J Oral Res
oral and craniofacial sciences

Review

Analysis of prevalence and diagnostic criteria of molar-incisor hipomineralization.

Análisis de prevalencia y criterios diagnósticos de hipomineralización molar-incisiva.

Lunna Farias.[1]
Isla Camilla Carvalho Laureano.[1]
Catarina Ribeiro Barros de Alencar.[1]
Alessandro Leite Cavalcanti.[2]

Affiliations: [1]School of Dentistry, State University of Paraíba, Campina Grande, Paraíba, Brazil. [2]Department of Dentistry, State University of Paraíba, Campina Grande, Paraíba, Brazil.

Corresponding author: Alessandro Leite Cavalcanti. Universidade Estadual da Paraiba, Depto de Odontologia Rua Baraúnas, 351, Bairro Universitário. Campina Grande, PB, Brazil. Email: alessandrouepb@gmail.com

Receipt: 03/21/2018 **Revised:** 04/03/2018
Acceptance: 06/03/2019 **Online:** 08/05/2019

Abstract: To identify the prevalence and diagnostic criteria of Molar-Incisor Hipomineralization (MIH) in the scientific literature. Materials and Methods: This is a bibliographical research conducted through the analysis of indexed articles until October 2017 in the PubMed, Web of Science and Scopus databases. The Medical Subject Headings (MESH) used were "Dental Enamel Hypoplasia" and "Molar Incisor Hypomineralization". The analysis of articles was carried out by two reviewers, who collected information independently. The following information was collected: author, year of publication, place of work (continent and country), sample calculation, sample number, age of participants, type of study, prevalence of molar-incisor hypomineralization and criteria used for diagnosis. Data were tabulated using Microsoft Excel for Windows and presented using descriptive statistics. Results: A total of 484 articles were found and 57 were included in the study. Most of the studies were conducted in Europe (35%), and 31.6% of the studies mentioned using a probability sampling. The number of study participants ranged from 99 for a study in Brazil to 3,591 in Kenya. The most frequent age was 8 years, while the predominant type of study was cross-sectional (91.2%). The prevalence varied from 0.4% to 37.3% and most studies (73.6%) employed the European Academy of Pediatric Dentistry criteria for the diagnosis of MIH. Conclusion: There is great variability in prevalence in different countries, probably due to the use of different diagnostic criteria being used, and due to different age groups and geographical variation.

Keywords: Dental enamel hypoplasia; molar incisor hypomineralization; child.

Resumen: Objetivo: Identificar la prevalencia y los criterios diagnósticos de la hipomineralización de incisivos molares (HIM) en la literatura científica. Materiales y métodos: Investigación bibliográfica realizada a través del análisis de artículos indexados hasta octubre de 2017 en las bases de datos PubMed, Web of Science y Scopus. Los Medical Subject Headings (MESH) utilizados fueron “Dental Enamel Hypoplasia" y "Molar Incisor Hypomineralization". El análisis de los artículos fue llevado a cabo por dos revisores, quienes recolectaron información de manera independiente. Se recopiló la siguiente información: autor, año de publicación, lugar de trabajo (continente y país), cálculo y número de muestra, edad de los participantes, tipo de estudio, prevalencia de hipomineralización molar-incisiva y criterios utilizados para el diagnóstico. Los datos se tabularon con Microsoft Excel para Windows y se presentaron con estadísticas descriptivas. Resultados: Se encontraron un total de 484 artículos y 57 se incluyeron en el estudio. La mayoría de los estudios se llevaron a cabo en Europa (35%), y el 31,6% de los estudios mencionados utilizaron una muestra probabilística. El número de participantes en el estudio varió de 99

Cite as:
Farias L, Laureano ICC, de Alencar CRB & Leite Cavalcanti A. Analysis of prevalence and diagnostic criteria of molar-incisor hipomineralization.
J Oral Res 2019; 8(3):254-262.
DOI: 10.17126/joralres.2019.038

ISSN Online 0719-2479 - www.joralres.com © 2019

en un estudio en Brasil a 3.591 en un estudio desde Kenia. La edad más frecuente fue de 8 años, mientras que el tipo de estudio predominante fue transversal (91,2%). La prevalencia varió de 0,4% a 37,3% y la mayoría de los estudios (73,6%) emplearon los criterios de la Academia Europea de Odontología Pediátrica para el diagnóstico de HIM. Conclusión: Existe una gran variabilidad en la prevalencia de HIM en diferentes países, probablemente debido al uso de diferentes criterios de diagnóstico, al utilizar diferentes grupos de etarios y a la variación geográfica.

Palabras Clave: *Hipoplasia del esmalte dental; Desmineralización dental; Niño.*

INTRODUCTION.

Molar-Incisor Hypomineralization (MIH) is a qualitative defect in tooth enamel development.[1] In general, it affects from one to four first permanent molars, and may also be present in permanent incisors.[2,3] The etiological factors of MIH remain uncertain, but prenatal, perinatal and postnatal factors, genetic and environmental conditions are related to this condition.[2,4-6] Diseases such as acute otitis media, chicken pox and respiratory illnesses during the first year of life, as well as prolonged use of antibiotics and exposure to dioxins due to prolonged breastfeeding are some of the associated factors described in literature.[2,4-6]

MIH is a result of an injury to enamel-forming cells during calcification or maturation of the dental organ and is characterized by the opaque appearance of the enamel.7,8 It presents as well-delimited spots varying in color from white, yellow to brown.[4,9,10] Due to the porous enamel, the affected teeth are more prone to fractures and, in more severe cases, may present unusual cavities and extensive disintegration,[7,8,11] leading to large bacterial biofilm deposits, responsible for increasing susceptibility of teeth with MIH to dental caries.[12,13] Hypersensitivity is another characteristic, which makes tooth brushing difficult14 as well as dental treatment due to the difficulty in achieving local anesthesia of the affected tooth.[16,17]

Therefore, teeth with MIH require recurrent interventions due to continuous disintegration from masticatory forces and difficulty in the adhesion of restorative materials to the defective enamel.[6] In severe cases with major coronary destruction, extraction of affected teeth is recommended in association with the use of orthodontic devices to manage the edentulous space.[13,17]

Children who suffer from MIH demonstrate behavior management problems and are at increased risk of developing fear and anxiety.[6] Thus, this condition has a negative impact on the patient's quality of life and represents a challenge for dentists.[3,18]

In the dental literature, there is a great variation regarding the occurrence of MIH in different countries.[19] European countries account for the largest number of studies, reporting distinct prevalences such as 7%[14] and 15,4%.[11] This variation also can be found in studies performed in other continents.[2,3,13,15]

The prevalence rate varies widely among populations due to the age of subjects examined (five to six years,[7] seven to nine years,[6,13] eight to twelve years,[8] and six to thirteen years),[15] due to methods of recording information, methodological differences (transversal[6,11,14] *versus* cohort[7] studies) and the criteria used for the diagnosis[19] (EAPD1, Kemoli[20] or another set of criteria developed by some study authors themselves).[11,20] Therefore, this study aimed to analyze, through a bibliographic review, the prevalence of molar-incisor hypomineralization and the methodological criteria adopted for its diagnosis.

MATERIALS AND METHODS.

Literature Search

This is a bibliographical research conducted through the analysis of articles indexed until October 2017 in the PubMed (US National Library of Medicine National Institutes of Health), Web of Science (Clarivate Analytics) and Scopus (Elsevier) databases. Medical Subject Headings (MESH) used were *"Dental Enamel Hypoplasia"* and *"Molar Incisor Hypomineralization"*. The PRISMA guidelines were followed (Available at: http://prisma-statement.org/).

The included studies met the following eligibility criteria: observational (cross-sectional, cohort and case-control) and experimental studies (clinical trials); studies that presented data regarding the prevalence or raw data that could be used to calculate the prevalence of MIH, and articles describing criteria used for the diagnosis of the condition.[4] Studies that reported only hypomineralization in deciduous molars were excluded.

The analysis of articles was carried out by two reviewers

(LF and ICCL), who collected information independently. At the end of the analysis, the collected information was compared and discrepancies were discussed. In cases of disagreements, a third researcher (CRBA) made the final decision to include or exclude the article.

The following information was collected: author, year of publication, workplace location (continent and country), use of probability sampling, sample number, age of participants, type of study, prevalence of molar-incisor hypomineralization and diagnosis criterion. Data were tabulated using Microsoft Excel 2016 for Windows (Microsoft Press, Redmond, WA, USA) and presented using descriptive statistics.

RESULTS.

Overall, 484 articles were found, of which 226 from PubMed, 163 from Web of Science and 95 from Scopus. After duplicate articles were removed, 240 articles remained, of which 61 were selected and carefully examined. Of these, 57 were selected for further analysis and 4 were excluded as they did not meet the eligibility criteria. (Figure 1)

Regarding the geographic distribution, most articles were carried out by researchers in Europe (35.1%) and Asia (29.8%), followed by those in the Americas (26.3%) and in Africa (8.8%). The number of participants ranged from 99 Brazilian children[2] to 3,591 Kenyan individuals.[20] Among the articles, 31.6% mentioned having performed sample calculation in their methodology.[5,8,10,14,18,21-33] The most frequent age was 8 years (77.2%), ranging from 034 to 19 years.[32] Regarding the type of study, the most common was the cross-sectional design (91.2%). The prevalence of MIH ranged from 0.48% in Indian children[28] to 37.3% in Danish children.[21] Most articles (73.6%) used the guidelines proposed by the European Academy of Pediatric Dentistry as a diagnostic criterion for MIH.

Table 1 shows the distribution of articles from the European continent. There was a predominance of cross-sectional studies (85%), involving children and adolescents from 0 to 16 years. The prevalence of MIH ranged from 5.9%35 to 37.3%.[21] With regard to the Asian continent, almost half of articles were conducted in India (41.1%) and included children and adolescents aged 6-16 years. (Table 2)

The highest prevalence found was 27.7% in a study conducted in Thailand.[44] Similarly, most articles adopted the criteria proposed by the European Academy of Pediatric Dentistry (82.3%). In the Americas, 73.3% of articles were conducted in Brazil (Table 3), involving individuals aged 5-17 years.[56] The prevalence varied from 2.5%, considering the Modified Enamel Developmental Defect Index (DDE)[5] to 33.2%, using the criteria of the European Academy of Pediatric Dentistry.[57]

Only 8.8% of articles found were conducted in Africa and they presented the lowest variation in prevalence, from 2.9%[63] to 13.7%20. (Table 4)

Figure 1. Flowchart of selection procedure for the articles included in the review.

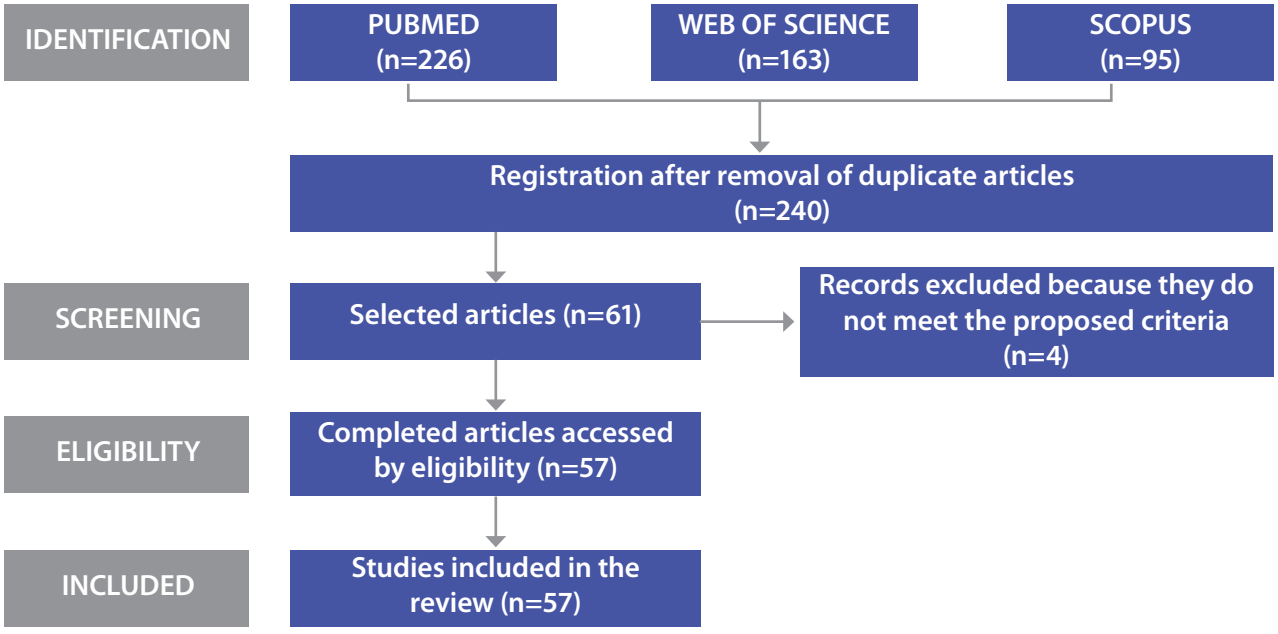

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Table 1. Distribution of studies conducted in Europe.

Author	Year	Country	Design	Probability Sampling	Sample (n)	Age (Years)	Prevalence	Diagnostic Criteria
Koch *et al.*[11]	1987	Sweden	CS	No	2.226	8-10	15.4%	Author's Criterion
Jälevik *et al.*[36]	2001	Sweden	CS	No	516	7 to 9	18.4%	DDE Modified
Jasulaityte *et al.*[6]	2007	Lithuania	CS	No	1.277	7 to 9	9.7%	EAPD
Preusser *et al.*[35]	2007	Germany	CS	No	1.022	6 to 12	5.9%	Other
Wogelius *et al.*[21]	2008	Denmark	CS	Yes	745	6 to 8	37.3%	EAPD
Laise *et al.*[37]	2009	Finland	CT	No	141	10.7*	16.3%	Other
Condó *et al.*[34]	2012	Italy	CS	No	1.500	0 to 15	7.3%	Author's Criterion
Elfrink *et al.*[7]	2012	Netherlands	CH	No	2.327	5 to 6	8.7%	EAPD
Kühnisch *et al.*[22]	2012	Germany	CH	Yes	693	10	14.7%	EAPD
Garcia-Margarit *et al.*[23]	2014	Spain	CS	Yes	840	8	21.7%	EAPD
Janković *et al.*[38]	2014	Serbia	CS	No	141	8	12.7%	EAPD
Wuollet *et al.*[39]	2014	Finland	CS	No	818	7 to 13	17.1%	EAPD
Kevrekidou *et al.*[24]	2015	Greece	CS	Yes	2.335	8 to 14	21.3%	EAPD
Kühnisch *et al.*[25]	2015	Germany	CS	Yes	1.048	10	13.6%	EAPD
Opydo-Szymaczek *et al.*[40]	2015	Poland	CS	No	470	6 to 8 12 to 14	8.1%	DDE Modified
Negre-Barber *et al.*[26]	2016	Spain	CS	Yes	414	8 to 9	24.1%	EAPD
Schmalfuss *et al.*[41]	2016	Norway	CS	No	794	16	13.9%	EAPD
Van Der Tas *et al.*[42]	2016	Netherlands	CS	No	2.370	6	8.5%	EAPD
Wuollet *et al.*[43]	2016	Finland	CS	No	287	7 to 12	11.5%	EAPD
Buchgraber *et al.*[14]	2017	Austria	CS	Yes	1.111	6 to 12	7%	EAPD

CS: Cross-sectional. **CT:** Clinical Trial. **CH:** Cohort. ***:** Average age. **EAPD:** European Academy of Paediatric Dentistry. **DDE:** Enamel Developmental Defect Index.

Table 2. Distribution of studies conducted in Asia.

Author	Year	Country	Design	Probability Sampling	Sample (n)	Age (Years)	Prevalence	Diagnostic Criteria
Cho *et al.*[45]	2008	China	CS	No	2.635	11 to 14	2.8%	Author's Criterion
Kuscu *et al.*[46]	2009	Turkey	CS	No	153	7 to 10	9.1%	EAPD
Ahmadi *et al.*[13]	2012	Iran	CS	No	433	7 to 9	12.7%	DDE Modified
Allazzam *et al.*[47]	2014	Saudi Arabia	CS	No	267	8 to 12	8.6%	EADP
Bhaskar *et al.*[27]	2014	India	CS	Yes	1.173	8 to 13	9.5%	EAPD
Pitiphat *et al.*[44]	2014	Thailand	CS	No	282	7 to 8	27.7%	EAPD
Pitiphat *et al.*[48]	2014	Thailand	CS	No	484	6 to 7	19.6%	EAPD
Shrestha *et al.*[49]	2014	Nepal	CS	No	747	7 to 12	13.6%	EAPD
Hussein *et al.*[50]	2015	Malaysia	CS	No	154	7 to 12	16.9%	EAPD
Kirthiga *et al.*[51]	2015	India	CS	No	2.000	11 to 16	8.9%	
Ng *et al.*[52]	2015	Singapore	CS	No	1.083	7.7*	12.5%	EAPD
Mishra *et al.*[53]	2016	India	CS	No	1.369	8 to 12	13.9%	EAPD
Mittal*et al.*[54]	2016	India	CS	No	1.726	12 v 16	9.8%	EAPD
Mittal *et al.*[55]	2016	India	CS	No	886	6 to 12	7.1%	EAPD
Salem *et al.*[15]	2016	Iran	CS	No	553	6 to 13	18.4%	EAPD
Subramaniam *et al.*[28]	2016	India	CS	Yes	2.500	7 to 9	0.4%	EAPD
Yannam *et al.*[8]	2016	India	CS	Yes	2.864	8 to 12	9.6%	EAPD

CS: Cross-sectional. **CT:** Clinical Trial. **CH:** Cohort. ***:** Average age. **EAPD:** European Academy of Paediatric Dentistry. **DDE:** Enamel Developmental Defect Index.

Table 3. Distribution of studies conducted in the Americas.

Author	Year	Country	Design	Probability Sampling	Sample (n)	Age (Years)	Prevalence	Diagnostic Criteria
Da Costa-Silva *et al.*[9]	2010	Brazil	CS	No	918	6 to 12	19.8%	EAPD
Biond *et al.*[58]	2011	Argentina	CS	No	1.098	11.3*	15.9%	DDE Modified
Biond *et al.*[59]	2012	Argentina/Uruguay	CS	No	975	11.6*	6.5%	Other
Jeremias *et al.*[10]	2013	Brazil	CS	Yes	1.157	6 to 12	12.3%	EAPD
Jordi *et al.*[60]	2014	Argentina	CS	No	1.716	10 to 16	14.7%	Other
De Lima *et al.*[29]	2015	Brazil	CS	Yes	594	11 to 14	18.3%	EAPD
Hanan *et al.*[61]	2015	Brazil	CS	No	2.062	6 to 10	9.1%	EAPD
Rodrigues *et al.*[5]	2015	Brazil	CC	Yes	1.179	7 to 14	2.5%	DDE Modified
Silva Júnior *et al.*[56]	2015	Brazil	CS	No	260	5 to 17	8.8%	EAPD
Dantas-Neta *et al.*[18]	2016	Brazil	CS	Yes	594	11 to 14	18.3%	EAPD.
Jeremias *et al.*[57]	2016	Brazil	CS	No	391	10*	33.2%	EAPD.
Tourino *et al.*[30]	2016	Brazil	CS	Yes	1.181	8 to 9	20.4%	EAPD
Andrade *et al.*[2]	2017	Brazil	CC	No	99	7 to 15	31.3%	EAPD
Teixeira *et al.*[3]	2017	Brazil	CS	No	334	8 to 15	29.3%	EAPD
Gurrusquieta *et al.*[62]	2017	Mexico	CS	No	1.156	6 to 12	15.8%	EAPD

CS: Cross-sectional. **CC:** Case control. **CH:** Cohort. ***:** Average age. **EAPD:** European Academy of Paediatric Dentistry. **DDE:** Enamel Developmental Defect Index.

Table 4. Distribution of studies conducted in Africa.

Author	Year	Country	Design	Probability Sampling	Sample (n)	Age (Years)	Prevalence	Diagnostic Criteria
Fteita *et al.*[63]	2006	Libya	CS	No	378	7-8.9*	2.9%	EAPD
Kemoli[20]	2008	Kenya	CS	No	3.591	6 to 8	13.7%	Author's Criterion
Temilola *et al.*[31]	2015	Nigeria	CS	Yes	237	8 to 10	9.7%	Kemoli[20]
Temilola *et al.*[32]	2015	Nigeria	CS	Yes	1.169	1 to 19	4.0%	EAPD
Oyedele *et al.*[33]	2016	Nigeria	CS	Yes	469	8 to 10	4.4%	EAPD

CS: Cross-sectional. **CT:** Clinical Trial. **CH:** Cohort. ***:** Average age. **EAPD:** European Academy of Paediatric Dentistry. **DDE:** Enamel Developmental Defect Index.

DISCUSSION.

In recent years, MIH has become a condition that has attracted the interest of researchers, who have published their findings. This is illustrated by a single study published in 2006 making reference to the prevalence of MIH,[63] and ten years later, this number had increased vertiginously, with a total of 14 publications in 2016.[8,15,18,26,28,30,33,41-43,53-55,57]

It could be suggested that this growth occurred due to the similarity of MIH with other recurrent oral pathologies, especially dental caries, and to its negative impact on oral health and consequently on the quality of life of children and adolescents.[32,64]

MIH can be considered a public health problem9, due to the prevalence of this disease in the population, the implications of this condition in general health, social relationships and vulnerability. The scientific community is still far from recognizing the real prevalence of MIH due to the great variability among surveys, ranging from low prevalence results[28] to studies that identified that more than one third of the studied population had such condition.[2,21] Most studies were conducted in Europe (35%). That the first report of MIH came from Sweden11 as well as the greater concentration of resources and investments in research in such geographical area can justify this predominance of studies from Europe. The results of studies that are concentrated in specific regions

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cannot be extrapolated to other countries due to regional differences.[27] Among studies conducted in the Americas, 73.3% correspond to Brazilian studies. In Brazil, the highest prevalence of MIH found was 33.2% in São Paulo among 10-year-old students.[57]

The wide variation in prevalence reflects the methodological differences of the studies. Divergences in sample size, diagnostic criteria and age groups may contribute to the lack of an uniform prevalence.[1,27]

In the selected studies, there are wide-ranging age groups with participants ranging from 1 to 19 years[32] or from 0 to 15 years,[34] for example. This factor may underestimate the prevalence, since when older children are evaluated, occlusal wear and restorations may hide developmental defects. In addition, the condition can be masked by the presence of dental caries[27] and this fact is not mentioned by the authors.

With regard to the sample number, there is a variation from 99[2] to 3,591 individuals;[20] however, few studies have used probability sampling.[5,8,10,14,18,21-33]

To estimate the prevalence of a condition in studies, it is necessary to have a minimum number of children randomly selected. In studies with a smaller number of children, the prevalence may be higher or lower than estimated.

The etiology of MIH is unclear, with several possibilities for etiological factors such as gestation problems, complications during delivery,[44] diseases of early childhood[44,47] and use of antibiotics.[13,47] These conditions increase the prevalence of MIH, as can be assessed in studies of HIV patients,[2] monozygotic twins[3] and individuals who have used antibiotics in the first year of life.[37]

Almost all studies have a cross-sectional design. This is a useful tool for the description of population characteristics and the identification of risk groups, but they are methodologically fragile, since they determine the exposure and the disease simultaneously, so that no cause and effect relationships can be established. Thus, this type of studies are useful to suggest the presence of associations, enabling the generation of hypotheses, without, however, testing them.

Regarding the diagnostic criteria, in 2003, the European Academy of Pediatric Dentistry defined the characteristics of MIH and created a method for the examination of the first permanent molars and incisors.[1] This body recommends studying MIH in 8-year-old children because incisors and first molars have already erupted by then,[45] facilitating the detection of the defect before being covered up by physiological wear or other pathologies.[23] However, some studies[7,25,34,40-42,45,48,51,54] have chosen other age groups to verify possible signs of MIH in other teeth, including second molars, premolars and canine teeth.[29]

The European Academy of Pediatric Dentistry established five criteria to be considered in epidemiological studies: absence or presence of demarcated opacities; post-eruptive fracture; atypical restoration; extraction due to MIH and failure in the eruption of a molar or incisor.[1,19]

However, even after establishing guidelines for the diagnosis of this condition, there are still studies adopting old criteria or following their own methods, making it difficult to compare results among surveys.[13,59]

In view of these findings, with the aim of carrying out studies that allow their replication and the comparison of results, further work should be carried out with representative groups of the population, using a probability sampling method, which allows for the extrapolating of results and guaranteeing the calculation of a reliable prevalence value.

In addition, the standardization of diagnostic criteria is of paramount importance so that conditions may be compared and assessed. The use of the method proposed by the European Academy of Pediatric Dentistry is recommended, as it is the most used among studies and the most consolidated in the relevant literature.

Current studies have important implications for the planning of public policies and aim to draw the attention of pediatric dentists to the identification of MIH, as well as the treatment and control of its etiology. In clinical matters, dentists need to consider the specific condition of each tooth and the needs and expectations of patients when deciding how to manage MIH, prioritizing whenever possible preventive and minimally invasive or conservative treatments.[65]

CONCLUSION.

The prevalence of MIH presents great variability due to the use of different diagnostic criteria, age groups and geographic variation in the analyzed surveys, which makes the comparison results difficult.

Epidemiological studies to assess the prevalence of MIH should be carried out with similar methodological criteria, allowing for the extrapolation of results to other regions.

Conflict of interests: There is no conflict of interest.

Ethics approval: It is not necessary.

Funding: None.

Authors' contributions: All the authors have contributed to the study.

Acknowledgements: This study was supported by the National Council for Scientific and Technological Development (CNPq) Fellowship of Research Productivity (Process 302850/2016-3).

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