Prevalence and Clinical Patterns of Molar–Incisor Hypomineralisation (MIH) and Hypomineralised Second Primary Molars (HSPM) in Italian and Turkish Children Aged 6–16: an epidemiological comparative cross-sectional study

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Abstract

Background Molar Incisor Hypomineralisation (MIH) and Hypomineralised Second Primary Molars (HSPM) are worldwide spread developmental enamel defects, with an increasing number of cases.
Aim To define MIH prevalence, HSPM co-presence, and delineate MIH/HSPM clinical patterns in Italian and Turkish children.
Study design Two-center cross-sectional observational study.
Methods 840 children (390 Italian, 450 Turkish) aged 6-16 years old were examined by two calibrated dentists. MIH and HSPM were diagnosed according to the European Academy of Pediatric Dentistry (EAPD) criteria. HSPM co-presence was evaluated in MIH-affected children having at least one second primary molar (SPM). The MIH/HSPM charting format for primary and permanent dentitions (long form) was used to record hypomineralised teeth.
Statistics A descriptive statistical analysis was performed. Chi-square and exact Fisher tests were used to analyse associations between selected variables (p value < 0.05).
Results The study sample comprised 97 MIH-affected subjects (50 Italian, 47 Turkish) with a mean age of 9.29 ± 2.4 years. The overall MIH prevalence was 11.54% and 60.31% of MIH-affected subjects had at least one HSPM. The associations between MIH, HSPM and restorations as well as between MIH and post-eruptive breakdown were significant. Significant differences were found between Italy and Turkey in the distribution of MIH lesions severity, and in the treatment needs for molars and lower incisors.
Conclusion MIH prevalence was similar in Italy and Turkey; HSPM was lower in Turkish children. More epidemiological standardised studies on large cohorts of subjects are needed.

KEYWORDS Molar Incisor Hypomineralisation, Hypomineralised Second Primary Molars, Demarcated opacities, Prevalence, Clinical pattern, Epidemiology.

Introduction

Molar-Incisor Hypomineralisation (MIH) is a worldwide spread [Lopes et al., 2021] qualitative developmental defect of the dental enamel with a multifactorial aetiology [Giuca et al., 2020] first defined in 2001 as a "hypomineralisation of systemic origins affecting one or more molars, usually permanent first molars (PFMs), with or without the involvement of one or more permanent incisors (PIs)" [Weerheijm et al., 2001]. Clinically, MIH lesions appear as demarcated variable-sized opacities with clear margins and a color ranging from creamy-white to yellow-brownish depending on the severity of the defect that is classified as mild or severe according to the European Academy of Paediatric Dentistry (EAPD) severity criteria [Jälevik, 2010; Lygidakis et al., 2010; Lygidakis et al., 2022]. The distribution of the lesions is asymmetrical; maxillary teeth seem to be more involved than mandibular teeth and opacities are usually limited to the middle and occlusal/incisal one-third of the crown, while the cervical enamel is rarely involved. In affected incisors, the severity of the defect is commonly milder than in affected molars and, the greater the number of affected teeth, the worse the pathology's expression [Lygidakis et al., 2022; Jorge et al., 2022]. Due to its porous structure with an altered prismatic organisation, a low mineral density and an increased protein content, the hypomineralised enamel has reduced micro-mechanical properties compared to the sound enamel [Elhennawy et al., 2017]. These histopathological features clinically translate into functional problems: above all, a higher risk of development of carious lesions and/or enamel post-eruptive breakdown (PEB) and aesthetic issues that, along with reduced retention rates of adhesive materials to the affected enamel and dentin hypersensitivity make MIH management challenging [Lygidakis et al., 2022; Romo Pérez et al., 2023]. In the last decade, an increasing incidence of MIH-like lesions in the primary dentition has been observed, with second primary molars (SPMs) as the most frequently affected teeth; the defect is now defined as Hypomineralised Second Primary Molars (HSPM) [McCarra et al., 2022]. The presence of HSPM is considered a predictive factor for developing MIH in permanent dentition, although

its absence cannot exclude future MIH development [Garot et al., 2018; Marcianes et al., 2023; Sidhu et al., 2020; Bani-Hani et al., 2025]. The early diagnosis of HSPM, based on the EAPD – MIH judgment adapted criteria [Elfrink et al., 2008; Weerheijm et al., 2003], may be helpful not only for preventing the most frequent MIH- related issues but also for early diagnosing MIH with the ultimate goal of reducing the healthcare and economic burden [McCarra et al., 2022; Schwendicke et al., 2018; Paglia, 2018]. Nowadays, MIH and HSPM are worldwide spread developmental enamel defects (DDE) affecting an increasing number of children and representing an eminent problem in paediatric dentistry [McCarra et al., 2022; Schwendicke et al., 2018; da Costa Rosa et al., 2022]. In 2015, the estimated global percentage of MIH-affected needing-care cases was 27.4% (about 240 million prevalent cases) out of 878 million prevalent cases [Hernandez et al., 2016]. According to two 2021 systematic reviews and meta-analyses evaluating the prevalence of MIH [Lopes et al., 2021] and HSPM [McCarra et al., 2022] at a global level, the overall prevalence of MIH was estimated at 13.5% (95% CI 12.0 – 15.1; data from 116 studies on 113.089 individuals) with high heterogeneity (I2 = 98.0%) and non-significant sex-related differences [Lopes et al., 2021], while the global prevalence of HSPM ranged from 0% and 41% with an overall pooled value of 6.8% (95% CI 4.98 – 8.86; data from 37 studies on 26.805 individuals) with also a high heterogeneity (I2 = 99.75%) [McCarra et al., 2022]. The broad variability in MIH and HSPM prevalence may reflect geographical differences as well as different characteristics of the examined populations, i.e., ethnicity, age, and socioeconomic status, but also the methodology of the performed analyses, including, e.g., the use of not standardised diagnostic criteria and the lack of calibration of the examiners; standardised epidemiological studies are therefore essential [da Costa Rosa et al., 2022; Elfrink et al., 2015]. As for MIH prevalence across continents, America and Asia show the highest and the lowest values, i.e., 15.3% (95% CI 12.8-18.3) and 10.7% (95% CI 78.5 – 13.5,) respectively, with no significant differences [Lopes et al., 2021]. In Europe, MIH prevalence ranges from 3.6 to 25.0%, with higher values in Northern countries where more studies have been performed compared to the countries of the Mediterranean area [Schwendicke et al., 2018; Hernandez et al., 2016]. As for the prevalence of HSPM in Europe, the literature reports a pattern similar to MIH, with Germany, Denmark, England, and the Netherlands being the countries most investigated besides Spain [McCarra et al., 2022]. Among the countries of the Mediterranean area, currently, only a few studies evaluating the prevalence of MIH have been performed in Italy and Turkey [Calderara et al., 2005; Kusku et al., 2008; Kılınç et al., 2019; Nisii et al., 2022]. The most recent ones report a prevalence rate of MIH of 18.2% in the city of Rome (3.611 school children aged 7-8 years; 2022) [Nisii et al., 2022] and 11.5% in the city of Izmir (1.234 school children aged 9-10 years; 2019) [Kılınç et al., 2019] respectively. In addition, although the scientific community has recently increasingly focused on evaluating the association between MIH and HSPM [Sidhu et al., 2020; Noor Mohamed et al., 2021], nowadays, to the best of our knowledge, there are no comparative studies estimating the prevalence of HSPM in MIH-affected individuals between Italy and Turkey. Given the current state of the literature, the present study aimed to deepen the knowledge of the prevalence rates of MIH, its clinical patterns and the association between MIH and HSPM in targeted Italian and Turkish children providing a very detailed epidemiological characterisation of these DDE. The null hypothesis was that, since Italy and Turkey are countries located in the Mediterranean region, the prevalence of MIH and HSPM would not differ between the studied populations.

Materials and methods

Study Design and Ethics Approval

This two-center cross-sectional observational study was carried out according to the principles expressed by the Helsinki Declaration. The ethics committee of both countries approved the study. Parents or legal guardians of eligible subjects were asked to sign a written informed consent to the study and data treatment before enrollment.

Study Objectives

The primary aim was to verify the prevalence of MIH in a group of Italian and Turkish 6-16 years old subjects. MIH diagnosis was formulated according to the EAPD – MIH judgment criteria [Weerheijm et al., 2003]. Secondary aims were to: I) describe MIH distribution by age (at 6, 8, 12 and 16 years) and delineate the clinical patterns in the two groups, II) report the concomitant presence of HSPM and MIH, III) assess the relationship between selected variables, i.e., distribution of MIH lesion' severity between the groups, association between MIH and carious lesions, restorations, PEB and treatment need as well as between HSPM and carious lesions and restorations in MIH-affected subjects, and IV) estimate the proportion of MIH treatment-needing cases according to the MIH – Treatment Need Index (MIH – TNI) [Steffen et al., 2017] in the groups.

Study Population

In each facility, participants were selected by a calibrated paediatric dentist among subjects attending the involved centers according to the following inclusion and exclusion criteria.

Inclusion criteria

MIH-affected subjects aged 6 to 16 years old in good health conditions (i.e., no coexisting systemic diseases, no drug intake) and adequately cooperative.

Exclusion criteria

Subjects presenting dental enamel defects in differential diagnosis with MIH e.g., fluorosis, amelogenesis imperfecta, white spots etc., and orthodontic devices hiding the teeth to be evaluated.

Each participant was identified with an alpha-numeric ID code known by the researchers and privacy was safeguarded.

Sample Size Calculation

The sample size was calculated on the study's primary outcome, assuming a prevalence rate of MIH equal to 44% (maximum global MIH prevalence rate according to Hernandez et al. [2016], setting alpha at 0.05 and considering a precision equal to 5%. The minimum expected sample size required was 379 subjects for each center to evaluate the presence of MIH (OpenEpi version 3, open-source calculator).

Examiners Calibration

Before starting the study, the two examining paediatric dentists performed a calibration exercise with the aid of MIH

VISUAL ABSTRACT

Summary

MIH prevalence was similar in Italy (12.82%) and Turkey (10.44%), with no significant difference between countries. HSPM co-presence was markedly higher in Italian MIH-affected children (82.92%) than Turkish ones (18.18%), highlighting geographical variability in the MIH–HSPM relationship.

Study design

two centre cross-sectional observational study

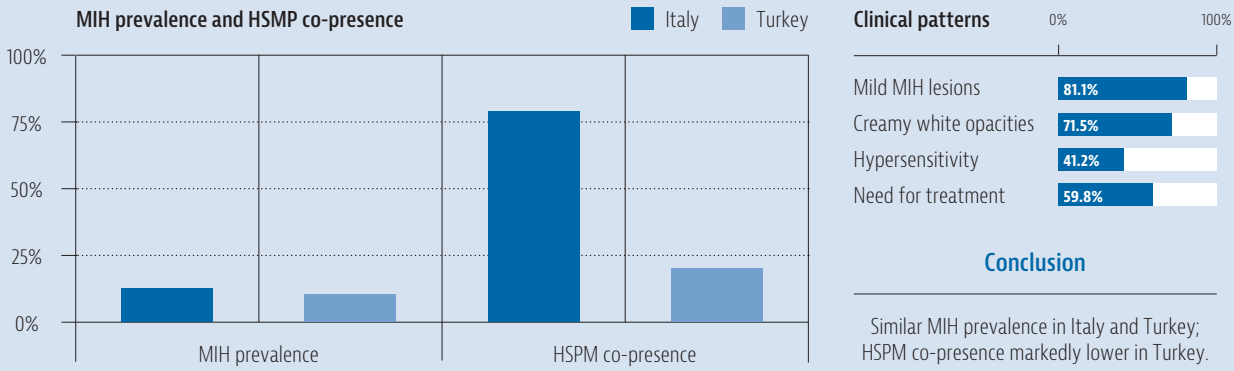
EAPD diagnostic criteria

Calibrated examiners

Population

children	mean age	Italian children Trieste IRCSS Burlo Garofalo	Turkish children Istanbul Yeditepe Univ.
840	9.3 ± 2.4 years	390	450

Outcomes



Conclusion

Similar MIH prevalence in Italy and Turkey; HSPM co-presence markedly lower in Turkey.

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clinical photographs, according to Ghanim et al [2017]. The reproducibility of MIH scoring was completed after two weeks; the kappa (κ) test confirmed a high level of intra-examiner and inter-examiner reliability (equal to 1 and 0.868, respectively).

Clinical Data Collection

Participants underwent a detailed dental check-up to evaluate their MIH and HSPM-affected teeth and their clinical characteristics according to the MIH – HSPM clinical data recording sheet for permanent and primary dentitions (long form) [Ghanim et al., 2015]. For each affected tooth, three surfaces: occlusal/incisal, buccal and palatal/lingual, were examined by visual analysis using the dental probe and were scored separately [Ghanim et al., 2015]. Teeth to be evaluated were gently cleaned using a rotating prophylaxis brush mounted on a blue ring handpiece at low speed to remove any food debris and plaque before their examination. In each center, a single calibrated paediatric dentist performed all clinical evaluations on cleaned teeth under optimal light conditions. Intraoral photographs of the affected teeth were taken using professional cameras. MIH diagnosis was formulated according to the EAPD – MIH judgment criteria [Weerheijm et al., 2003] and HSPM was diagnosed according to the EAPD – MIH judgment adapted criteria [Elfrink et al., 2008]. The following additional criteria proposed by the authors were evaluated to provide a more detailed clinical picture and estimate the proportion of needing-treatment cases: type of restorative material (filled teeth), presence of fissure sealants (molars), aesthetic issues (incisors) and dentin hypersensitivity. As for restored teeth, the following restorative materials were considered: composite, glass ionomer cements (GICs), amalgam and preformed metal crowns (PMCs); conversely, for fissure sealants, the retention, the type of material (resinous, glass ionomer sealants) and the presence of secondary carious lesions were evaluated. Aesthetic issues were assessed by asking participants if MIH lesions on incisors were perceived as an aesthetic problem. Dentin hypersensitivity was evaluated at the dental chair using the air syringe (jet of compressed air spray at 45 psi pressure and at an environmental temperature of 19 - 24 °C applied for 1 second at a distance of 1 cm perpendicular to the tooth to be examined) [Raposo et al., 2019] and scored as present/absent. The severity of MIH and HSPM was classified as mild or severe according to the EAPD – MIH severity criteria [Jälevik, 2010; Lygidakis et al., 2010; Lygidakis et al., 2022] and the adapted EAPD criteria, respectively [Elfrink et al., 2008; Weerheijm et al., 2003]. The MIH – Treatment Need Index (TNI) [Steffen et al., 2017] was used to score MIH-affected teeth and calculate the percentage of needing-treatment cases, i.e., subjects complaining of dentin hypersensitivity, aesthetic issues, presenting carious lesions and/or PEB. Needing-treatment cases were treated according to the clinical recommendations for MIH management [Lygidakis et al., 2022].

Teeth			16, 26	36, 46	12 – 22	42 – 32	55, 56	75, 85
			n = 189	n = 190	n = 318	n = 366	n = 120	n = 128
Parameter		Group						
Severity	0	IT	10 (10.20)	9 (9.09)	79 (50.00)	118 (63.44)	28 (40.58)	37 (48.05)
	M		72 (73.47)	78 (78.79)	79 (50.00)	68 (36.56)	40 (57.97)	39 (50.65)
	S		16 (16.33)	12 (12.12)	0 (0.00)	0 (0.00)	1 (1.45)	1 (1.30)
	0	TR	37 (40.66)	38 (41.76)	111 (69.38)	140 (77.78)	46 (90.20)	46 (90.20)
	M		26 (28.57)	21 (23.08)	46 (28.75)	40 (22.22)	3 (5.88)	5 (9.80)
	S		28 (30.77)	32 (35.16)	3 (1.88)	0 (0.00)	2 (3.92)	0 (0.00)

Severity is scored according to the European Academy of Pediatric Dentistry (EAPD) MIH severity criteria and the adapted EAPD criteria for HSPM. Abbreviations: 0 = No defect; M = Mild defect (demarcated enamel opacities without enamel breakdown, occasional sensitivity to external stimuli e.g., air/water but not at brushing and only mild aesthetic concerns on discoloration of the incisors); S = Severe defect (demarcated enamel opacities with breakdown, caries, persistent/spontaneous hypersensitivity affecting function e.g., during brushing and strong aesthetic concerns that may have a socio-psychological impact).

TABLE 1 Severity data of fully erupted hypomineralised upper and lower PFMs, PIs and SPMs in the Italian group (IT) and in the Turkish group (TR). Data are expressed in numbers n and percentages (in brackets).

Teeth			16, 26	36, 46	12 – 22	42 – 32	55, 56	75, 85
			n = 142	n = 143	n = 128	n = 108	n = 46	n = 45
Parameter		Group						
Demarcated opacities†	Creamy white	IT	48 (48.98)	69 (69.70)	72 (45.57)	63 (33.87)	37 (53.62)	34 (44.16)
		TR	34 (37.36)	27 (29.67)	40 (25.00)	36 (20.00)	2 (3.92)	4 (7.84)
	Yellow brown	IT	40 (40.82)	21 (21.21)	7 (4.43)	5 (2.69)	4 (5.80)	6 (7.79)
		TR	19 (20.88)	25 (27.47)	9 (5.63)	4 (2.22)	2 (3.92)	1 (1.96)
Post Eruptive Breakdown (PEB)†		IT	16 (16.33)	8 (8.08)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.30)
		TR	5 (5.49)	1 (1.10)	0 (0.00)	0 (0.00)	1 (1.96)	0 (0.00)
Restorations†	Resin composite	IT	16 (16.33)	35 (35.35)	2 (1.27)	1 (0.54)	16 (23.19)	26 (33.77)
		TR	14 (15.38)	14 (15.38)	1 (0.63)	0 (0.00)	1 (1.96)	0 (0.00)
	Glass Ionomer Cements	IT	1 (1.02)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
		TR	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Carious lesions‡		IT	3 (3.06)	4 (4.04)	0 (0.00)	0 (0.00)	12 (17.39)	8 (10.39)
		TR	18 (19.78)	15 (16.48)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Missing teeth†		IT	0 (0.00)	1 (1.01)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
		TR	2 (2.20)	1 (1.10)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)

Parameters are scored according to the charting criteria of the MIH – HSPM clinical data recording sheet – permanent and primary dentitions (long form) by Ghanim et al., 2015 and the additional criteria proposed by the authors.
† Percentages of teeth presenting demarcated opacities, PEB, restorations and missing teeth are evaluated on the total number of fully erupted hypomineralised teeth.
‡ Percentages of teeth presenting carious lesions are evaluated on the total number of fully erupted teeth (i.e. MIH-affected and non-affected).

TABLE 2 Clinical characteristics of hypomineralised upper and lower PFMs, PIs and SPMs in the Italian group (IT) and in the Turkish group (TR). Data are expressed as numbers n and percentages (in brackets).

Statistical Analysis

A descriptive analysis was performed on the variables of interest using Microsoft Excel spreadsheets (MS Excel, Version 2020). Categorical variables were described with numbers and percentages, while continuous variables, normally distributed, were described with means and standard deviations and, otherwise, with medians and interquartiles; the presence/absence of normal distribution was assessed by performing the Shapiro-Wilk test. The prevalence of MIH was calculated as the ratio between the number of subjects aged 6-16 years with MIH and the total number of visited subjects. The above prevalence was calculated for the total sample for each center and was stratified by sex and age. The Chi-square test and the exact Fisher test were used to analyse possible associations between selected categorical variables, i.e., MIH lesions severity between the groups, MIH and carious lesions, restorations, PEB and need for treatment as well as HSPM and carious lesions and restorations in MIH-affected subjects, MIH needing treatment cases between the groups. The Pearson's chi-squared test was used to analyse whether the prevalence of MIH (%) was different in the groups. The statistical significance threshold was fixed at p value < 0.05. Statistical analysis was performed using the SAS software, Version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Study Population

840 subjects (390 Italian, 450 Turkish) were evaluated. The total study sample comprised 97 MIH-affected subjects (53

Teeth		16, 26	16, 26	36, 46	36, 46
Group		IT	TR	IT	TR
		n = 104	n = 27	n = 95	n = 28
Not Decayed or filled teeth and without PEB		66 (67.35)	22 (24.18)	60 (60.61)	25 (27.47)
Fissure sealants	All	38 (57.58)	5 (22.73)	35 (58.33)	3 (12.00)
	1A	20 (52.64)	5 (100.00)	19 (54.29)	2 (66.67)
	1B	2 (5.26)	0 (0.00)	2 (5.71)	1 (33.33)
	2A	13 (34.21)	0 (0.00)	10 (28.57)	0 (0.00)
	2B	3 (7.89)	0 (0.00)	4 (11.43)	0 (0.00)
Abbreviations: 1 = Resinous sealant; 2 = Glass Ionomer sealant; A = completely retained material; B = partially retained material.					

TABLE 3 Fissure sealants data of fully erupted intact MIH-affected upper and lower PFMs in the Italian group (IT) and in the Turkish group (TR). Data are expressed as numbers n and percentages (in brackets).

Teeth		16, 26	36, 46	12 – 22	42 – 32	55, 56	75, 85
		n = 142	n = 143	n = 128	n = 108	n = 46	n = 45
Group	IT	14 (14.29)	9 (0.09)	2 (1.27)	1 (0.54)	1 (1.45)	0 (0.00)
	TR	22 (24.18)	22 (24.18)	10 (6.25)	10 (5.56)	0 (0.00)	0 (0.00)

TABLE 4 Dentin Hypersensitivity data of hypomineralised upper and lower PFMs, PIs and SPMs in the Italian group (IT) and in the Turkish group (TR). Data are expressed as numbers n and percentages (in brackets).

Teeth		16, 26	36, 46	12 – 22	42 – 32
		n = 142	n = 143	n = 128	n = 108
Group	MIH – TNI score				
IT	1	59 (66.29)	71 (78.88)	70 (86.42)	67 (98.53)
	2, 3, 4	30 (33.71)	19 (21.12)	11 (13.58)	1 (1.47)
TR	1	21 (39.63)	19 (53.84)	38 (80.86)	30 (75.00)
	2, 3, 4	32 (60.37)	34 (64.15)	9 (19.14)	10 (25.00)
p value		0.0035*	6.78x10-7*	0.56	0.00035*
Abbreviations: 1= MIH without hypersensitivity without defect; 2 = MIH without hypersensitivity with defect; 3 = MIH with hypersensitivity without defect; 4 = MIH with hypersensitivity with defect. ** Statistically significant p-values.*					

TABLE 5 MIH – Treatment Need Index (TNI) data of hypomineralised upper and lower PFMs and PIs in the Italian group (IT) and in the Turkish group (TR). Data are expressed as numbers n and percentages (in brackets).

females, 44 males) with a mean age of 9.29 ± 2.4 years. The two groups are described in detail as follows. The Italian study group comprised 50 MIH- affected subjects (27 females, 23 males) with a mean age of 9.58 ± 2.3 years. Specifically, 2 subjects were 6 years old and, 12, 4 and 0 subjects were 8, 12 and 16 years old, respectively. All subjects lived in Italy and, in particular, 46 subjects were from the Friuli Venezia Giulia region and 2, 1 and 1 subjects were from Veneto, Liguria and Lombardia regions, respectively. The Turkish group comprised 47 MIH-affected subjects (26 females, 21 males) with a mean age of 10.29 ± 2.4 years. As regards the distribution of MIH by age, 2 subjects were 6 years old and, 24, 8 and 1 subjects were 8, 12 and 16 years old, respectively. All subjects lived in the Marmara region.

MIH Prevalence and Co-presence of HSPM

The overall prevalence of MIH in both study groups was 11.54%. In the Italian group, out of 390 visited subjects, 50 were diagnosed with MIH (12.82%). Regarding the co-presence of HSPM, 41 subjects (82.00%) had all four SPMs present in the arch and, out of these, 34 subjects (82.92%) had at least one HSPM; in particular, 6 subjects had one HSPM (17.64%), 16 subjects had two HSPMs (47.08%) and 6 and 6 subjects had three (17.64%) and four (17.64%) HSPMs, respectively. As for the Turkish group, out of 450 visited subjects, 47 were diagnosed with MIH (10.44%). Regarding the co-presence of HSPM, 22 subjects (46.80%) had all four SPMs present in the arch and, out of these, 4 subjects (18.18%) had at least one HSPM; in particular, 1 subject had one HSPM (25.00%), 2 subjects had two HSPMs (50.00%), 1 subject had three HSPMs (25.00%), no subjects had four HSPMs. The comparison of MIH prevalence between the groups was not significant (p value = 0.283).

Clinical Data

Clinical data about the severity of hypomineralised lesions in fully erupted upper and lower permanent first molars (PFMs), permanent incisors (PIs) and second primary molars (SPMs) in the two groups are reported in Table 1. Overall, mild lesions were prevalent representing 81.13% and 95.60% of all MIH and HSPM-affected teeth lesions, respectively. Maxillary and mandibular PFMs were equally affected while maxillary PIs were more affected than mandibular PIs (54.24% vs 45.76%). The Chi-square test revealed a significant

difference in the distribution of MIH lesions severity between the groups ($p < 0.05$). Specifically, Italians showed a significantly higher prevalence of mild lesions while Turkish had a greater prevalence of severe forms. Clinical characteristics of hypomineralised PFMs, PIs and SPMs in the two groups are described in Table 2, Table 3 and Table 4. In detail, Table 2 shows the clinical features of hypomineralised upper and lower PFMs, PIs and SPMs scored according to the charting criteria of the MIH – HSPM clinical data recording sheet permanent and primary dentitions (long form) [Ghanim et al., 2015] and the additional parameters on the type of restoration proposed by the authors. Creamy white opacities were predominant, representing 75.14% and 85.55% of all lesions in MIH and HSPM-affected teeth, respectively. 1.27% of all hypomineralised PIs were restored while none was decayed; as for molars, 48.98% and 69.23% of all hypomineralised PFMs and SPMs, respectively, had an experience of carious lesions i.e., untreated lesions and/or performed restorations. 98.81% and 100% of the restorations in MIH and HSPM-affected teeth, respectively, were resin composites. No amalgam restorations or preformed metal crowns were noticed. The associations between MIH and carious lesions as well as HSPM and carious lesions in MIH-affected subjects were not significant (p value = 0.09 and 0.61, respectively) while those between MIH and restorations as well as HSPM and restorations in MIH-affected subjects were significant (p value = 0.02 and 0.001). PEB cases involved hypomineralised PFMs (10.53%) and SPMs (2.20%); the association between MIH and PEB was significant (p value = 0.04). Data about fissure sealants i.e., type of fissure sealant and its retention in intact fully erupted MIH-affected upper and lower PFMs are presented in Table 3. Overall, sealed PFMs were 46.82% of all intact hypomineralised molars; resinous sealants were more common than glass ionomer (GI) sealants (62.96% vs 37.04%). Table 4 shows dentin hypersensitivity data assessed chairside on hypomineralised upper and lower PFMs, PIs and SPMs in the two groups. 40 patients (41.23% of all MIH-affected subjects; n = 97) complained of dentin hypersensitivity in at least one MIH-affected tooth; in detail, 13 subjects were Italian (6 females, 7 males) and 27 Turkish (16 females, 11 males). Overall, PFMs were more sensitive than PIs (23.50% vs 9.74%). As regards the altered aesthetics of hypomineralised PIs, overall, 15 subjects (15.46%) complained of aesthetic issues; in detail, 7 were Italian (6 females, 1 male) and 8 Turkish (7 females, 1 male). Data on needing-treatment cases evaluated according to the MIH – Treatment Need Index (TNI) [Steffen et al., 2017] are presented in Table 5. Among Turkish (n = 47) and Italian (n = 50) MIH- affected subjects, patients with at least one hypomineralised needing-treatment tooth were 33 and 25, respectively. Significant differences between the groups in the treatment needs of PFMs (p values = 0,0035 and 6,78x10-7 for upper and lower molars, respectively and lower PIs (p value = 0.00035) were found.

Discussion

This two-center cross-sectional study aimed to describe the prevalence of MIH and co-presence of HSPM in a group of Italian and Turkish 6-16-years old subjects and delineate the clinical patterns of affected teeth, providing a very detailed epidemiological picture of those DDE using an EAPD validated collection form [Ghanim et al., 2015]. In the study population (n = 840), the overall prevalence of MIH was 11.54% without an evident sex prevalence, in accordance with literature data estimating a mean global prevalence of MIH at 13.5% with non-significant sex-related differences [Lopes et al., 2021]. The prevalence of MIH in the Italian group was 12.82% and in the Turkish group 10.44% with no significant difference between the two samples (p-value = 0.283); thus, the null hypothesis was accepted. The similar prevalence rates of MIH in Italy and Turkey might be explained by the fact that they are countries located in the Mediterranean region. The mean age of participants was 9.29 ± 2.4 years, which, according to the literature, is the optimal age range for evaluating the relationship between MIH and HSPM [McCarra et al., 2022; Garot et al., 2018; Marcianes et al., 2023; Sidhu et al., 2020]. The high variability of the described co-presence of HSPM in MIH-affected children having at least one SPM in the Italian and Turkish groups (82.92% and 18.18% respectively) highlighted that, although HSPM seems to be predictive for MIH, its absence cannot exclude the future MIH development [Garot et al., 2018; Marcianes et al., 2023; Sidhu et al., 2020; Bani-Hani et al., 2025]. In detail, for the Turkish group, HSPM may have been overlooked due to the great number of SPMs not present in the dental arches; out of the 47 MIH-affected subjects evaluated, only 22 had all four SPMs. Concerning the severity of hypomineralised lesions [Lygidakis et al., 2022; Elfrink et al., 2008; Weerheijm et al., 2003], overall, the mild form was the most frequent as described in other studies [Borrego-Marti et al., 2021; McCarra et al., 2022; Garot et al., 2018; da Costa Rosa et al., 2022; Bani- Hani et al., 2025]. The 81.13% and 95.60% of MIH and HSPM lesions, respectively, were classified as mild. Mild HSPM is considered a more likely risk factor for MIH development than severe HSPM, probably because the last SPMs mineralisation phase overlaps with the first FPMs mineralisation stages, when ameloblasts are highly sensitive to external influences [Garot et al., 2018; Marcianes et al., 2023]. The severity, however, is not a constant parameter but may change over time as other conditions, e.g., the individual caries receptivity, vary [Marcianes et al., 2023]. The MIH/HSPM distribution patterns showed that FPMs were more frequently involved than PIs (54.24% vs 45.76%) and buccal surfaces were the most affected. These observations were in agreement with most epidemiological studies [Sidhu et al., 2020]. Overall, hypomineralised teeth showed a positive experience of carious lesions and restorations confirming that the affected enamel, due to its histopathological features [Elhennawy et al., 2017], is more at risk of decay than the sound enamel [Ben Salem et al., 2023]. However, the lower prevalence of carious lesions diagnosed in MIH-affected teeth compared to HSPM (7.67% vs 21.97%), contrasted with the 2023 systematic review reporting a higher lesions' prevalence in the permanent dentition [Ben Salem et al., 2023]. The detection of all carious lesions and PEB cases in MIH-affected FPMs was in line with literature data explaining that molars, being placed backward in the mouth, undergo higher masticatory loads than incisors and are more difficult to be adequately brushed with a consequent greater risk of plaque accumulation and thus carious lesions and/or PEB development [Elhennawy et al., 2017]. As for restoration and sealing materials, resin composites and resin-based fissure sealants were the most frequently used materials in both countries followed by GICs which are helpful when the moisture control is inadequate and the patient's cooperation is limited [Lygidakis et al., 2022; Somani et al., 2022]. The higher dentin hypersensitivity prevalence rate observed in MIH-affected females (55.00%) was in line with literature data, reporting that girls complain

of hypersensitivity more frequently than boys [Romo Pérez et al., 2023]. In the evaluation of dentin hypersensitivity, however, it has to be considered that obtaining reliable findings may be challenging in children [Raposo et al., 2019]. Females were also found to be more conscious of the aesthetic impact on their teeth, complaining more often than males about aesthetic issues (86.66%) [Romo Pérez et al., 2023]. Finally, the high percentage of MIH needing treatment cases found in this study (59.79%) confirmed the healthcare and economic impact of MIH and highlighted the importance of early diagnosis as well as prevention to improve the affected subjects' oral-health-related quality of life and reduce the care burden [Schwendicke et al., 2018; Paglia, 2018; Lygidakis et al., 2022]. This study presents some limitations that need to be discussed. First of all, it is a cross-sectional study; therefore, to provide more substantial evidence, prospective studies would be required primarily to obtain more accurate data on the relationship between HSPM and MIH. In addition, the fact that it was performed in dental practice settings in specific locations may limit the applicability of the obtained findings to other populations. Lastly, since not all participants had all four SPMs present in the mouth at the assessment time, the evaluated co-presence of HSPM in MIH-affected subjects might have been underestimated.

Conclusion

This two-center cross-sectional observational study showed similar prevalence rates of MIH and therapeutic approaches, particularly regarding the types of materials used, between Italy and Turkey. However, there was high variability in the co-presence of HSPM among MIH-affected children in the two groups. Further standardised longitudinal studies focusing on large cohorts of HSPM-affected and unaffected subjects followed up until the eruption of FPMs and PIs are fundamental to deepen the knowledge about the relationship between HSPM and MIH.

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