Hypomineralised Second Primary Molars (HSPM): Prevalence, Clinical Characteristics and Association with Molar Incisor Hypomineralisation (MIH) in Children in Jordan

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Abstract

Aims The purpose of this study was to determine the prevalence of HSPM, its clinical presentation and any association to MIH in Jordanian children.

Materials and methods A cross-sectional study involving six-to-eight-year-old schoolchildren was carried out by two calibrated examiners. The MIH/HSPM index was used for scoring defects. A self-administered questionnaires exploring pre-, peri-, and post-natal relevant histories were also completed by parents. Descriptive statistics and chi-square test were used for data analysis with a p set at 0.05.

Results A total of 783 children (417 males and 366 females) with a mean age of (7.27 ± 0.6) years were enrolled in the study. The prevalence reported for MIH and HSPM was 40.1% and 44% respectively. Gender had no influence on the prevalence of HSPM (p=0.28), however, for MIH, the condition was more significantly reported in females compared to males (53.5% vs. 46.5%, p =0.002). The lower molars were significantly more affected than upper molars. Demarcated opacities were the most common clinical presentation. Mild lesion severity was the most frequently reported for both MIH and HSPM. The two conditions were significantly associated with each other (p =0.00,). However, HSPM was not predictive of MIH (OR=1.17, 95% CI=0.95 to 1.44). Regarding potential etiological/risk factors, maternal intake of vitamin D during pregnancy was significantly associated with less MIH in their children.

Conclusion MIH and HSPM were quite prevalent in Jordanian schoolchildren. The two conditions were significantly associated with each other, but HSPM was not predictive of MIH.

KEYWORDS Hypomineralisation, HSPM, MIH, prevalence, Children.

Introduction

Molar Incisor Hypomineralisation (MIH) is a qualitative developmental enamel defect of systemic origin that affects one or more first permanent molars (FPMs), with or without the involvement of the permanent incisors [Weerheijm et al., 2001]. Recently, MIH has been recognised as a significant public health issue, with an incidence of 17.5 million new cases reported in 2016 [Schwendicke et al., 2018]. In 2021, the global prevalence of MIH was estimated at 13.5%, though this figure varies widely across different regions [Lopes et al., 2021].

The aetiology of MIH is likely multifactorial, involving both genetic and environmental factors [Garot et al., 2022]. Although enamel formation is genetically controlled, it is also susceptible to environmental influences, which can disrupt amelogenesis and lead to enamel defects. The risk factors for MIH can be categorised based on their timing into prenatal, perinatal, or postnatal factors [Garot et al., 2022]. Despite extensive research, the precise cause of MIH remains unclear, and the condition is generally considered to be multifactorial [Almuallem & Busuttil-Naudi, 2018; Garot et al., 2022]. Clinically, MIH is characterised by demarcated opacities of enamel that range in color from creamy-white to yellow-brown, depending on the severity of the condition. The affected enamel is typically soft, porous, and prone to post-eruptive breakdown due to masticatory forces [Weerheijm et al., 2004]. Diagnostic criteria for MIH also include the presence of atypical caries, atypical restorations, or extractions resulting from MIH [Weerheijm et al., 2004]. Additionally, aesthetic concerns and subsequent social and emotional impacts can be significant when permanent incisors are visibly affected [Jälevik et al., 2022]. Subsequently, individuals with MIH often require extensive and repeated dental care [Al-Batayneh & Abdelghani, 2022]. In the primary dentition, a similar type of enamel hypomineralisation has been identified in the second primary molars, a condition now known as Hypomineralised Second Primary Molars (HSPMs) [Elfrink et al., 2008]. The etiological factors implicated in the pathogenesis of MIH and HSPM are believed to be similar, owing to the temporal overlap in the mineralisation periods of the affected teeth. Due to this overlap, MIH and HSPM are likely to co-exist when a disturbance or risk factor occurs during this critical period. Numerous studies have reported an association between MIH and HSPM [Elfrink et al., 2012; Mittal et al., 2016; Gambetta-Tessini et al., 2018]. Therefore, HSPM has been proposed as a potential predictor for MIH [Garot et al., 2018]. However, this association has not been consistently observed across studies [Ghanim et al., 2013; Costa-Silva et al., 2013; Sidhu et al., 2019]. Recently, there has been increased interest globally in investigating the epidemiology of HSPM and its association with MIH, given that these conditions pose challenges for clinicians and patients

and contribute to significant economic burdens on public health. A recent systematic review and meta-analysis by McCarra et al. reported considerable variation in the prevalence of HSPM, ranging from 0% to 41% [McCarra et al., 2021]. The studies included in this review differed markedly in methodology, including study design, population characteristics, and sample size. Variation was also evident in examination settings and scoring indices used. In the literature, the European Academy of Paediatric Dentistry (EAPD) judgment criteria have been the most commonly used index for scoring MIH/HSPM [Lopes et al., 2021]. Other indices, such as the modified index of Developmental Defects of Enamel (mDDE) and various self-devised indices, have also been utilised. However, some indices, including the mDDE, were not specific to MIH/HSPM defects and failed to account for teeth with extensive breakdown, atypical restorations, or extractions, leading to an underestimation of true cases [Ghanim et al., 2017]. Moreover, the MIH/HSPM index has been recently developed to standardise scoring methods across studies [Ghanim et al., 2015], with the aim to improve methodological consistency and standardise data collection in epidemiological surveys at both individual and population levels. To the best of our knowledge, there is no existing prevalence data on HSPM in Jordan, nor has any study been conducted using the MIH/HSPM index to assess MIH prevalence. Therefore, our present study aims to determine the prevalence of HSPM using the MIH/HSPM index, record the clinical characteristics of the condition, and examine its association with MIH in children. Providing prevalence data on HSPM and its relationship with MIH will aid in the early diagnosis of these conditions and facilitate targeted preventive care and management strategies for at-risk children. Additionally, this survey aims to explore potential risk and etiological factors within the study population.

Material and methods

Study design

This was a cross-sectional survey that sought to report the prevalence of HSPM and its association with MIH in schoolchildren in Jordan.

Inclusion/exclusion criteria of the study population

This study employed a cross-sectional survey design to assess the prevalence of HSPM and its association with MIH among schoolchildren in Jordan. The study included a consecutive sample of children aged six to eight years from different primary schools in Jordan. Schools were randomly selected from a list provided by the Ministry of Education. Of these, five public and four private primary schools agreed to participate. Children within the specified age range, who were present at school on the examination day, and had parental/legal guardian consent to participate were included in the study. Conversely, children outside the age range, those who declined oral screening, or who did not have valid parental consent were excluded.

Sample size calculation

The minimum sample size required for this prevalence study was determined using the formula provided by Naing et al. [Naing et al., 2016], which is given by: (n) = [Z2 x P(1-P)]/d2 where Z represents the statistical confidence level (1.96 for a 95% confidence interval), P denotes the expected prevalence, and d is the precision [Elfrink et al., 2015]. Based on the previously reported prevalence of MIH in Jordan, estimated at 17.6% [Zawaideh et al., 2011], the calculated minimum sample size was 217 children. However, a larger sample size of 300 was deemed appropriate for robust prevalence estimation [Elfrink et al., 2015]. Consequently, the sample size was increased to enhance the study's statistical power and external validity.

Ethical considerations

The study was approved by the Institutional Research Board (IRB) of the Jordan University of Science and Technology (JUST) (Research Grant No. 2022/6, Date: March 31, 2022). All procedures adhered to the ethical standards outlined in the Declaration of Helsinki. Primary schools from various cities in Jordan were randomly selected and invited to participate. An invitation letter, along with a brief explanation of the study, was sent to the administration of the selected schools. Upon receiving approval from the schools, the examination date and time were scheduled. One week prior to the examination, information leaflets and consent forms were distributed to parents, requesting permission for their children to participate in the study.

Examiners calibration

The MIH/HSPM grading system, as outlined by Ghanim et al. [Ghanim et al., 2015], was employed for scoring the index teeth, which included FPMs, second primary molars, and permanent incisors. Two pediatric dentists served as examiners and underwent a comprehensive training and calibration process for the examination of HSPM and MIH. The training consisted of a theoretical component that explained the clinical diagnostic criteria for both HSPM and MIH. This was followed by a practical session where examiners scored a series of clinical photographs depicting various presentations and severities of HSPM and MIH. Additionally, the clinical presentation of other enamel defects that could be mistaken for HSPM or MIH was discussed. The images presented by Ghanim et al. [Ghanim et al., 2017] in Module V were also evaluated by the examiners. Two calibration sessions were conducted one week apart, and clinical calibration was confirmed by examining ten affected patients before the survey. The agreement between the two examiners on the scoring of sound and hypomineralised teeth was high. Intra- and inter-examiner reliability was assessed using Kappa scores, yielding substantial intra-rater agreement (86.7%) and inter-rater agreement (93.3%).

Children's examination and teeth scoring

The screening was performed by the two calibrated examiners in the classroom setting. Teeth were examined in a wet state, with gauze used to remove any plaque or excess saliva. An artificial light source and a disposable dental mirror were employed for the examination. Strict infection control measures were followed, including disinfection between subjects, the use of disposable gloves and mirrors for each participant, and alcohol hand gel for disinfecting examiners' hands after each examination. In each subject, only the index teeth were systematically scored, beginning with the upper right quadrant and proceeding in a clockwise direction to the lower right quadrant. For each quadrant, the index teeth were coded using the short form of the MIH/HSPM index. The current survey incorporated several modifications to the index to address specific scenarios (Table 1). First, stainless-steel crowns (SSCs) were excluded from the atypical restorations category (code 4) and were instead categorised separately within a new subcategory (code 4B). Second, when an index molar was missing in an otherwise intact dentition, with no signs of HSPM or MIH, the reason for the extraction could not be determined. In such cases, these teeth were sub-grouped and assigned a separate score within the extraction code (6B). Lastly, code 7 (cannot be scored) was subdivided to address two conditions: code 7A for teeth that could not be scored due to being unerupted or partially

Code	Definition by MIH/HSPM index	Modifications (if any) in this study
0	No visible enamel defect	--
1	Non-HSPM/MIH enamel defect	--
2	Demarcated opacities: 2A- white-creamy 2B- yellow-brown	--
3	Post-eruptive enamel breakdown	--
4	Atypical restorations	4A- Atypical restorations 4B- Stainless steel crowns (SSCs)
5	Atypical caries	--
6	Missing due to MIH/HSPM	6A: Missing due to MIH/HSPM 6B: Extracted in non-HSPM/MIH patient (i.e. no signs of MIH/HSPM)
7	cannot be scored	7A: Cannot be scored due to un- or partial eruption (with less than one third of the crown visible) 7B: Cannot be scored due to extensive coronal breakdown

TABLE 1 Modifications to the MIH/HSPM index codes used in the current study.

erupted, and code 7B for teeth that could not be scored due to extensive coronal breakdown. Additionally, affected index teeth were categorised based on lesion extension and severity as defined in the MIH/HSPM index: mild (code I = less than one-third of the tooth surface affected), moderate (code II = at least one-third but less than two-thirds affected), and severe (code III = at least two-thirds of the tooth surface affected). Two research assistants, both qualified general dentists, were designated to assist with recording scores on data collection sheets. They also collected consent forms and completed questionnaires from participants. For children identified with treatment needs, a letter advising a dental visit was provided to their parents.

Questionnaire

In this survey, parents were asked to complete a brief questionnaire regarding their child's pregnancy, childbirth, and early childhood health. This questionnaire was developed based on identified risk factors from a comprehensive review of the literature [Crombie et al., 2009; Alaluusua, 2010; Elfrink et al., 2014] and aimed to gather information about any maternal or early childhood systemic illnesses occurring during the prenatal, perinatal, and postnatal periods. Additionally, mothers were asked to report any drugs or supplements taken during pregnancy and any medications administered to the child during the first three years of life as accurately as they could recall. It is important to note that recall bias was a potential limitation in this context. The questionnaire was piloted with five mothers to ensure question clarity, and no confusion or misunderstanding was reported.

Statistical analysis

All collected data were anonymised using reference numbers for each subject, coded, and entered into Microsoft Excel (version 16.47). The data were subsequently analysed using the Statistical Package for Social Sciences (SPSS version 27).

Descriptive statistics were employed to calculate frequencies and percentages of teeth and children affected by hypomineralisation and to determine the distribution of various clinical presentations of index teeth. The chi-square test was utilised to assess the association between MIH and HSPM. Odds ratios were calculated to estimate the risk of MIH in patients with HSPM. Furthermore, the binary logistic regression was applied to explore the association between hypomineralisation and maternal/childhood illnesses or medications. Statistical significance was set at a p-value of <0.05.

Gender	N (%)	Total
Males	417 (53.3)	783
Females	366 (46.7)	
Age (years)		
6	121 (15.5)	783
7	380 (48.5)	
8	282 (36)	
Type of school		
Public	482(61.6%)	783
Private	301 (38.4%)	

TABLE 2 Demographic characteristics of the study population.

Results

Demographic characteristics of the study population

A total of 783 children aged six to eight years (mean age: 7.27 ± 0.6 years) were enrolled in the study, achieving a maximum power of 100%. The number of teeth that were available for examination was 9339 (after excluding the unerupted or extracted index teeth). All screened subjects were included in the final analysis. The study sample consisted of 417 males (53.3%) and 366 females (46.7%) from nine different primary schools in Jordan. The demographic characteristics of the study population are detailed in Table 2.

HSPM and MIH distribution and clinical characteristics in the study sample

Screening was conducted by two examiners between October 2022 and February 2023. The prevalence of HSPM and MIH, both at the tooth and child levels, is provided in Table 3. No gender predilection was observed for HSPM (p = 0.28). However, MIH was more prevalent in females (53.5%) compared to males (46.5%), with this difference being statistically significant (p = 0.002) (Table 3). A significant association was found between HSPM and MIH in the study population (p = 0.000, Pearson's Chi-square = 30.159). Nonetheless, HSPM was not a predictive factor for MIH (OR = 1.17, 95% CI: 0.95 to 1.44) (Table 4). The lower molars were significantly more affected than the upper molars, as shown in Figure 1. This was evident for both lower FPMs (p < 0.05; Chi-square = 22.3) and lower second primary molars (p < 0.05; Chi-square = 42.2) compared to their upper counterparts. No statistically significant difference was observed between right and left molars for either MIH or HSPM. Figure 1 illustrates the percentages of teeth affected by hypomineralisation, with incisor involvement being notably less frequent. Among incisors, upper incisors were significantly more affected than lower incisors (p = 0.039), and central incisors showed a higher prevalence of involvement compared to lateral incisors (p = 0.000). No significant difference was noted between the right and left incisors (p = 0.654). The mean number of af-

	HSPM	MIH	Total
Tooth level	621 (19.8%)	645 (20.6%)	9339
Child level	345 (44.1%)	314 (40.1%)	783
Males	176 (51.0%)	146 (46.5%) *	417
Females	169 (49.0%)	168 (53.5%) *	366
**Statistically significant difference(P<0.05)*			

TABLE 3 Prevalence of HSPM and MIH, and their distribution by gender.

MIH/HSPM presence	No	Yes	Total	P-value	OR	95% CI
NO	299 (68.3)	167 (48.8)	466	0.000*	1.17	0.95 - 1.44
Yes	139 (31.7)	178 (51.2)	317			
Total	438	345	783			
**Pearson's Chi-square = 30.159*						

TABLE 4 Association between HSPM and MIH in the study sample.

Code* / Tooth group	0	1	2A	2B	3	4A	4B	5	6A	6B	7A	7B
FPMs	1823 (58.3)	271 (8.7)	490 (15.7)	90 (2.9)	30 (1.0)	3 (0.1)	3 (0.1)	28 (0.9)	1 (0.03)	3 (0.09)	381 (12.2)	6 (0.2)
SPMs	2008 (64.1)	118 (25.9)	180 (5.7)	23 (0.7)	10 (0.3)	53 (1.5)	152 (4.9)	178 (5.7)	25 (0.8)	171 (5.5)	0 (0)	214 (6.8)
CIs	1991 (63.6)	171 (5.5)	140 (4.5)	43 (1.4)	2 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	783 (25.0)	0 (0)
LIs	1157 (36.9)	83 (2.6)	43 (1.4)	18 (0.6)	2 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.03)	1827 (58.3)	0 (0)

**As modified by authors of the current study*
Abbreviations: FPMs: First Permanent Molars, SPM: Second Primary Molars, CIs: Central Incisors, LIs: Lateral incisors
Codes: 2A: White-creamy, 2B: Yellow-brown, 3: Post-eruptive enamel breakdown, 4A: Atypical restorations, 4B: Stainless steel crown, 5: Atypical caries, 6A: Missing due to MIH/HSPM, 6B: Missing, no MIH/HSPM signs,7A: Cannot be scored due to un- or partial eruption (with less than one third of the crown visible), 7B: Cannot be scored due to extensive coronal breakdown.

TABLE 5 Frequency (percentage) of various clinical presentations by tooth group in the study population.

fected teeth per child was 1.8 ± 2.1. This figure was not influenced by gender or age. Among children diagnosed with HSPM, 169 (21.6%) had one molar affected, 104 (13.3%) had two molars, 44 (5.6%) had three affected molars, and 28 (3.6%) had all their second primary molars involved. For MIH, the distribution was as follows: 133 (17.0%) had one molar affected, 81 (10.3%) had two molars, 55 (7.0%) had three molars affected, and 45 (5.7%) had all their FPMs affected. Additionally, 33.1% of children with MIH had involvement of permanent incisors. Regarding clinical presentations, Table 5 displays the distribution of various clinical presentations by tooth group. Figure 2 illustrates the distribution of diagnostic criteria for MIH and HSPM (i.e., codes 2-6). Demarcated opacities were the most frequent clinical presentation and were significantly more common in MIH compared to HSPM ($p < 0.05$). Conversely, atypical restorations, atypical cavities, and extractions due to hypomineralisation were more frequently observed in HSPM ($p < 0.05$). Furthermore, unerupted teeth were grouped separately (code 7A) and excluded from the prevalence calculation. Table 5 shows the frequency of unerupted teeth by type (FPMs, SPMs, central incisors, and lateral incisors). To prevent overestimation of the prevalence figures, teeth crowned with stainless steel crowns were sub-grouped and excluded in a separate statistical analysis. The prevalence of MIH remained at 40%, while the prevalence of HSPM decreased to 36.3%.Among the FPMs affected by hypomineralisation (n = 640), 450 (70.3%) were classified as mild, 136 (21.3%) as moderate, and 54 (8.4%) as severe (Figure 3). For HSPM, 178 (40.5%) second primary molars exhibited mild hypomineralisation, 137 (31.2%) had moderate hypomineralisation, and 124 (28.2%) had severe presentation (Figure 3). Severity was not influenced by age or the number of teeth affected per child.

Questionnaire results

Out of 783 distributed questionnaires, 518 were returned by parents, yielding a response rate of 66%. Despite this, the calculated power of this part of the study remained high at 93.6%. Chi-square tests and binary logistic regression revealed no significant association between maternal or early childhood systemic illnesses and HSPM or MIH. Regarding drugs or supplements taken during pregnancy and medications administered during the child's first three years of life, no significant associations with HSPM were found. However, for MIH, the intake of vitamin D during pregnancy was found to significantly reduce the incidence of hypomineralisation in children ($p = 0.021$). MIH was present in 42.1% of children whose mothers did not take vitamin D during pregnancy, compared to 30.9% in those whose mothers reported taking the vitamin. Perinatal conditions or complications were not

associated with the presence of HSPM or MIH ($p > 0.5$).

Discussion

Study design and population

This study represents the first comprehensive assessment of HSPM prevalence in Jordan. The primary aim was to determine the prevalence of HSPM and document its clinical characteristics using the MIH/HSPM-specific index. While a previous study estimated the prevalence of MIH in Jordan [Zawaideh et al., 2011], the use of the EAPD criteria for scoring defects in that study may have influenced the reported figures. The MIH/HSPM index [Ghanim et al., 2015], specifically developed to standardise scoring methods and enhance data collection consistency, was employed in this study to provide a more accurate and up-to-date prevalence of MIH. The study further investigated the association between HSPM and MIH among Jordanian schoolchildren. Additionally, the study aimed to identify potential etiological factors in the study population. The minimum required sample size, calculated using the formula provided by Naing et al. [Naing et al., 2006], was 217 children. However, due to the study's timeline, the actual sample size was increased to 783 children from various public and private schools in Irbid and Amman, Jordan, thereby achieving a study power of 100%. This extensive sample size enhances the reliability of the findings. Children aged six to eight years were selected for this study, aligning with recommendations for examining conditions such as MIH and HSPM at an age where they are most recognisable [Elfrink et al., 2015]. Moreover, children within this age range are generally more cooperative, which aids in the data collection process during dental examinations. To ensure high-quality data, the scoring of teeth was conducted by two calibrated examiners at schools, who demonstrated relatively high inter- and intra-examiner agreement. This calibration process is crucial for minimising variability and ensuring the accuracy of the diagnostic assessments.

Prevalence of HSPM and MIH

This survey provides significant insights into the prevalence of HSPM and MIH among Jordanian schoolchildren. The prevalence rates reported in this study are notably higher than the estimated global figures for both conditions. A similar high prevalence of MIH, 42.4%, was reported in schoolchildren aged 6-12 years in Mexico [Villanueva Gutiérrez et al., 2019]. Similarly, in Brazil, a prevalence of 40.2% was observed, although this study focused on demarcated opacities in permanent molars without specifically targeting MIH [Soviero et al., 2009]. In contrast, Balmer et al. reported high prevalence rates of HSPM in Leeds (40%) and Sydney (44%). However, these studies involved small sample sizes (25 subjects per group) and broad age ranges, limiting the generalisability of their findings and complicating direct comparison with the current study [Balmer et al., 2005]. In a neighboring country, Syria, a high prevalence of HSPM (41%) was reported [Halal and Raslan, 2020]. The authors attributed this high rate to the use of different diagnostic criteria (EAPD criteria) and the inclusion of a younger age group (preschoolers), which may have prevented the masking of hypomineralisation by secondary caries or fillings. For MIH, a recent study in Syria reported a prevalence of 39.9% [Al-Nerabieah et al., 2023], with a high prevalence likely influenced by the ongoing crisis's impact on healthcare and population health [Al-Nerabieah et al., 2023]. In Jordan, HSPM prevalence had not been previously reported, while MIH prevalence was reported as 17.2% in a prior study [Zawaideh et al., 2011]. The discrepancy may reflect differences in diagnostic criteria . Another possible explanation is the slightly younger age group in the current study.

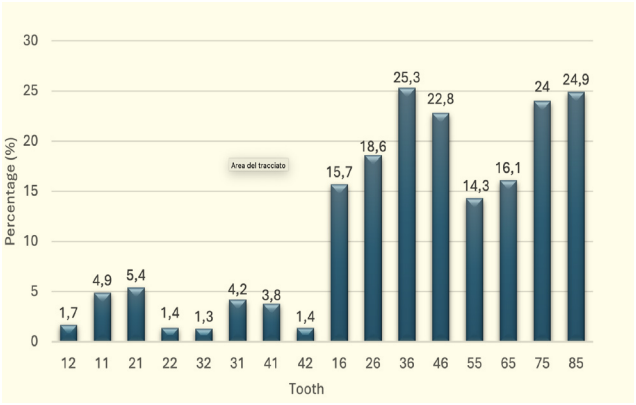

FIG. 1 Percentage of teeth affected by hypomineralization.

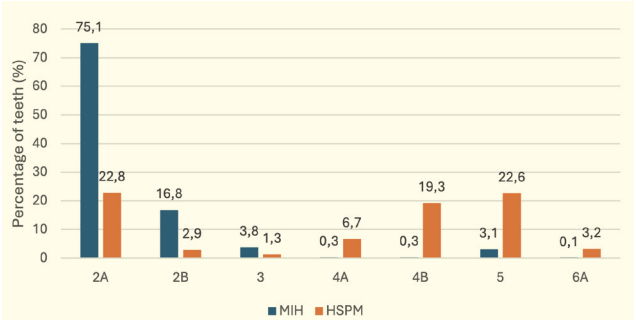

FIG. 2 Distribution of clinical presentations in HSPM and MIH.

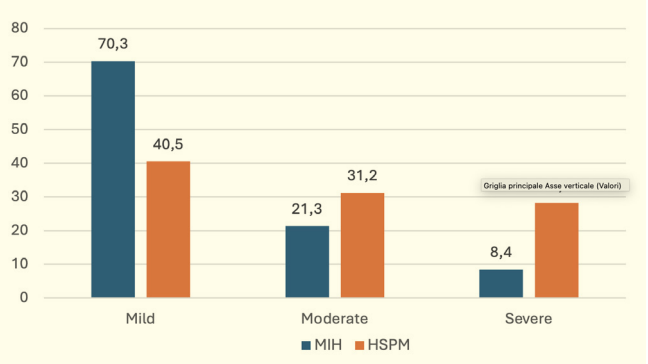

FIG. 3 Severity of lesions for HSPM and MIH.

Zhao et al. have noted a decrease in prevalence with age, possibly due to more severe cases being treated or masked by interventions such as extractions [Zhao et al., 2017]. The high prevalence could also indicate an actual recent increase in MIH prevalence in the region and warrants further studies to confirm this finding. As expected, the prevalence of HSPM and MIH at the child level (44% and 40.1%, respectively) was higher than at the tooth level (19.8% and 20.6%, respectively), indicating that not all molars in affected children were involved. Regarding gender differences, the current study found a statistically significant higher prevalence of MIH in females compared to males. This finding is consistent with previous reports from Jordan [Zawaideh et al., 2011], where it was suggested that earlier dental development and tooth eruption in females might make MIH more apparent. Similar findings have been reported in Iran [Ghanim et al., 2014] and Venezuela [Rodríguez-

Rodríguez, 2021]. Conversely, some studies have reported a higher prevalence in males [Preusser et al., 2007; Garcia-Margarit et al., 2014]. A recent systematic review failed to identify a significant sex difference in MIH prevalence [Zhao, 2018; Lopes et al., 2021], suggesting that observed gender differences may be incidental rather than indicative of a direct association with the condition.

Distribution and clinical characteristics

The current survey revealed that lower molars were more frequently affected by both HSPM and MIH compared to upper molars. This finding aligns with the results reported by Zawaideh et al. [Zawaideh et al., 2017], yet contrasts with studies suggesting a higher prevalence of these conditions in maxillary molars [Ghanim et al., 2013; Biondi, 2019]. Such spatial differences in the involvement of dental anomalies between upper and lower arches, as well as between right and left sides, are likely incidental and may not indicate a specific underlying cause. As noted by Brook, amelogenesis is a complex process involving intricate interactions among genetic, epigenetic, and environmental factors. In addition, different tooth germs may be at varying stages of formation, and any disturbance may manifest differently depending on the developmental stage of the teeth at that time [Brook, 2009]. The survey identified demarcated opacities as the most common clinical presentation, consistent with several other studies [Ghanim et al., 2013; Sidhu et al., 2019; McCarra et al., 2021; Rodríguez-Rodríguez et al., 2021], and this high prevalence may be attributed to the relative ease of detecting demarcated opacities, which are captured by various diagnostic indices. The occurrence of atypical restorations was low in this study. It is proposed that hypomineralised teeth with atypical cavities are more likely to be restored with stainless steel crowns (SSCs) rather than intracoronal restorations, which have a higher failure rate [Seale & Randall, 2015]. Notably, this study calculated the prevalence of hypomineralisation, both including and excluding crowned teeth. Since SSCs are often the preferred restoration for carious molars, particularly in children with high caries risk, the presence of a crown does not necessarily indicate hypomineralisation [Elfrink et al., 2008]. When crowned teeth were excluded, the prevalence of HSPM decreased from 44% to 36.3%, while the prevalence of MIH remained unchanged. However, it is worth noting that the current study involved only few crowned FPMs.In the current study, mild lesion severity was the most commonly observed presentation for both HSPM and MIH. This finding is consistent with previous research [Zawaideh et al., 2017; Sidhu et al., 2019; Rodríguez-Rodríguez et al., 2021]. Notably, the severity of HSPM was generally greater than that of MIH in this study. This difference may be partially attributed to the age of the study population. The literature suggests that the optimal age for diagnosing HSPM is around 5 years [Elfrink et al., 2015]. As children age, the likelihood of post-eruptive breakdown (PEB), atypical caries, and atypical restorations increases. Thus, the age of the study population may have influenced the profiling of HSPM, as older children might have experienced more severe destruction of the affected primary molars, potentially leading to their loss. Regarding condition extension, the involvement of a single molar per child was the most frequent presentation for both HSPM and MIH, which is considered relatively favorable. Only a small proportion of cases—3.6% for HSPM and 5.7% for MIH—had all molars affected. This pattern is in line with findings from Elfrink et al. [Elfrink et al., 2012], who reported that hypomineralisation most often affected only one molar. Furthermore, the current study observed an association between HSPM and MIH. This correlation has been documented in the literature, likely due to the shared mineralisation period for the FPMs and the second primary molars [Elfrink et al., 2012]. However, this study did not find HSPM to be a predictive factor for MIH, suggesting that the two conditions may represent distinct clinical entities [Sidhu et al., 2019]. This finding contrasts with a recent systematic review and meta-analysis, which reported that, despite considerable heterogeneity across studies, the presence of HSPM was predictive of MIH [Garot et al., 2018]. It is possible that the lack of predictive value in this study could be attributed to the sample size; a larger population might have revealed a stronger correlation and predictive capacity. The positive predictive value of HSPM could be leveraged to identify at-risk children for timely diagnosis and management, particularly in populations with a high prevalence, such as those investigated here. The high frequency of these conditions underscores a significant burden. It is estimated that approximately one-quarter of children with MIH require dental treatment [Schwendicke et al., 2018]. Moreover, a recent study indicated that 80% of children screened required dental treatment for molars affected by MIH, with 70% needing vital pulp therapy for molars with deep caries [Al-Batayneh and Abdelghani, 2022]. The current survey aimed to investigate potential etiological factors associated with HSPM and MIH, similar to other prevalence studies in the literature. A significant association was found between maternal vitamin D deficiency and MIH. Specifically, mothers who reported taking vitamin D supplements during pregnancy had a significantly lower incidence of MIH in their children. This finding aligns with a recent longitudinal study, which observed a higher occurrence of hypomineralised teeth associated with maternal vitamin D insufficiency [Børsting et al., 2022]. Although the precise aetiology of MIH remains unclear, disturbances affecting the amelogenesis of second primary molars and FPMs have been implicated [Garot et al., 2022]. It is important to note that, according to Elfrink et al. [Elfrink et al., 2015], a sample size of at least 1000 is generally recommended for studies on etiological factors. Consequently, the sample size in the current study may have been insufficient for a comprehensive exploration of potential causes. Additionally, recall bias may have affected the accuracy and reliability of data collected through parental questionnaires. Therefore, prospective cohort studies are recommended to obtain more accurate data.

Despite these interesting findings, our current study had several limitations that should be acknowledged. First, the examination conducted in a school setting may have led to an underestimation of defects due to limited viewing conditions. However, this study employed an artificial light source to enhance illumination and improve visibility. Furthermore, the accuracy of coding and data quality in epidemiological research depends on examiner calibration and training. Despite this, the survey achieved a high Kappa score for intra- and inter-rater agreement, suggesting that the prevalence figures reported can be considered a reliable estimate for Jordan. Additionally, the study's reliance on convenience sampling is another limitation. Although schools were randomly selected, children were enrolled consecutively from each school. Random sampling of students would have provided a more accurate representation and enhanced the generalisability of the results to the broader population.

Conclusion

A significant proportion of schoolchildren in this study were found to be affected by HSPM, with or without concurrent MIH. While the two conditions were significantly associated with each other, HSPM was not predictive of MIH. The prevalence rates reported in this study were generally higher than the global estimates for both HSPM and MIH but are consistent with figures from other regional studies. To validate these high prevalence rates, further research of similar designs in neighboring countries

is necessary. This elevated prevalence represents a substantial public health issue and warrants serious attention. It is crucial to implement early screening and targeted interventions for affected children to address potential oral, psychological, and economic complications proactively.

Statements and Declarations

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Conflict of interest

All authors declare no conflict of interest.

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