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Prevalence, clinical characteristics, and treatment needs of Molar Incisor Hypomineralization (MIH) in Turkish children: a cross-sectional study

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Abstract

Background Molar Incisor Hypomineralization (MIH), with a reported global prevalence of 15.5%, is considered a significant dental public health problem due to its distinct clinical manifestations in affected teeth. This study aimed to determine the prevalence of MIH in a large sample of Turkish children attending a university pediatric dental clinic and to evaluate lesion characteristics, treatment needs, and patterns of hypersensitivity at both the patient and tooth levels.

Methods This study was designed as a clinic-based cross-sectional study. A total of 1,680 children aged 8–13 years presenting to a university pediatric dental clinic were initially examined; of these, 97 children in whom not all first permanent molars were clinically assessable were excluded. The final analytical sample therefore comprised 1,583 children. Clinical status, lesion extension, and the Treatment Need Index (TNI) were recorded for first permanent molars and incisors. Hypersensitivity was assessed clinically using the Schiff Cold Air Sensitivity Scale and dichotomized as present (scores 1–3) or absent (score 0). Prevalence and confidence intervals (CIs) were calculated using binomial methods. Group comparisons were performed using chi-square tests. Patient-level analyses were conducted using count regression models to describe the distribution of MIH-affected teeth per child, while tooth-level associations with hypersensitivity were analyzed using binary logistic regression models with adjustment for within-child clustering.

Results MIH was diagnosed in 295 children, corresponding to a prevalence of 18.6% (95% CI: 16.6–20.5). Molars were more frequently affected (79.7%) than incisors (22.9%; $p < 0.001$). Hypersensitivity was predominantly concentrated in molars, with the highest proportions observed in mandibular molars (up to 24%), whereas incisors showed minimal involvement. Logistic regression showed that post-eruptive enamel breakdown and atypical caries were most strongly associated with hypersensitivity (OR = 4.94 and OR = 6.44, respectively; $p < 0.001$).

Conclusions MIH affected nearly one in five to six children in this clinic-based pediatric population. First permanent molars were the most severely affected teeth, whereas incisors were predominantly characterized by demarcated

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opacities. Hypersensitivity was primarily associated with destructive lesion types, particularly post-eruptive enamel breakdown and atypical caries.

Keywords Dental public health, Enamel defects, Hypersensitivity, Molar incisor hypomineralisation, Molar incisor hypomineralization, Oral epidemiology, Pediatric dentistry, Prevalence, Public health dentistry, Treatment need

Background

From an epidemiological perspective, Molar Incisor Hypomineralization (MIH) is recognized as one of the most common developmental enamel defects [1]. The condition was first defined in 2001 as a hypomineralization affecting at least one first permanent molar, often accompanied by involvement of permanent incisors [2]. Since then, the number of prevalence studies has increased substantially, reflecting both greater clinical awareness and a possible rise in its occurrence. A recent systematic review, including 135 studies from 53 countries, estimated a worldwide prevalence of 15.5% (95% confidence interval [CI]: 14.4–16.6), with individual study rates ranging from 0.6% to 46.6% [3]. However, these estimates vary considerably depending on study design, diagnostic criteria, and sampling strategies, particularly between population-based and clinic-based studies.

The etiology of MIH remains unclear and is considered multifactorial. Proposed contributing factors include prenatal influences such as maternal illness and medication use; perinatal factors including prematurity and birth complications; and postnatal conditions such as early childhood illnesses, high fever, and antibiotic exposure. Environmental pollutants and, more recently, genetic and epigenetic mechanisms have also been suggested to play a role in the susceptibility to MIH [4–6].

Clinically, MIH presents as qualitative enamel defects, typically appearing as demarcated opacities on first permanent molars and incisors. Lesions may range from white/cream to yellow/brown, with darker discolorations generally indicating greater mineral loss and increased enamel porosity [7, 8]. This structurally compromised enamel is prone to post-eruptive enamel breakdown (PEB), leading to rapid tissue loss under functional loading [9]. MIH-affected teeth are also associated with hypersensitivity, which is defined as an increased sensitivity response to external stimuli (e.g., thermal, evaporative, or tactile stimuli) [10], as well as an increased risk of atypical caries, the presence of atypical restorations, and, in severe cases, the extraction of affected first permanent molars due to extensive structural breakdown [11, 12].

Managing MIH-affected teeth presents considerable clinical challenges. Hypersensitivity may impair effective oral hygiene, reduce dietary comfort, and complicate routine dental procedures due to difficulties in achieving adequate local anesthesia [13, 14]. Restorative management is often complex, with a frequent need for repair or replacement, and severe cases may require multidisciplinary approaches [11].

From a public health perspective, MIH contributes substantially to dental morbidity in children. Its impact extends beyond immediate treatment needs by increasing healthcare costs, complicating long-term oral health maintenance, and affecting the quality of life of school-aged children [15, 16]. Esthetic concerns, particularly when anterior teeth are involved, may also lead to psychosocial distress [17, 18].

Despite the growing body of research, evidence regarding the detailed clinical presentation and treatment needs of MIH across different populations remains limited. In Türkiye, although several prevalence studies have been conducted, comprehensive clinic-based investigations integrating lesion characteristics, hypersensitivity, and treatment needs within a unified analytical framework are still scarce, particularly those employing standardized indices and tooth-level analyses adjusted for within-child clustering. The MIH Treatment Need Index (MIH-TNI), introduced by Steffen et al. [19], was developed to classify affected teeth according to treatment needs by incorporating structural integrity, PEB, and hypersensitivity into a single framework. Unlike indices that primarily describe lesion appearance, MIH-TNI provides a treatment-oriented assessment of disease severity. Importantly, although MIH-TNI is applied at the tooth level, it reflects clinically relevant outcomes such as hypersensitivity and structural breakdown, which directly influence treatment decisions and collectively contribute to the overall patient-level treatment burden. In this context, differences in lesion severity between molars and incisors may translate into distinct treatment needs, with molars more frequently associated with functional impairment and restorative interventions, whereas incisors are often linked to esthetic concerns. Therefore, MIH-TNI offers a clinically meaningful framework for interpreting both tooth-level severity and its potential implications for patient management and comparison across studies [20].

Therefore, the present study was designed to evaluate the clinical burden of MIH in a sample of Turkish children attending a university pediatric dental clinic by assessing lesion characteristics, hypersensitivity, and treatment needs at both the patient and tooth levels.

Methods

Ethical considerations

This cross-sectional study was reviewed and approved by the Clinical Research Ethics Committee of Marmara University (Approval No. 2019/360). All procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki. Detailed information regarding the study protocol was provided to all participants and their parents or legal guardians. Written informed consent was obtained from each child and his or her parent or legal guardian prior to participation. Participation was entirely voluntary, and the confidentiality of all personal information was strictly maintained. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies.

Study design and population

This investigation was conducted at the Department of Pediatric Dentistry, School of Dentistry, Marmara University, Istanbul, Türkiye. The study was carried out between December 2022 and December 2023. During this period, two weekdays per week were selected using a simple randomization procedure from Monday to Friday at the beginning of each week, and all children presenting to the pediatric dentistry clinic on those days were examined. No fixed pattern (e.g., the same weekdays each week) was used, and selection was independent of clinic schedules, clinician availability, and patient characteristics. This approach was adopted to estimate the clinical burden and prevalence of MIH within a clinic-based pediatric population rather than to derive population-level estimates.

Children were eligible for inclusion if they were between 8 and 13 years of age, had all four first permanent molars clinically assessable, and attended the pediatric dentistry clinic on the designated study days. Children in whom one or more first permanent molars were not yet erupted and therefore could not be evaluated were excluded from the final analysis to ensure complete assessment in accordance with the European Academy of Paediatric Dentistry (EAPD) diagnostic principles [21]. Exclusion criteria included conditions that precluded adequate intraoral examination, such as behavioral management problems, limited mouth opening, severe intellectual disability, or ongoing orthodontic treatment, as well as cases with incomplete clinical records.

Sample size calculation

The required sample size for estimating the prevalence of MIH within the study population was calculated using a single-proportion formula: $n = (Z\alpha/2^2 \times p \times (1 - p)) / d^2$, where p is the expected prevalence, d is the margin of error, and $Z\alpha/2$ is the standard normal deviate at the 95% confidence level. Based on a previous epidemiological study in Türkiye reporting an MIH prevalence of 11.5% [22], we used $p = 0.115$, $d = 0.02$, and $Z\alpha/2 = 1.96$. This yielded a minimum required sample size of 973 children. This calculation was performed a priori based on expected prevalence estimates to ensure adequate statistical power for the study. The final analytical sample of 1,583 children exceeded the minimum required sample size, indicating that the study was sufficiently powered for the planned analyses.

Clinical examination and diagnostic standards

All examinations were carried out under standardized conditions by a single experienced pediatric dentist at the Department of Pediatric Dentistry, School of Dentistry, Marmara University. Children were examined in a dental unit (Planmeca Sovereign, Planmeca Oy, Helsinki, Finland) under an integrated operating light. A standard dental mirror (Hu-Friedy, Chicago, IL, USA) and a periodontal probe (WHO probe, Hu-Friedy, Chicago, IL, USA) were used for intraoral examination. Prior to assessment, all teeth were cleaned of visible debris with gauze and dried for 2–3 s using compressed air from the unit's three-way syringe to optimize the visualization of enamel defects.

Prior to the calibration process, the examiner underwent training in the diagnosis and classification of MIH based on the EAPD criteria [21]. This training included a review of clinical photographs and reference cases, as well as the discussion of diagnostic thresholds to ensure consistency in the identification and categorization of MIH lesions.

Intra-examiner reproducibility was assessed by re-examining 20 children with previously diagnosed MIH, who were not included in the final sample, at a one-week interval. MIH presence, clinical status (lesion type), and MIH-TNI categories were reassessed, and agreement was evaluated using Cohen's kappa coefficient, which demonstrated a high level of agreement ($\kappa = 0.97$).

MIH-related enamel defects were diagnosed according to the criteria of the EAPD [21]. Each first permanent molar (16, 26, 36, 46) and permanent incisor (11, 12, 21, 22, 31, 32, 41, 42) was scored, with tooth numbers designated according to the Fédération Dentaire Internationale/World Dental Federation (FDI) two-digit notation system. Clinical status was recorded as follows: 0 = no defect; 1 = enamel defect not consistent with MIH; 21 = white/cream demarcated opacity; 22 = yellow/brown demarcated opacity; 3 = PEB; 4 = atypical restoration; 5 = atypical caries; 6 = missing due to MIH. In cases where more than one lesion characteristic was observed in a single tooth (e.g., demarcated opacity with PEB or atypical caries), a hierarchical approach was applied, and the tooth was classified according to the most severe

condition. Extension status was scored as 0 when no defect was present, I when less than one-third of the tooth surface was affected, II when one-third to two-thirds of the surface was involved, and III when more than two-thirds of the surface was affected. Eruption status was initially recorded for all teeth; however, only children in whom all four first permanent molars were clinically assessable were included in the final analyses. Accordingly, all analyses were restricted to children with four assessable first permanent molars to ensure complete evaluation in line with EAPD diagnostic principles.

Hypersensitivity was evaluated using the Schiff Cold Air Sensitivity Scale [23]. A standardized air stimulus was applied perpendicularly to the middle of the buccal surface of the tooth at a distance of approximately 1 cm for one second, using the air syringe of the dental unit at room temperature. Adjacent teeth were shielded with the examiner's fingers to avoid false-positive responses. Scores were assigned as 0 for no response, 1 for a mild response without a request to stop, 2 for a moderate response accompanied by a request to stop or visible discomfort, and 3 for severe pain or immediate withdrawal. For analysis, hypersensitivity was dichotomized as present (scores 1–3) or absent (score 0). This approach was adopted to ensure consistency with the MIH-TNI, in which hypersensitivity is considered as a binary component (present/absent) rather than graded by severity. Accordingly, although hypersensitivity was clinically assessed using the Schiff Cold Air Sensitivity Scale, the analytical coding was aligned with the MIH-TNI framework. In this context, the Schiff scale was used as a standardized method for eliciting and recording hypersensitivity, while the MIH-TNI classification guided its categorization for analysis.

To further classify disease severity, the MIH-TNI [19, 24] was applied. In this system, TNI 0 indicated teeth free of MIH, while TNI 1 referred to MIH without hypersensitivity and without structural defects. TNI 2 described MIH with structural defects but without hypersensitivity and was further divided according to lesion extent: 2a when less than one-third of the surface was involved, 2b when more than one-third but less than two-thirds was affected, and 2c when more than two-thirds of the surface was affected, when the lesion was close to the pulp, or when atypical restorations or extractions were present. TNI 3 denoted MIH with hypersensitivity but without structural defects. Finally, TNI 4 encompassed MIH with both hypersensitivity and structural defects and was similarly subdivided into 4a (< 1/3 of the surface affected), 4b (> 1/3 to < 2/3), and 4c (> 2/3 of the surface, lesions judged to be close to the pulp based on clinical findings and patient-reported symptoms, with radiographic findings used as an adjunct when available as part of routine clinical care, or those requiring atypical restorations or extractions).

Statistical analysis

The prevalence of MIH was calculated as the proportion of affected children among all examined children within the clinic-based sample, and 95% CIs were estimated using the binomial distribution. Differences in prevalence between sexes were assessed using Pearson's chi-square test.

Analyses were performed at both the patient and tooth levels. At the tooth level, descriptive statistics (counts and percentages) were computed for clinical status, extension, and TNI categories. Between-group comparisons by arch (upper vs. lower), side (right vs. left), and tooth type (molars vs. incisors) were conducted using chi-square tests. Associations between age and individual lesion types were explored using Spearman's rank correlation, treating each lesion category as a binary variable (presence/absence).

The normality of continuous variables was assessed using the Shapiro–Wilk test. Because multiple teeth were nested within individual children, tooth-level regression analyses were performed using cluster-robust standard errors to account for within-child clustering, with the child specified as the clustering unit. Hypersensitivity was analyzed as a binary outcome (present/absent) using a logistic regression model with cluster-robust standard errors. Clinical status was included as the main predictor, with adjustment for age, sex, tooth type, and arch. Results were expressed as odds ratios (ORs) with 95% CIs. All tests were two-sided with $\alpha = 0.05$. Analyses were conducted using Python (statsmodels, SciPy, pandas, matplotlib) and IBM SPSS Statistics v26.0 (IBM Corp., Armonk, NY, USA).

Results

During the study period, a total of 1,739 children presented to the pediatric dentistry clinic on the designated study days. Of these, 59 were excluded due to conditions that precluded reliable examination or assessment ($n = 18$ with severe intellectual disability, $n = 19$ with cooperation problems, $n = 22$ with ongoing orthodontic treatment). The initial study sample consisted of 1,680 children, all of whom underwent a full clinical examination. Subsequently, 97 children in whom not all first permanent molars were clinically assessable were excluded to ensure complete assessment of all first permanent molars in accordance with EAPD diagnostic principles and to minimize the risk of misclassification due to unerupted teeth. Teeth recorded as missing due to MIH were identified based on clinical records and radiographic findings, including documented extractions attributed to MIH-related structural breakdown. Unerupted or congenitally

Table 1 Distribution of clinical status, lesion extension, and Treatment Need Index (TNI) categories of examined teeth

Category	Code / Group	Count (*n*)	Percentage (%)
Clinical status	*0 (No defect)*	2059	58.2
	21 (White/cream demarcated opacity)	387	10.9
	22 (Yellow/brown demarcated opacity)	320	9.0
	3 (Post-eruptive enamel breakdown)	80	2.3
	4 (Atypical restoration)	131	3.7
	5 (Atypical caries)	503	14.2
	6 (Missing due to MIH)	60	1.7
Lesion extension status	*0 (No defect)*	2059	59.2
	I (< 1/3)	615	17.7
	II (1/3 – 2/3)	286	8.2
	III (> 2/3)	520	14.9
TNI categories	*0*	2059	59.2
	1	1121	32.2
	2a	45	1.3
	2b	41	1.2
	2c	72	2.1
	3	27	0.8
	4a	3	0.1
	4b	13	0.4
	4c	99	2.8

n number, *MIH* Molar Incisor Hypomineralization, *TNI* Treatment Need Index

missing teeth were distinguished using clinical examination findings in conjunction with radiographic assessment. The final analytical sample therefore comprised 1,583 children. At the patient level, MIH was diagnosed in 295 children, corresponding to a prevalence of 18.6% (95% CI: 16.6–20.5). The mean age of affected children was 9.50 ± 1.47 years (range: 8–13 years). Of these, 136 (46.1%) were male and 159 (53.9%) were female, with no statistically significant difference in prevalence between sexes ($\chi^2 = 1.80$, $p = 0.180$).

At the tooth level, the analysis of lesion characteristics is presented in Table 1. Overall, most examined teeth showed no defects (58.2%), while MIH-related changes were distributed across several clinical categories. Demarcated opacities were common, with white/cream lesions observed in 10.9% and yellow/brown lesions in 9.0% of teeth. Atypical caries represented one of the more frequent MIH-related findings (14.2%), whereas PEB and atypical restorations were less common. A small proportion of teeth (1.7%) were recorded as missing due to MIH. With respect to lesion extension, the majority of teeth were classified as having no defect (59.2%), while varying degrees of involvement were observed among affected teeth, including lesions affecting more than two-thirds of the tooth surface (14.9%).

The distribution of the TNI categories is presented in Table 1. Most teeth were classified as TNI 0 (59.2%), indicating no defect. Among affected teeth, TNI 1 constituted the largest proportion (32.2%), followed by lower frequencies of TNI 2 (4.6%), TNI 3 (0.8%), and TNI 4 (3.3%).

In the tooth-level analysis of clinical status (Fig. 1), first permanent molars were the most affected teeth within this clinical sample. Tooth 46 exhibited MIH-related changes in 82.4% of cases, followed by tooth 36 (79.7%), tooth 16 (78.6%), and tooth 26 (78.0%). In contrast, the least affected tooth was tooth 22, with 7.9% of cases showing defects. Among molars, atypical caries represented the most frequent finding, while PEB and atypical

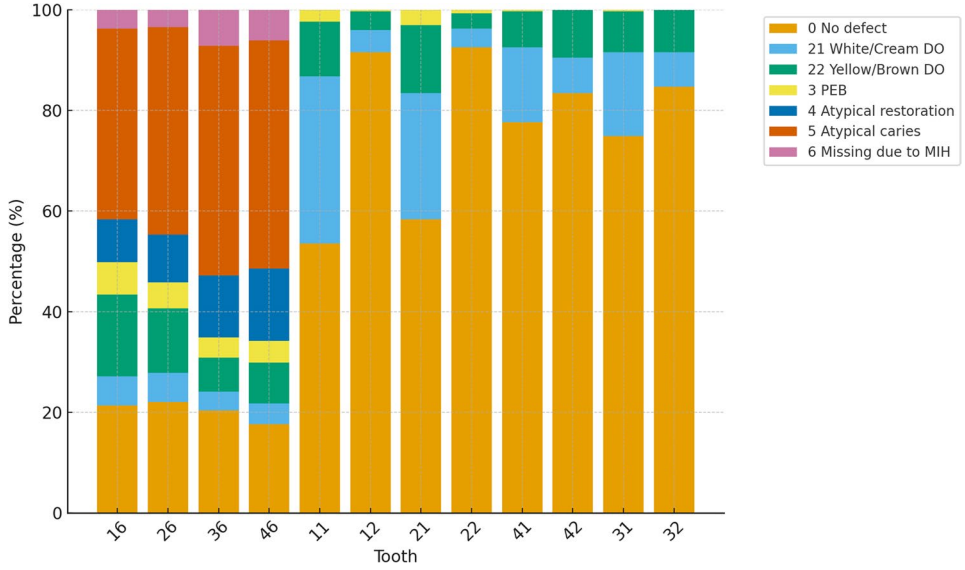


Fig. 1 Distribution of clinical status categories of first permanent molars and incisors according to the European Academy of Paediatric Dentistry (EAPD) criteria. (DO: demarcated opacity, PEB: post-eruptive enamel breakdown, MIH: Molar Incisor Hypomineralization)

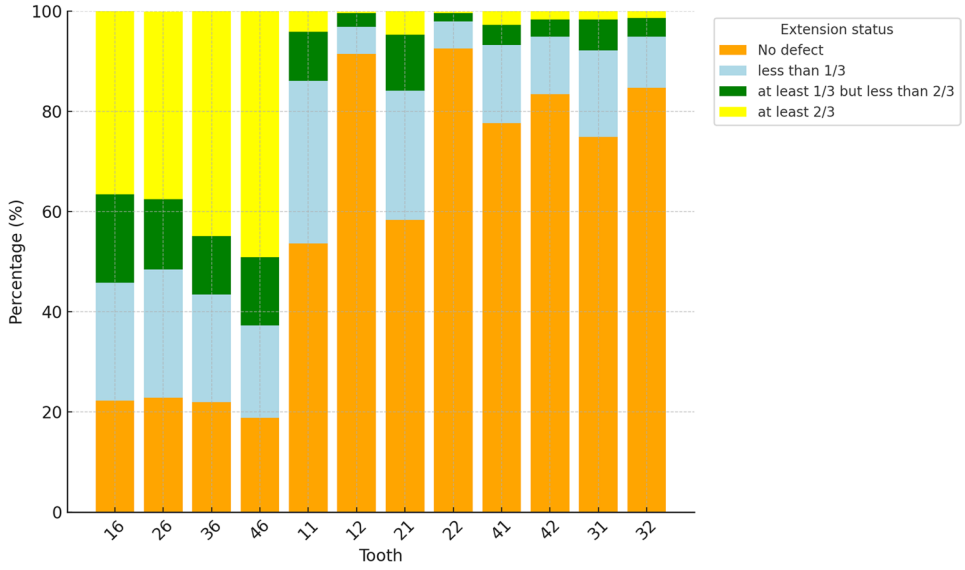


Fig. 2 Distribution of lesion extension in first permanent molars and incisors according to the European Academy of Paediatric Dentistry (EAPD) criteria

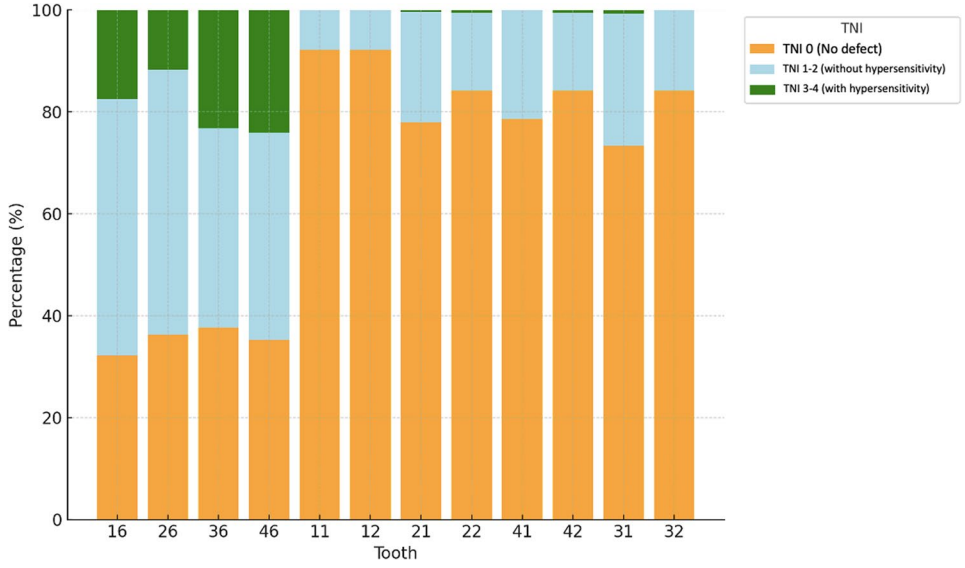


Fig. 3 Distribution of hypersensitivity across examined teeth in relation to MIH-TNI (Molar Incisor Hypomineralization Treatment Need Index) classification, comparing lower (TNI 1–2) and higher (TNI 3–4) categories

restorations were less common. In incisors, the predominant lesions were demarcated opacities, particularly in maxillary incisors. Overall, molars were characterized by more destructive lesion types, whereas incisors were mainly affected by demarcated opacities without structural breakdown.

In the analysis of lesion extension (Fig. 2), first permanent molars exhibited the highest rates of severe lesions in this clinic-based population. The proportion of teeth with defects affecting ≥ 2/3 of the crown surface ranged from 36.1% to 50.0% across molars, while teeth without defects were observed in 18.6–22.3% of these teeth. In contrast, anterior teeth were largely free of defects, with 84.1–92.1% of lateral incisors classified as having no defect. When present, defects in incisors were predominantly limited to < 1/3 of the surface. Overall, molars showed a markedly higher burden of extensive lesions, whereas incisors were predominantly unaffected or mildly affected.

In the tooth-level analysis of hypersensitivity in relation to MIH-TNI classification (Fig. 3), most incisors fell within TNI categories 0–2, whereas molars showed higher proportions of TNI categories 3–4, which include hypersensitivity. The lowest proportions of teeth without hypersensitivity were observed in molars, while anterior teeth showed the highest frequencies of TNI = 0–2.

Table 2 Tooth-level comparison of MIH involvement among examined teeth by jaw, side, and tooth type

Comparison		Total teeth	MIH (*n*)	MIH (%)	Chi^2	df	*p*-value[†]
Arch	**Maxillary**	1770	769	43.4	3.64	1	0.056
	Mandibular	1770	712	40.2			
Side	**Left**	1770	662	37.4	0.37	1	0.546
	Right	1770	678	38.3			
Tooth type	**Molar**	1180	940	79.7	1038.36	1	**< 0.001**
	Incisor	2360	541	22.9			

Bold values indicate statistically significance

n number, *MIH* Molar Incisor Hypomineralization, *df* degree of freedom

[†]Chi-square test

Table 3 Correlation between age and MIH lesion characteristics

Lesion type	Spearman ρ	*p*-value[†]
White/cream demarcated opacity (code 21)	-0.037	0.529
Yellow/brown demarcated opacity (code 22)	-0.117	0.056
Post-eruptive enamel breakdown (code 3)	0.006	0.920
Atypical restoration (code 4)	0.151	**0.009**
Atypical caries (code 5)	-0.068	0.245
Missing due to MIH (code 6)	0.217	**< 0.001**

Bold values indicate statistically significance

MIH Molar Incisor Hypomineralization

[†]Spearman correlation analysis, treating each lesion category as a binary variable (presence/absence)

Table 4 Binary logistic regression analysis of predictors of hypersensitivity, accounting for within-child clustering

Predictor	OR	95% CI	*p*-value[†]
Age	0.99	0.91–1.10	0.844
Sex[‡]	0.94	0.71–1.36	0.655
Tooth type[§]	14.44	7.04–30.44	**< 0.001**
Arch[¶]	0.61	0.41–0.82	**0.001**
Demarcated opacity (code 21 and 22)	2.13	1.09–4.02	**0.028**
Post-eruptive enamel breakdown (code 3)	4.94	2.19–10.76	**< 0.001**
Atypical restoration (code 4)	1.91	0.87–4.17	0.106
Atypical caries (code 5)	6.44	3.74–11.02	**< 0.001**

Bold values indicate statistically significance

OR Odds ratio, *CI* Confidence interval

[‡]Male sex, [§]incisors as tooth type, and [¶]mandibular teeth as arch location were used as references, [†]Binary logistic regression analysis with cluster-robust standard errors (child as clustering unit)

Among molars, hypersensitivity was more frequently observed in mandibular teeth, whereas it was rare among incisors (≤ 0.7% across all anterior teeth). Overall, molars accounted for the majority of teeth exhibiting hypersensitivity.

Tooth-level comparisons of MIH involvement among examined teeth are presented in Table 2. MIH involvement was observed in 43.4% of maxillary teeth and 40.2% of mandibular teeth, with no statistically significant difference between arches ($p = 0.056$). Similarly, MIH involvement was detected in 37.4% of left-side teeth and 38.3% in right-side teeth ($p = 0.546$). In contrast, a significant difference was observed between tooth types. Among teeth in MIH-affected children, molars showed a substantially higher frequency of MIH involvement than incisors (79.7% vs. 22.9%, $p < 0.001$).

Correlation analyses between age and lesion characteristics are presented in Table 3. Significant positive associations were observed for atypical restorations ($\rho = 0.151$, $p = 0.009$) and missing teeth due to MIH ($\rho = 0.217$, $p < 0.001$), suggesting that these outcomes were more frequently observed with increasing age.

Binary logistic regression analysis at the tooth level was performed to assess the association between clinical status categories and hypersensitivity, accounting for within-child clustering and adjusting for age, sex, tooth type, and arch (Table 4). Demarcated opacities were associated with approximately a twofold increase in hypersensitivity risk (OR = 2.13, 95% CI: 1.09–4.02, $p = 0.028$), while PEB showed a strong association (OR = 4.94, 95% CI: 2.19–10.76, $p < 0.001$). Atypical caries demonstrated the highest odds of hypersensitivity among the evaluated lesion types (OR = 6.44, 95% CI: 3.74–11.02, $p < 0.001$). These findings indicate that hypersensitivity is primarily associated with lesion severity and type.

Among the covariates, tooth type and arch location were also significantly associated with hypersensitivity. Molars exhibited higher odds of hypersensitivity compared with incisors (OR = 14.44, 95% CI: 7.04–30.44, $p < 0.001$), and maxillary teeth showed lower odds than mandibular teeth (OR = 0.61, 95% CI: 0.41–0.82, $p = 0.001$). These associations should be interpreted in the context of the distribution of lesion types, which were more severe and more frequently observed in molars.

Discussion

This cross-sectional study investigated the prevalence and clinical characteristics of MIH among Turkish children attending a university pediatric dental clinic. Among the 1,583 children included in the final analytical sample, 295 were diagnosed with MIH, corresponding to a prevalence of 18.6%. In addition to estimating prevalence, the study characterized lesion types and treatment needs, and examined factors associated with hypersensitivity.

The findings indicate that MIH is relatively common in this clinic-based sample and is frequently associated with more pronounced clinical involvement in first permanent molars.

The prevalence of MIH has been widely investigated; however, estimates vary considerably depending on study design, population characteristics, and diagnostic criteria. A recent comprehensive meta-analysis by Ammar et al. [3] reported a global prevalence of 15.5%. Nevertheless, substantial heterogeneity exists across studies, and this variability is largely influenced by methodological differences, particularly the distinction between population-based and clinic-based samples, which may affect both prevalence estimates and the observed severity of lesions. In Türkiye, previously reported MIH prevalence rates have generally ranged between approximately 9% and 14.9% [25, 26]. In this context, the prevalence of 18.6% observed in the present study is higher than most earlier national estimates. This difference may be attributed, at least in part, to the clinic-based design of the study, as children seeking dental care are more likely to present with treatment needs and clinically detectable defects. Accordingly, the present findings may better reflect the clinical burden of MIH rather than its population-level frequency. Importantly, the present study is based on a large and contemporary analytical sample of 1,583 children examined over a one-year period. Therefore, it provides updated evidence on the current burden of MIH in Turkish pediatric dental practice and contributes to the limited national literature by integrating prevalence data with detailed assessments of lesion characteristics, hypersensitivity, and treatment needs within a single study framework. The relatively broad age range of the study population (8–13 years) should also be considered when interpreting these findings, as age-related differences may influence both the prevalence estimates and the clinical severity of MIH.

While prevalence estimates of MIH are well documented, fewer studies have focused on characterizing the clinical burden of the condition through an integrated evaluation of lesion characteristics, treatment need, and hypersensitivity. In this context, the present study extends existing epidemiological evidence by combining standardized clinical indices with tooth-level analyses adjusted for within-child clustering, allowing a more nuanced assessment of disease severity beyond prevalence alone. Rather than generating etiological hypotheses, this approach aims to support clinical stratification by describing how different lesion types and clinical presentations correspond to treatment need and hypersensitivity in a pediatric dental care setting.

Clinical characteristics of MIH lesions in this study population were dominated by demarcated opacities, with white/cream opacities (10.9%) more frequent than yellow/brown opacities (9.0%). This distribution is consistent with findings from Iraq and Lebanon, where white/cream demarcated opacities predominated over more destructive forms [27, 28], and aligns with earlier data from Greece and Germany reporting demarcated opacities as the most common presentation [29, 30]. Although the frequencies of some severe outcomes—such as PEB (2.3%) and atypical restorations (3.7%)—were lower than those reported in several international studies, the proportion of atypical caries (14.2%) indicates that structural compromise remains clinically relevant in this population. Guerra et al. [31] reported that cusp involvement and endodontic treatment needs were present in approximately one-quarter of affected Brazilian children, whereas Afzal et al. [32] found that dentine-level caries occurred in up to 30.8% of Norwegian children with severe MIH. This apparent discrepancy may reflect differences in how severity is expressed, with MIH-affected enamel progressing toward breakdown and secondary caries over time, particularly in molars. It may also be influenced by variations in study setting (community vs. clinic), age distribution, and care-seeking behavior. Given that the study population comprised children aged 8–13 years, age-related differences in lesion progression may not have been fully captured, particularly for earlier-stage defects such as PEB. Notably, no significant association was observed between age and PEB in the present study. This finding may be partly explained by patterns of care-seeking behavior, as children may present for dental care at more advanced stages of disease rather than during earlier phases such as PEB, potentially limiting the detection of age-related trends. Accordingly, while early-stage defects appear to predominate in this study population, the relatively high burden of atypical caries suggests a substantial restorative need. The proportion of teeth missing due to MIH (1.7%) was modest yet clinically important, consistent with meta-analytical evidence identifying extraction as a relatively infrequent but significant outcome of MIH progression [33]. Taken together, these findings indicate that although the initial presentation of MIH in this clinic-based population is largely characterized by milder defects, the progression toward caries represents a meaningful component of disease burden.

Lesion extension in the present study demonstrated a clear contrast between molars and incisors, with first permanent molars showing the highest proportions of extensive defects ($\geq 2/3$ of the crown surface), whereas permanent incisors were predominantly unaffected or limited to $< 1/3$ of the surface. This pattern is consistent with previous reports indicating that molars are more frequently and more severely affected by MIH, while incisors tend to present with milder defects [29, 30]. Although severe outcomes may appear less frequent

when defined strictly in terms of extensive structural breakdown, the relatively high proportion of atypical caries observed in molars indicates that structural compromise remains clinically significant. This pattern may reflect the progression of MIH-affected enamel toward PEB and dental caries over time, particularly in posterior teeth, as also noted in previous studies [30]. However, age-related patterns could not be meaningfully explored in incisors in the present study, as these teeth predominantly exhibited mild defects with limited variation in lesion severity and no higher TNI categories. This limited variability may have constrained the ability to detect potential age-related trends in incisor involvement. Accordingly, lesion extension may be considered a practical clinical descriptor of increasing treatment complexity in MIH, rather than an independent predictive factor.

Hypersensitivity is one of the most clinically relevant consequences of MIH, as it significantly affects children's comfort and treatment needs. In the present study, hypersensitivity was observed in 4.1% of all examined teeth and 17.6% of MIH-affected teeth, indicating that nearly one in six lesions was associated with symptoms. Similar variability has been reported in the literature, with estimates ranging from 5.6% to over 25% [32, 34]. Consistent with previous findings, hypersensitivity was predominantly associated with more severe lesion types, particularly PEB and atypical caries, and was rarely observed in teeth presenting only demarcated opacities [35]. Moreover, molars were the primary teeth affected by hypersensitive lesions, whereas incisors were largely unaffected [34]. However, this pattern likely reflects the higher prevalence of severe lesion types in molars rather than an independent effect of tooth type.

When evaluating predictors of hypersensitivity, cluster-adjusted regression analyses confirmed that lesion type was the primary determinant, whereas age and sex were not significantly associated. This is consistent with previous studies reporting that demographic factors have limited influence on hypersensitivity compared with lesion severity [34]. Demarcated opacities showed a modest increase in risk (OR ≈ 2), while PEB (OR ≈ 5) and atypical caries (OR ≈ 6) demonstrated the strongest associations. In contrast, atypical restorations were not independently associated with hypersensitivity after adjustment for covariates. Among the covariates, tooth type was also significantly associated with hypersensitivity, with molars showing higher odds compared with incisors. However, this association should be interpreted in the context of the distribution of lesion types, as more severe defects were more frequently observed in molars. These findings indicate that hypersensitivity in MIH is primarily driven by local structural breakdown rather than patient-level characteristics, supporting its interpretation as a marker of lesion severity.

From a clinical perspective, the clustering of hypersensitivity within higher TNI categories highlights its relevance for disease severity and patient management. In this context, MIH-TNI may provide a useful framework for identifying children at higher risk of symptomatic lesions, particularly those in the TNI-3 and TNI-4 categories, who may require closer clinical monitoring and timely management. However, it is also important to emphasize that early-stage lesions, such as demarcated opacities, represent a critical window for preventive and minimally invasive interventions aimed at preserving enamel integrity. Given the compromised structural properties of MIH-affected enamel, even in the absence of breakdown, early management strategies—including remineralization approaches, protective sealants, and resin infiltration techniques—may help maintain or reinforce the biological barrier function of enamel and potentially reduce progression to PEB and hypersensitivity.

The assessment of hypersensitivity also raises important ethical considerations. In the present study, hypersensitivity was evaluated using a brief and standardized air stimulus routinely applied in clinical practice, with measures taken to minimize patient discomfort [36]. While such assessments are necessary to characterize symptom burden, they should be performed with particular caution in pediatric populations [37]. From a clinical perspective, the identification of hypersensitivity as a present or absent condition reflects a treatment-oriented approach, where the key distinction lies in whether intervention is required. This approach may also help avoid unnecessary or repeated stimulation in children by focusing on clinically actionable thresholds rather than symptom gradation alone. These considerations highlight the importance of balancing standardized assessment with patient comfort and support the use of clinically meaningful thresholds in studies evaluating MIH-related hypersensitivity.

The present study makes an important contribution to the literature by providing a comprehensive and contemporary evaluation of MIH in a large clinic-based Turkish pediatric population, encompassing a substantially larger sample compared with previous national reports. While earlier Turkish studies were limited to regional cohorts and smaller sample sizes, this investigation offers robust prevalence data (18.6%), thereby contributing to the epidemiological evidence from Türkiye. Beyond prevalence, this study also characterized lesion characteristics, hypersensitivity, and treatment needs using standardized indices, providing a multidimensional profile of MIH in a single population. From a clinical standpoint, these findings highlight that although most lesions were mild, a notable proportion presented with hypersensitivity or PEB, indicating the need for early preventive and therapeutic interventions. Although population-based data

remain essential for national estimates, these clinic-based findings help identify lesion patterns and subgroups most likely to require intensive management in clinical practice. In doing so, this study contributes to aligning Turkish data with global evidence and provides a foundation for improving care strategies tailored to children most at risk of pain, caries, and functional impairment.

This study possesses several methodological strengths that enhance the robustness of its findings. First, the large sample size provided substantial statistical power and enhanced the reliability of prevalence estimates compared with earlier Turkish reports. Second, MIH was assessed using internationally recognized and validated indices, ensuring comparability with global studies. Third, all examinations were performed by an experienced pediatric dentist, and intra-examiner reliability was established, minimizing potential diagnostic variability. Additionally, the study's comprehensive design, which not only quantified prevalence but also evaluated lesion characteristics, hypersensitivity, and treatment needs, enabled a multidimensional understanding of the MIH burden in children.

Nevertheless, several limitations should be acknowledged. As the sample was derived from children attending a university pediatric dental clinic, the findings reflect a clinic-based population rather than the general pediatric population. This may introduce selection bias, as children seeking dental care are more likely to present with existing dental conditions, potentially influencing both the observed prevalence and the severity profile of MIH. Accordingly, the reported prevalence should be interpreted as a clinic-based estimate and may not be directly generalizable to all Turkish children. As the study included children aged 8–13 years, the findings may not fully represent younger or older pediatric age groups. In addition, children with uncooperative behavior were excluded because standardized intraoral examination could not be reliably performed; this may have led to underrepresentation of patients with higher treatment needs or more severe clinical presentations. Although intra-examiner reliability was ensured, the absence of inter-examiner calibration limits the assessment of diagnostic reproducibility across different clinicians. Furthermore, due to the cross-sectional design, it was not possible to assess the initial severity of MIH lesions or their progression over time. Therefore, differences observed across age groups should be interpreted with caution, as baseline variations in lesion severity cannot be excluded as a potential confounding factor.

Conclusions

In this study, the prevalence of MIH among Turkish children was 18.6%, affecting nearly one in five to six participants. First permanent molars were the most frequently involved teeth, typically presenting with post-eruptive enamel breakdown, atypical caries, and atypical restorations, whereas incisors were predominantly affected by demarcated opacities. Hypersensitivity was closely linked to lesion type, with demarcated opacities, post-eruptive enamel breakdown, and atypical caries associated with a two- to six-fold increase in risk compared with sound teeth.

These findings provide clinically relevant insights into the burden of MIH in a Turkish pediatric dental care setting and highlight the substantial treatment needs associated with more severe lesions. At the same time, the findings underscore the importance of early detection and management of initial lesions, such as demarcated opacities, to preserve enamel integrity and maintain its biological barrier function. Early detection and preventive management—including remineralization strategies, protective sealants, and minimally invasive interventions—may help reduce progression and symptom-related complications. Future studies using population-based and longitudinal designs are warranted to complement clinic-based findings and further clarify the determinants and progression of MIH.

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Authors' contributions
Conceptualization: [Berkant Sezer], [Nihan Tuğcu], [Başak Durmuş], [Betül Kargül]; Methodology: [Berkant Sezer], [Nihan Tuğcu], [Başak Durmuş], [Betül Kargül]; Formal analysis and investigation: [Berkant Sezer], [Nihan Tuğcu]; Writing - original draft preparation: [Berkant Sezer]; Writing - review and editing: [Berkant Sezer]; Supervision: [Betül Kargül].

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Data availability
The data that support the findings of this study are available from the corresponding author (B.S.) upon reasonable requests.

Declarations

Ethics approval and consent to participate
This cross-sectional study was reviewed and approved by the Clinical Research Ethics Committee of Marmara University (Approval No. 2019/360). All procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki. Detailed information regarding the study protocol was provided to all participants and their parents or legal guardians. Written informed consent was obtained from each child and his or her parent or legal guardian prior to participation.

Competing interests
The authors declare no competing interests.

Consent for publication
Not applicable.

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