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Exploring the Prevalence of Hypomineralised Second Primary Molars (HSPM) and Molar Incisor Hypomineralisation (MIH) as Perceived by Northern Italian Dentists: A Comprehensive Survey

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Abstract Background: The purpose of this study was to collect prevalence data of Hypomineralized Second Primary Molars (HSPM) and Molar Incisor Hypomineralization (MIH) among pediatric patients treated by dental practitioners in Northern Italy and assess the practitioners' awareness of these conditions. Methods: A cross-sectional pilot study was conducted using a structured online questionnaire administered through Google Forms. The survey comprised 10 single-choice questions addressing the prevalence of opacities affecting molars and an index of HSPM and MIH in caries-free children aged 6-9 years, categorized by percentage. Results: A total of 315 dentists participated in the survey, yielding a response rate of 31.5%. The majority of respondents (59%) reported HSPM prevalence in 1-25% of their patients, while 18% observed no opacity in any of their patients. MIH was observed in HSPM patients in 1-25% and 25-50% of cases, as reported by 44% and 31% of respondents, respectively. Among non-HSPM patients, MIH was observed in 1-25% of children (reported by 74% of respondents). Conclusion: The findings from this pilot survey show substantial agreement with existing prevalence data on HSPM and MIH. The co-occurrence rate of HSPM and MIH defects supports the hypothesis of HSPM potentially serving as a predictor of MIH.

Keywords: developmental enamel defects; HSPM; hypomineralisation; MIH; prevalence; survey

1. Introduction

In recent decades, a substantial body of literature has extensively documented developmental enamel defects (DDE), impacting both primary and permanent teeth. These defects involve alterations in the quality and/or quantity of dental enamel due to damage during formation [1,2]. Molar Incisor Hypomineralisation (MIH), officially defined in 2001 and endorsed by the European Academy of Paediatric Dentistry (EAPD), delineates a specific hypomineralisation pattern, primarily affecting at least one permanent first molar and often extending to associated incisors [3–7]. In 2008, Elfrink et al. introduced the term "hypomineralized second primary molars (HSPM)" for DDE on deciduous teeth [8].

Teeth affected by MIH exhibit demarcated white, yellow, or brown opacities, causing aesthetic concerns, hypersensitivity, inflammation, tooth wear, post-eruptive breakdown, and an elevated risk of caries, significantly impacting the oral health-related quality of life in children [9,10].

In comparison to healthy teeth, teeth with DDE exhibit a histologically prism sheath that is less distinct. These defects are characterized by a scarcity of hydroxyapatite crystals. The

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hypomineralized enamel possesses diminished mechanical properties, including lower hardness and elasticity, in contrast to normal enamel. Furthermore, enamel affected by these conditions displays an increased presence of proteins such as serum albumin, type I collagen, ameloblastin, a1-antitrypsin, and antitrobin III. These proteins inhibit the growth of hydroxyapatite crystals, leading to a reduction in enamel minerals [11].

The etiology of MIH is multifactorial, encompassing genetic, iatrogenic, perinatal, pregnancy-related conditions, diseases, and environmental contaminants [12,13]. A review by Butera underscores the complexity of these pathologies, summarizing numerous studies exploring environmental or genetic factors, often yielding inconclusive findings [14].

The maturation period of enamel affected by defects spans from the last trimester of pregnancy to the third year of a child's life. During this period, genetic variations may interact with environmental factors. Prenatal, perinatal, and post-natal factors can influence enamel pH, hindering enzyme action and crystal development [14]. While various factors, such as smoking and alcohol consumption during pregnancy, premature birth, perinatal complications, hypoxia, low birth weight, calcium metabolic disorders, prolonged breastfeeding, childhood diseases, high fever episodes, use of antibiotics/drugs, asthma, and respiratory problems, have been extensively investigated, a definitive cause remains unidentified.

The association between dental caries and enamel hypomineralization has also been established [15,16]. A systematic review [15] indicated that the probability of finding a child with both MIH and dental caries is 2.1-4.6 times higher than finding a child with MIH without dental caries. Proposed explanations for this association include alterations in the structure and composition of hypomineralized teeth, such as increased porosity, higher carbon and carbonate content, and the presence of posteruptive enamel breakdown. However, the relationship between hypomineralization and the activity of the dental caries lesion has been poorly investigated.

Management strategies involve preventive measures, including oral hygiene, diet, remineralizing agents, desensitizing agents, and appropriate fissure sealants. In severe cases, restorative options encompass bioactive, glass ionomer cement-based, hydrophilic, or traditional resin-based materials [17,18]. MIH and HSPM share similar clinical features, including demarcated opacities and atypical dental caries lesions/restorations [6]. Recent studies highlight the association between HSPM and MIH [14,15,18]. Garot et al.'s [19] systematic review demonstrated HSPM's higher probability of presenting MIH, suggesting a potential predictive role of HSPM. Quintero [20] illustrated a strong association between MIH and HSPM, emphasizing the role of the dental caries lesion in influencing the strength of this association and the severity of the defects.

The reported prevalence of MIH spans a considerable range, fluctuating from 2.9% to 44%, with a specific estimate centering around 13.5%. HSPM is identified in approximately 3.6% of MIH cases, presenting an overall lower prevalence that falls within the range of 0% to 21.8%. Notably, HSPM often manifests in milder forms compared to MIH [21–24]. The co-occurrence of HSPM and MIH displays geographical variability and is influenced by a spectrum of factors, encompassing environmental, genetic, health-related, and lifestyle considerations [20]. Despite HSPM 'tendency to go unnoticed, owing to its lower prevalence, early identification assumes paramount importance for effectively managing potential MIH cases [25].

In light of these considerations, this study aims to collect prevalence data of HSPM and MIH as perceived by dental practitioners in Northern Italy, with the objective of elucidating practitioners' levels of awareness regarding these conditions.

2. Materials and Methods

A cross-sectional pilot study was designed as a survey to collect data on the prevalence of Molar Incisor Hypomineralisation (MIH) and hypomineralised second primary molars (HSPMs) in children. A structured online questionnaire was administered through Google Forms (Google LLC, Mountain View, CA, USA). No specific approval for this type of study was required from the local ethics committee. The University of Brescia was responsible for data collection and management. The questionnaire was directed to Italian dentists and distributed through the authors' mailing list, the

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local national dental association (ANDI Brescia), and social networks. Participation in the questionnaire was voluntary, anonymous, and without any form of remuneration. The invitation email outlined the research objectives and indicated that the project and its results would be disseminated through scientific publications.

The questionnaire, formulated in the Italian language, comprised 10 single-choice questions. The queries addressed the percentage of children among the total number of annual patients, the proportion of pediatric patients aged 6 to 9 years, and the percentage of children with opacities on second primary molars and/or first permanent molars among caries-free children aged 6 to 9 years (see Supplementary Material S1). The validity of the questionnaire was assessed through a preliminary test involving ten randomly selected dentists from the target population. Factors such as survey length, question appropriateness, and the clarity of definitions were considered.

The sample size was determined a priori, with a population of 1000 dentists, a confidence level of 95%, and a margin of error of 5%, requiring a sample size of 100 respondents. The collected data were exported to an Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) and analyzed using STATA17 (Stata Corp., College Station, TX, USA).

3. Results

Three hundred and fifteen dentists actively participated in the survey, reflecting a response rate of 31.5%, considering the initial pool of 1000 surveyed professionals. Notably, the majority of respondents (83%) reported treating fewer than 100 pediatric patients annually. In further detail, 11.43% of participants handled a patient load ranging between 101 and 200 children, while a smaller percentage (5.08%) managed more than 200 pediatric patients.

In terms of the demographic composition, pediatric patients constituted up to 25% of the annual patient pool for 82% of the surveyed dentists. Specifically focusing on children aged 6-9 years, approximately 55% of respondents indicated that this age group represented less than a quarter of their annual pediatric patients, while 41% reported a range of 25-50%. Examining caries prevalence in children aged 6-9 years, 72% of dentists reported encountering less than 25% of caries-free cases, and 10.48% identified a prevalence falling between 25 and 50%.

Regarding recall practices, nearly half of the participants (47.94%) scheduled follow-up appointments for pediatric patients every six months, with 23.81% opting for a more frequent interval of every three months. Conversely, a minor fraction (10.16%) of respondents reported seeing pediatric patients primarily for urgent treatment. A comprehensive overview of the sample characteristics is presented in Table 1.

Among caries-free children aged 6-9 years, opacities on deciduous second molars were observed in less than 25% of patients (59.37%, 187/315). Eighteen percent (57/315) of respondents observed no opacity in any patients, while 14.92% (47/315) of dentists noted opacities in 25-50% of the children.

Among patients with opacities on deciduous second molars, the presence of opacities on permanent first molars were reported by 59.68% (188/315) of dentists. The prevalence of opacities on permanent first molars was observed by 43.62% (82/188) of dentists in 1-25% of patients, by 30.85% (58/188) of respondents in 25-50% of patients, and by 25.53% (48/188) of dentists in 50-75% of children.

Among caries-free patients without opacities on deciduous second molars, the presence of opacities on permanent first molars were reported by 49.52% (156/315) of respondents. Within this subgroup, the percentage of opacities on the first permanent molars was reported by 73.72% (115/156) of dentists in 1-25% of children, by 8.97% (14/156) in 25-50% of children, and by 17.31% (27/156) of dentists in 50-75% of children.

Comprehensive prevalence data of opacities in caries-free patients are detailed in Table 2.

Table 1. Characteristics of respondents.

	N (%)
Number of respondents	315/1000 (31,5%)

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Number of pediatric patients treated in clinical practice	
0-100	263 (83.49)
101-200	36 (11.43)
> 200	16 (5.08)
Percentage of pediatric patients compared with the total number of patients	
1-25%	259 (82.22)
25-50%	16 (5.08)
50-75%	13 (4.13)
75-100%	27 (8.57)
Percentage of children aged 6-9 years among the pediatric patients	
0-25%	174 (55.24)
25-50%	128 (40.63)
50-75%	8 (2.54)
75-100%	5 (1.59)
Percentage of caries-free children among patients between 6 and 9 years	
None	33 (10.48)
1-25%	226 (71.75)
25-50%	33 (10.48)
50-75%	18 (5.71)
75-100%	5 (1.59)
Frequency of scheduled check-up visits for patients between 6 and 9 years	
Yearly	57 (18.10)
Every six months	151 (47.94)
Every three months	75 (23.81)
Not periodically but only out of necessity	32 (10.16)

Table 2. Prevalence of opacities in caries-free children.

	N (%)
Prevalence of opacities on deciduous second molars	
None	57 (18.10)
1-25%	187 (59.37)
25-50%	47 (14.92)
50-75%	19 (6.03)
75-100%	5 (1.59)
Presence of opacities on the first permanent molars, in patients with opacities on the deciduous second molars	

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Yes	188 (59.68)
No	127 (40.32)
Prevalence of opacities on the first permanent molars in patients with opacities on the deciduous second molars	
1-25%	82 (43.62)
25-50%	58 (30.85)
50-75%	48 (25.53)
75-100%	0 (0)
Presence of opacities on the first permanent molars, in patients without opacities on the deciduous second molars	
Yes	156 (49.52)
No	159 (50.48)
Prevalence of opacities on the first permanent molars in patients without opacities on the deciduous second molars	
1-25%	115 (73.72)
25-50%	14 (8.97)
50-75%	27 (17.31)
75-100%	0 (0)

4. Discussion

DDE exert diverse impacts on both deciduous and permanent dentition, the severity of which varies based on the timing of the disrupting factor during odontogenesis. Certain manifestations are experiencing a noticeable surge and are increasingly prevalent in clinical practice. However, the under-diagnosis of structural anomalies remains a pervasive challenge.

Recognizing these anomalies at an early stage is crucial for effective clinical management, warranting attention from dentists. Timely identification is paramount for enhancing treatment outcomes and the overall quality of life for affected individuals. Treatment objectives encompass alleviating symptoms and achieving aesthetic, morphological, and functional restoration of affected teeth, often necessitating a multidisciplinary approach.

To curb the potential harm inflicted by enamel structure anomalies, regular and early visits, along with vigilant follow-ups, emerge as indispensable preventive measures. As we delve into the specific context of Northern Italy, this article endeavors to assess the awareness levels among dentists regarding the presence of enamel alterations in children and to investigate the prevalence of enamel hypomineralization defects on primary second molars (HSPM) and permanent first molars (MIH) as perceived by them.

For a substantial majority of the participants (82%), pediatric patients constituted only a limited segment of their routine clinical practice, falling within the range of 1-25%. Furthermore, nearly 90% of the surveyed respondents indicated that less than half of these pediatric cases pertained to the specific age bracket of 6-9 years. When considering these combined characteristics of the sample, it is plausible that the representativeness of the study cohort may have been influenced. This, in turn, could have impacted the likelihood of identifying HSPM and MIH defects, potentially leading to an underestimated prevalence of these conditions.

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A notable proportion of the participants (72%) conveyed that fewer than 25% of their pediatric patients exhibited a caries-free status. Ten percent of respondents reported having no caries-free pediatric patients, while only 7% of respondents reported that more than half of their patients in the age group of 6-9 years were caries-free. Further in the survey, caries-free children aged 6-9 years were indicated as the population of reference for assessing enamel defects presentation.

The prevalence of children identified as caries-free in this survey revealed a notable disparity from the established target of achieving 80% caries-free children, a benchmark set forth by the WHO Oral Health Goals for 2020. A mere 1.5% of the respondents reported having a patient pool that approached such desirable percentages [26]. A comparable scenario was observed in Southern Italy (Sicily), where a significant majority, 75% of young children, exhibited at least one carious lesion [27]. Nevertheless, a substantial degree of heterogeneity in the reported percentages of caries-free preschool children emerged across diverse geographical regions of Italy, Europe, and globally [28–30].

This variability can be attributed to divergent preventive strategies adopted at both individual and public health levels in different regions [31]. Furthermore, the lack of homogeneity and standardization in the diagnostic criteria employed for detecting and recording caries adds another layer of complexity to interpreting these variations [32]. The multifaceted nature of these contributing fac-tors underscores the need for a nuanced understanding of the challenges in achieving uniform oral health outcomes across diverse populations and regions.

Regarding routine follow-up examinations, the prevailing practice among the majority of respondents involved scheduling recalls for their pediatric patients at least every six months. This adherence to a semi-annual recall schedule aligns with the general guidelines advocated by scientific societies. However, it is noteworthy that trimestral recalls are recommended for children deemed to be at a high risk of developing caries [33].

Conversely, a substantial proportion of respondents (28%) disclosed a practice of conducting annual recalls or attending to young patients solely when urgent care is required. In such instances, there is an increased likelihood that enamel defects may escape detection, given the swift changes in dentition and the potential progression of conditions such as caries or other overlapping oral health issues in young patients [34]. This diversity in recall practices emphasizes the need for a nuanced approach to ensure timely identification and management of oral health issues, especially in pediatric populations.

A significant portion of the participants, comprising almost two-thirds, reported a prevalence ranging from 1% to 25% of opacities affecting second primary molars in caries-free children. This observation strongly suggests the existence of HSPM. Interestingly, only 18% of the participants noted the absence of such defects in their pediatric patient pool.

Within the subset of HSPM patients, the prevailing trend, as reported by the majority (73%) of participants, indicated that up to one in every two children also exhibited affected first permanent molars, contributing to the manifestation of Molar Incisor Hypomineralization (MIH). Conversely, in 40% of the reported cases, the defects did not extend to involve the first permanent molars, as highlighted by the corresponding percentage of respondents.

These comprehensive data sheds light on the intricate interplay between HSPM and MIH and underscores the diverse presentations of enamel defects in the pediatric population.

Recent reviews examining the prevalence and presentation patterns of these defects have highlighted significant variability in the data, underscoring the necessity for standardized investigation protocols. Elfrink et al., for instance, reported a prevalence range of 2.9–44% for MIH and 0–21.8% for HSPM [14]. The prevalence data obtained from our present survey largely align with these ranges and are consistent with findings from other studies [23,35]

HSPM has been suggested as a possible predictive factor for the development of MIH. Many studies support this hypothesis, with HSPM and MIH co-occurrence rates ranging between 11 and 20% [19,36,37]. Conversely, a study conducted on both healthy children and children with medical conditions reported low co-occurrence rates and concluded that HSPM could not be considered

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predictive for MIH. However, the author stated that the presence of other systemic factors, as well as medication usage, could have influenced the MIH/HSPM distribution patterns [24].

Further well-designed prospective studies should be planned to investigate the actual predictability and reliability of HSPM as a risk marker for the development of MIH.

The results of the present study indicate a slightly higher percentage range of co-occurrence of HSPM and MIH compared to other data in the literature. However, these results must be considered with caution due to the lack of direct examination, potential non-standardization of diagnostic criteria, and the consideration of affected molars only, which may have influenced the estimates of the number of cases.

Additionally, to minimize possible misdiagnosis, only caries-free children were considered for the detection of HSPM and MIH in this survey, which might have influenced the reported prevalence. The potential use of different and heterogeneous diagnostic criteria by various clinicians may have led to the inappropriate consideration of possible differential diagnoses of other enamel defects involving molars, such as diffuse fluorotic opacities, enamel hypoplasia, amelogenesis imperfecta, and white spots [10,38]. However, the generally limited incidence of such defects in this region is unlikely to have significantly affected the overall estimated percentage ranges [39].

Another major limitation of this research is the survey design, susceptible to recall bias, a common pitfall when assessing self-reported outcomes. This bias may, to varying degrees, compromise the robustness of the evidence produced.

Additionally, distribution and severity of the defects, clinical presentations other than opacities, and associated symptoms were not considered in this survey, providing only indicative prevalence information. This information was beyond the scope of this study. The authors chose a very simple questionnaire, taking only a few minutes to complete, to encourage participation in the survey. Nevertheless, the limited response rate (31.5%) led us to consider it a pilot study, highlighting the need to raise awareness of this topic among pediatric dentists as well as general dentists.

Interestingly, a survey conducted among dental students about their knowledge of MIH showed positive feedback, indicating the usefulness of implementing awareness and education on this topic starting from the undergraduate level for future dentists [40].

Lastly, although the data collected do not provide precise prevalence percentages but rather broad categories, they do give an idea of the local burden of this condition and still allow for an overall comparison with estimated prevalence data worldwide.

Future cross-sectional studies with a similar focus should emphasize the importance of raising awareness and urging all dental practitioners to carefully observe index teeth, identifying potential HSPM and MIH defects during examinations of young patients. The systematic recording of such cases should be encouraged by implementing specific, simple, guided checklists that ensure the application of validated and standardized diagnostic criteria and protocols. This approach would facilitate the early detection of this condition and the prompt management of these patients or referral to pediatric dental specialists when appropriate.

5. Conclusions

Despite some limitations in the estimates, the results of this pilot survey offer valuable insights into the prevalence of HSPM and MIH defects within the specific region of Northern Italy. Notably, the prevalence rates observed in this study closely mirror those documented in existing literature, suggesting a consistency of findings across different geographical contexts.

Furthermore, the co-occurrence rate of HSPM and MIH defects, as evidenced by our survey results, provides additional support for the hypothesis regarding the potential predictive role of HSPM in the development of MIH. This finding underscores the critical importance of early detection and subsequent follow-up and management of patients presenting with these enamel defects. Timely intervention is essential in mitigating the potential complications associated with these conditions and ensuring optimal oral health outcomes for affected individuals.

Moreover, our study underscores a pressing need to raise awareness of hypomineralization defects among dental practitioners. By increasing knowledge and understanding of these conditions,

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clinicians can enhance their ability to recognize and diagnose such defects accurately. Additionally, the promotion and adoption of standardized diagnostic protocols are imperative to facilitate the collection of precise and reliable data regarding prevalence and presentation patterns. Through concerted efforts to improve awareness and diagnostic practices, we can advance our understanding of hypomineralization defects and ultimately enhance the quality of care provided to individuals affected by these conditions.

Supplementary Materials: Figure S1

Author Contributions: "Conceptualization, A.M and F.A.; methodology, G.C. and F.A; software, G.C.; investigation, G.C and F.V.; writing—original draft preparation, E.B. and F.V.; supervision, A.M. and E.B; project administration, G.C., F.A .All authors have read and agreed to the published version of the manuscript." Please turn to the CRediT taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

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