yes (Reference)	1 (0.5)	9 (0.7)	1		
No	188 (99.5)	1,364 (99.3)	0.44	0.84–1.22	0.47

(*continued on next page*)

Table 4 (*continued*)

Variable	MIH-affected (N = 189) N (%)	Non-MIH-affected (N = 1,373) N (%)	Adjusted odds ratio	Confidence interval 95%	p-value
History of tonsillitis					
Yes (Reference)	56 (29.6)	302 (22.0)	1		
No	133 (70.4)	1,071 (78.0)	12.65	9.12–44.62	0.02
Antibiotic intake					
Yes (Reference)	114 (60.3)	802 (58.4)	1		
No	75 (39.7)	571 (41.6)	0.62	0.98–11.54	0.69

itation because of its effect on sample distribution. The questionnaire may have affected the response rate, as parents may not want to share private information or have no time to complete the survey while caring for small children.

We found no gender predilection for MIH, which is consistent with the findings of previous studies (Allazzam et al. 2014; Al-Hammad et al. 2018). The majority of MIH-affected participants in our sample (79.4%) had affected PIs. In our study, boys with MIH had a statistically higher prevalence of affected PIs, which is similar to the findings of Ghanim et al. (2011). When FPMs are affected by MIH, any similar lesion on the PI is usually assumed to be an MIH lesion. However, the demarcated lesions on PIs are not always caused by MIH and can be due to other factors, such as a history of periapical infection affecting the primary predecessors as a result of trauma or caries. However, this could not be confirmed without a dental history, which was not possible in the current study. Therefore, it remains unclear whether boys with MIH have a higher tendency for PI involvement, or whether this may be due to other causes. For example, dental trauma is more common among boys (Petti et al. 2018).

Approximately 55.9% of the MIH-affected participants in this study had HSPMs. This further supports the use of HSPMs as predictors of MIH (Ghanim et al. 2017). For 18.6% of the SPMs, the clinical status was recorded as 'cannot be scored'. In populations with a high prevalence of caries, such as in Saudi Arabia (Alhabdan et al. 2018), SPMs are likely to be severely damaged by eight years of age. As a result, there may be difficulties in diagnosis and overestimation of MIH severity. A younger age group (3–5 years) may provide more accurate information on HSPMs.

Furthermore, we found differences in tooth susceptibility. Similar to previous studies, the maxillary arch and maxillary PIs were more commonly affected in this study (Al-Hammad et al. 2018; Ghanim et al. 2011). Consistent with previous findings, we also found that demarcated lesions (mild defects) were the most frequent type of defect (Ghanim et al. 2011; Saber et al. 2018). PEB, atypical caries, atypical restorations, and extraction due to MIH were considered severe MIH defects. Comparing the severity of MIH defects with age, the eight-year-old group had the lowest number of severe MIH lesions and the 12-year-old group had the highest, although formal statistical testing did not show a significant increase in MIH severity with age. Comparing MIH severity between the sexes, boys had more PEB defects in the PIs, which was consistent with the findings of a previous study (Ghanim et al. 2011). In contrast, girls had a significantly greater number of severe lesions in FPMs. The more severe lesions affecting the FPMs in girls may be related to tooth eruption occurring earlier in most girls, as the earlier presence of the FPMs could provide the opportunity for lesions to progress.

Regarding the extent of the defects, 57.4% of the defects in the FPMs involved over one-third of the tooth surface. In contrast, 80.7% of the lesions in the PIs occupied less than one-third of the tooth surface. It has been reported that larger defect areas are significantly associated with increased enamel breakdown and carious lesion severity (Ghanim et al. 2011). In the current sample, the lesion extent in FPMs was greater than that in PIs, which may explain the more severe MIH lesions in FPMs. In addition, FPMs are subjected to greater masticatory forces, making them more susceptible to breakdown. In contrast, 45.3% of MIH lesions in SPMs involved at least 2/3 of the tooth surfaces. Investigating the extent of lesions in HSPMs in the 8–12-year age group, in a population with a very high caries prevalence, could lead to an overestimation of the severity of MIH.

Regarding the possible aetiological factors for MIH, we found a significant association between early childhood illness and MIH. Ear infection, respiratory distress, and history of tonsillitis were significant predictors of MIH. These results concur with previous findings from Saudi Arabia (Allazzam et al. 2014) and Iraq (Ghanim et al. 2013). Pregnancy-related problems were not significantly associated with MIH. This finding is also consistent with previous reports (Silva et al. 2016b; Allazzam et al. 2014). Respiratory distress has been reported to affect mineralisation because it causes hypoxia, which has been shown to affect the enamel matrix pH in some experiments (Koruyucu et al. 2018). A systematic review by Garot et al. (2021) found that perinatal hypoxia increased the risk of MIH development three-fold. Children with ear infections or tonsillitis often suffer from a high fever and are frequently treated with antibiotics. In the current study, high fever and antibiotic intake were not significantly associated with MIH, although some previous studies have found significant associations (Allazzam et al. 2014; Koruyucu et al. 2018). Laisi et al. (2009) reported that early use of amoxicillin could disturb mineralisation and, therefore, cause MIH. Our questionnaire method for detecting aetiological factors was limited by recall bias. Therefore, the collected data may not accurately reflect the actual medical history of the children. However, the causative mechanism of MIH is complex and multifactorial. It has been suggested that certain aetiological factors may contribute to MIH more than others, but the duration, strength, and timing of the risks should also be considered (Garot et al. 2021). Recent studies have suggested that MIH may be caused by the interaction between systemic and genetic factors. The genetic influence is supported by twin studies that showed a higher concordance rate for monozygotic twins than for dizygotic twins in the presentation of MIH (Teixeira et al. 2018). In addition, a previous study by Lygidakis et al. (2008) found that 12.2% of MIH-affected participants had no relevant medical history, which supports the hypothesis that genetic influence may play a role in aetiology (Garot et al. 2021). The presence of epigenetic factors may also play a role in the development of MIH (Garot et al. 2021), as these factors tend to mediate environmental influences on gene expression.

The current study has limitations and does not represent the entire Saudi community; however, our results indicate that MIH is common among Saudi children. According to a study conducted in 2016, awareness of MIH among Saudi dental staff is inadequate (Silva et al. 2016a). It has been reported that approximately 40% of GDPs, 80% of paediatric dentists, and almost 50% of other dental specialists have knowledge on MIH. Because five years have passed since that study was published, the level of awareness needs to be re-assessed. Increasing the awareness of MIH is important for early diagnosis and reducing dental complications. Despite the variation in treatment options (Somani et al. 2021), GDPs in primary care are responsible for the early detection of MIH and referral to specialist care if indicated. Thus, an awareness of the clinical signs of MIH and its treatment strategies among GDPs is highly important (Almuallem, Busuttil-Naudi 2018). Moreover, an awareness of MIH among dental specialists is also critical, as some MIH cases require multidisciplinary management.

Ethical approval

Ethical approval was obtained from the Ethics Committee at King Fahad Medical City, Ministry of Health, Saudi Arabia (No: H-01-R-012) and consent for publication was obtained from the Institutional Review Board at King Fahad Medical City, Ministry of Health, Saudi Arabia (IRB No: 19-016E).

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Zahra Almuallem: Methodology, Formal analysis, Data curation, Writing – original draft, Visualization, Supervision. **Abdulmalik Alsuhaim:** Investigation, Data curation, Project administration. **Abdulaziz Alqudayri:** Investigation, Data curation, Project administration. **Sarah Aljarid:** Investigation, Data curation, Project administration. **Mona Mousa Alotaibi:** Investigation, Data curation, Project administration. **Rawan Alkraida:** Investigation, Data curation, Project administration. **Rania Faden:** Investigation, Data curation, Project administration. **Faten Mojaleed:** Writing – review & editing, Project administration. **Moatazbellah Alruwaithi:** Resources, Writing – review & editing. **Haila Al-Huraishi:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors are very thankful to Dr Aghareed Ghanim (Melbourne Dental School, The University of Melbourne, Australia), for providing us with training and scientific materials as well as helping us in the statistical analysis. We also would like to thank; Riyadh Specialized Dental Center, Ministry of Health and Ministry of Education at Saudi Arabia for their help in facilitating this research.

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