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The 100 most cited articles about molar-incisor hypomineralization: a bibliometric analysis

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Abstract: **Introduction:** Molar-Incisor Hypomineralization (MIH) is an enamel defect of systemic origin that affects from 1 to 4 permanent first molars and is frequently associated with permanent incisors. Bibliometric studies may be considered a useful approach to describing a trend of development of a research field. **Objective:** To identify the 100 most cited articles about MIH and analyze their characteristics. **Material and Methods:** Two authors evaluated the articles found in Web of Science (WOS) database. The extracted data included: number and mean number of citations, title, authors, country, year, impact factor of journals, study design, thematic field, institutions. To create collaboration and co-occurrence network maps between keywords, the VOSviewer software was used. **Results:** The most cited articles received 5,354 citations and 138.92 citations per year. The majority of studies were published in the decade of 2010 (58%) and were related to Epidemiology (35%). Europe was the continent with the greatest contribution to the list of the most cited articles (43%). Australia was responsible for most of the papers included (23%). The majority of the studies were of the cross-sectional type (39%). **Conclusion:** Evaluation of the 100 most cited articles in the area of enamel defects allowed better understanding of the world scenario with reference to MIH.

Key words: bibliometrics, dental enamel hypoplasia, molar incisor hypomineralisation.

Os 100 artigos mais citados sobre hipomineralização molar-incisivo: uma análise bibliométrica

Resumo: **Introdução:** A Hipomineralização Molar-Incisivo (HMI) é um defeito de esmalte de origem sistêmica que afeta de 1 a 4 primeiros molares permanentes e está frequentemente associada a incisivos permanentes. Estudos bibliométricos podem ser considerados uma abordagem útil para descrever a tendência de desenvolvimento de um campo de pesquisa. **Objetivo:** Identificar os 100 artigos mais citados sobre HMI e analisar suas características. **Materiais e Métodos:** Dois autores avaliaram os artigos encontrados na base de dados Web of Science (WOS). Os dados extraídos incluíram: número e número médio de citações, título, autores, país, ano, fator de impacto dos periódicos, desenho do estudo, área temática, instituições. Para criar mapas de rede de colaboração e coocorrência entre as palavras-chave, foi utilizado o software VOSviewer. **Resultados:** Os artigos mais citados receberam 5.354 citações e 138,92 citações por ano. A maioria dos estudos foi publicada na década de 2010 (58%) e estava relacionada à Epidemiologia (35%). A Europa foi o continente com maior contribuição para a lista dos artigos mais citados (43%). A Austrália foi responsável pela maioria dos artigos incluídos (23%). A maioria dos estudos foi do tipo transversal (39%). **Conclusão:** A avaliação dos 100 artigos mais citados na área de defeitos de esmalte permitiu melhor compreensão do cenário mundial referente à HMI.

Palavras-chave: bibliometria, hipoplasia do esmalte dentário, hipomineralização molar incisivo.

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Los 100 artículos más citados sobre hipomineralización molar-incisivo: un análisis bibliométrico

Resumen: **Introducción:** La Hipomineralización Molar-Incisivo (HMI) es un defecto del esmalte de origen sistémico que afecta de 1 a 4 primeros molares permanentes y frecuentemente se asocia con incisivos permanentes. Los estudios bibliométricos pueden considerarse un enfoque útil para describir la tendencia de desarrollo de un campo de investigación. **Objetivo:** Identificar los 100 artículos más citados sobre HMI y analizar sus características. **Materiales y Métodos:** Dos autores evaluaron los artículos encontrados en la base de datos *Web of Science* (WOS). Los datos extraídos incluyeron: número y promedio de citas, título, autores, país, año, factor de impacto de la revista, diseño del estudio, área temática, instituciones. Para crear mapas de red de colaboración y co-ocurrencia entre las palabras clave, se utilizó el *software VOSviewer*. **Resultados:** Los artículos más citados recibieron 5.354 citas y 138,92 citas por año. La mayoría de los estudios se publicaron en la década de 2010 (58 %) y estaban relacionados con la epidemiología (35 %). Europa fue el continente con mayor contribución a la lista de artículos más citados (43%). Australia representó la mayoría de los artículos incluidos (23%). La mayoría de los estudios fueron transversales (39%). **Conclusión:** La evaluación de los 100 artículos más citados en el área de defectos del esmalte permitió una mejor comprensión del escenario mundial en cuanto a HMI.

Palabras clave: bibliometría, hipoplasia del esmalte dental, hipomineralización molar incisivo.

Introduction

Molar-Incisor Hypomineralization (MIH) is an enamel defect of systemic origin that affects from 1 to 4 permanent first molars and is frequently associated with permanent incisors.[1] Clinically, it presents as alterations in the translucency of enamel that produce well demarcated opacities, in shades of colors between white and brown, ranging in localization and severity.[2]

In many cases, molars with severe MIH have post-eruptive breakdown (PEB) due to reduction in hardness and high porosity of the enamel.[3,4] Hypomineralized teeth are more susceptible to biofilm accumulation, caries lesions and esthetic problems.[5–7] There are multiple treatment options for teeth affected by MIH, which ranges from preventive treatments, to the use of adhesive materials and the association between tooth extraction and orthodontic treatment.[8]

MIH is a public health problem that has the potential to cause severe suffering for children and their families. Disseminating information about this enamel defect is important for improving monitoring and the possibility of consistently performing early diagnosis.[9]

As a result, a significant increase in the number of research studies has been observed over the last few years, together with the exponential growth of publications about enamel defects, especially about MIH. For the purpose of evaluating and following up on scientific production worldwide, some analytical instruments have been used with the objective of determining a retrospective pattern of a topic and speculating about the direction of future research.[10]

Therefore, bibliometric studies may be considered a useful approach to describing a trend of development of a research field.[11] Determining the number of times an article has been cited by other authors is an important method for evaluating the scientific importance of that article.[12]

Although the number of citations does not really reflect the quality of an article, studies that are frequently cited may promote changes in clinical practice, trigger discussions and lead to new research in a specific area.[13]

Over the last few years, various bibliometric studies have been conducted to analyze the most cited articles in some areas of dentistry, such as periodontics, endodontics, orthodontics and pediatric dentistry.[14–17] However, to the best of the authors' knowledge, an analysis of the most cited articles in the area of enamel defects has not been performed yet. This is why the objective of the present study was to identify the 100 most cited articles about MIH and analyze their characteristics.

Material and Methods

A search was performed using Web of Science (WOS), property of Clarivate Analytics, and included the publications in all databases (Web of Science Core Collection (WOS), Derwent Innovations Index (DIIDW), KCI-Korean Journal Database (KJD), Russian Science Citation Index (RSCI) and Scientific Electronic Library Online Citation Index (SciELO)) in the category of "Dentistry, oral surgery, and medicine", without restriction on the period of time, language, type of article or journal.

Data were collected on May 31, 2021 using the topic search (TS) command and the following search strategy: (enamel abnormalit* OR enamel hypoplasia OR enamel permeability OR hypoplasia enamel OR mottled enamel OR enamel hypomineralization OR enamel hypomineralisation OR enamel defect OR enamel agenesis OR enamel opacit* OR hypomineralized molar OR hypomineralised molar OR opaque spot OR cheese molar OR hypoplastic enamel OR tooth hypomineralization OR tooth hypomineralisation OR hypomineralization OR hypomineralisation).

Two authors independently evaluated the articles found and any disagreement about the articles was resolved by consensus after a third author of the review had been consulted. The evaluation ceased on reaching the one hundredth most cited article. Furthermore, a search was made in the Scopus database, to compare the total number of citations of the selected articles.

Afterwards, the final list was ordered by the number of citations in decreasing order, and the following data were extracted from each article: number of citations, mean number of citations per year, title, authors, country (based on the first author's affiliation), continent, year of publication, impact factor of scientific periodicals in which the studies were published, study design (cross-sectional, experimental, observational, longitudinal, diagnostic, systematic review, review of the literature, clinical study and case series), thematic field, proponent institutions and keywords). Based on the thematic field, the articles were grouped under the following topics of interest: dental caries, diagnosis, epidemiology, etiology, hypersensitivity, esthetic perception, morphological properties, quality of life and treatment.

The data extracted were organized in an Excel spreadsheet (Microsoft Office for Mac 2011 package). Descriptive statistics were prepared for the information collected by using Jamovi v.1.2 (The jamovi project,

Sydney, Australia). To develop the keyword collaboration and co-occurrence network maps, the VOSviewer software was used.

Results

The searches conducted in Web of Science and Scopus led to identification of a total of 10,196 and 8,928 articles, respectively. The 100 most cited articles relative to MIH are presented in Table 1, listed in decreasing order according to the number of citations received and the number of citations per year. In general, the most cited articles received 5,354 citations and 138.92 citations per year. The article with the highest number of citations was "Weerheijm KL, Jalevik B, Alaluusua S. Molar incisor hypomineralization. Caries Res 2001; 35(5):390-1", was cited 303 times (mean: 14.48 citations / year). The majority of studies were published in the 2010s (58%), followed by the 2000s (38%) (Figure 1).

The most cited articles were published in 32 journals and 40% were published in specific journals of pediatric dentistry: International Journal of Paediatric Dentistry (26), European Archives of Paediatric Dentistry (6), Pediatric Dentistry (4), Journal of Dentistry for Children (2) and European Journal of Paediatric Dentistry (2). The impact factor (IF) of the journals ranged from 0.339 to 10.317. The journal with the highest IF (10.317) was Biomaterials that published one article.

Table 1. *The 100 most cited articles in MIH.*

No	Title	Authors	Year	Number of citations	Average of citations	Thematic fields	Types of studies	Country
1	Molar-incisor hypomineralization	Weerheijm *et al.*	2001	303	14.48	Diagnosis	Literature review	Netherlands
2	Nonfluoride hypomineralizations in the permanent first molars and their impact on the treatment need	Leppaniemi *et al.*	2001	181	8.62	Diagnosis	Cross-sectional	Finland
3	Etiology of developmental enamel defects not related to fluorosis	Pindborg, JJ.	1982	158	3.95	Aetiology	Observational	Denmark
4	Molar incisor hypomineralization: Review and recommendations for clinical management	William *et al.*	2006	135	8.44	Treatment	Literature review	Australia
5	Aetiology of molar-incisor hypomineralization: a critical review	Crombie *et al.*	2009	132	10.15	Aetiology	Systematic review	Australia
6	The prevalence of demarcated opacities in permanent first molars in a group of Swedish children	Jalevik *et al.*	2001	121	5.66	Epidemiology	Cross-sectional	Sweden
7	Epidemiologic-study of idiopathic enamel hypomineralization in permanent teeth of swedish children	Koch*et al.*	1987	118	3.37	Epidemiology	Longitudinal	Sweden

Table 1. *The 100 most cited articles in MIH.* ***(cont.)***

No	Title	Authors	Year	Number of citations	Average of citations	Thematic fields	Types of studies	Country
8	Etiology of molar incisor hypomineralization - A systematic review	Silva *et al.*	2016	102	17.17	Aetiology	Systematic review	Australia
9	Molar incisor hypomineralization: prevalence, severity and clinical consequences in Brazilian children	da Costa-Silva *et al.*	2010	102	8.50	Epidemiology	Cross-sectional	Brazil
10	Mechanical properties and microstructure of hypomineralised enamel of permanent teeth	Mahoneyet *et al.*	2004	101	5.61	Morphological Properties	Experimental	Australia
11	Molar incisor hypomineralization in Hong Kong Chinese children	Cho *et al.*	2008	97	6.93	Epidemiology	Observational	China
12	Deciduous Molar Hypomineralization and Molar Incisor Hypomineralization	Elfrink *et al.*	2012	95	9.60	Diagnosis	Observational	Netherlands
13	Etiologic factors influencing the prevalence of demarcated opacities in permanent first molars in a group of Swedish children	Jalevik *et al.*	2001	95	4.52	Aetiology	Cross-sectional	Sweden
14	3D X-ray microscopic study of the extent of variations in enamel density in first permanent molars with idiopathic enamel hypomineralisation	Fearne *et al.*	2004	91	5.06	Morphological Properties	Experimental	England
15	Molar incisor hypomineralization: a study of aetiological factors in a group of UK children	Whatling *et al.*	2008	88	6.29	Aetiology	Observational	England
16	Genes expressed in dental enamel development are associated with molar-incisor hypomineralization	Jeremias *et al.*	2013	86	9.56	Aetiology	Observational	Brazil
17	Amoxicillin May Cause Molar Incisor Hypomineralization	Laisi *et al.*	2009	86	6.62	Aetiology	Experimental	Finland
18	Prevalence and distribution of demarcated opacities and their sequelae in permanent 1st molars and incisors in 7 to 13-year-old Brazilian children	Soviero *et al.*	2009	81	6.23	Epidemiology	Cross-sectional	Brazil
19	Secondary ion mass spectrometry and X-ray microanalysis of hypomineralized enamel in human permanent first molars	Jalevik *et al.*	2001	81	3.86	Morphological Properties	Experimental	Sweden
20	Prevalence and severity of molar incisor hypomineralization in a region of Germany - A brief communication	Preusser *et al.*	2007	78	5.20	Epidemiology	Cross-sectional	Germany
21	Prevalence of cheese molars in eleven-year-old Dutch children	Weerheijm *et al.*	2001	74	3.52	Epidemiology	Cross-sectional	Netherlands
22	Standardised studies on Molar Incisor Hypomineralisation (MIH) and Hypomineralised Second Primary Molars (HSPM): a need	Elfrink *et al.*	2015	67	9.71	Diagnosis	Literature review	Australia

Table 1. *The 100 most cited articles in MIH.* ***(cont.)***

No	Title	Authors	Year	Number of citations	Average of citations	Thematic fields	Types of studies	Country
23	Microshear bond strength of resin composite to teeth affected by molar hypomineralization using 2 adhesive systems	William *et al.*	2006	67	4.19	Treatment	Experimental	Australia
24	Developmental defects of enamel and dentine: challenges for basic science research and clinical management	Seow, WK	2014	65	8.25	Treatment	Literature review	Australia
25	Bacterial invasion of dentinal tubules beneath apparently intact but hypomineralized enamel in molar teeth with molar incisor hypomineralization	Fagrell *et al.*	2008	64	4.57	Hypersensitivity	Experimental	Sweden
26	Global burden of molar incisor hypomineralization	Schwendicke *et al.*	2018	63	16.00	Epidemiology	Systematic review	Germany
27	Cheese molars - a pilot-study of the etiology of hypocalcifications in first permanent molars	Vanamerongen *et al.*	1995	63	2.33	Aetiology	Cross-sectional	Netherlands
28	Molar-incisor hypomineralisation: prevalence and defect characteristics in Iraqi children	Ghanim *et al.*	2011	62	5.64	Epidemiology	Cross-sectional	Australia
29	Surface Integrity Governs the Proteome of Hypomineralized Enamel	Mangum *et al.*	2010	62	5.17	Morphological Properties	Experimental	Australia
30	Chemical, mechanical and morphological properties of hypomineralized enamel of permanent first molars	Fagrell *et al.*	2010	62	5.25	Morphological Properties	Experimental	Sweden
31	A systematic review on the association between molar incisor hypomineralization and dental caries	Americano *et al.*	2017	61	12.20	Dental Caries	Systematic review	Brazil
32	On the structure-property relationship of sound and hypomineralized enamel	Xie *et al.*	2007	59	3.93	Morphological Properties	Experimental	Australia
33	Mechanical properties across hypomineralized/hypoplastic enamel of first permanent molar teeth	Mahoney *et al.*	2004	59	3.28	Morphological Properties	Experimental	Australia
34	Mineral density of hypomineralised enamel	Farah *et al.*	2010	58	4.83	Morphological Properties	Experimental	New Zealand
35	A practical method for use in epidemiological studies on enamel hypomineralisation	Ghanim *et al.*	2015	56	8.00	Epidemiology	Diagnostic study	Australia
36	Dental caries experience and Molar-Incisor Hypomineralization	Jeremias *et al.*	2013	56	6.33	Dental Caries	Cross-sectional	Brazil
37	The prevalence of molar incisor hypomineralization: evidence from 70 studies	Zhao *et al.*	2018	55	14.00	Epidemiology	Systematic review	China
38	Enamel Defects Reflect Perinatal Exposure to Bisphenol A	Jedeon *et al.*	2013	54	6.0	Aetiology	Experimental	France
39	Prevalence and distribution of demarcated opacities in permanent 1st molars and incisors in 6 to 8-year-old Danish children	Wogelius *et al.*	2008	52	3.71	Epidemiology	Cross-sectional	Denmark

Table 1. *The 100 most cited articles in MIH.* ***(cont.)***

No	Title	Authors	Year	Number of citations	Average of citations	Thematic fields	Types of studies	Country
40	On the Etiology of Molar-Incisor Hypomineralization	Vieira *et al.*	2016	49	8.17	Aetiology	Literature review	U.S.A
41	The prevalence of molar incisor hypomineralisation in Northern England and its relationship to socioeconomic status and water fluoridation	Balmer *et al.*	2012	47	4.80	Epidemiology	Cross-sectional	England
42	Molar-incisor hypomineralization and oral hygiene in 10-to-12-yr-old Swedish children born preterm	Brogardh-Roth *et al.*	2011	47	4.27	Aetiology	Observational	Sweden
43	Protein content of molar-incisor hypomineralisation enamel	Farah *et al.*	2010	47	3.92	Morphological Properties	Experimental	New Zealand
44	Risk factors in the occurrence of enamel defects of the first permanent molars among schoolchildren in Western Australia	Arrow, P	2009	47	3.62	Aetiology	Cross-sectional	Australia
45	Increase in severity of molar-incisor hypomineralization and its relationship with the colour of enamel opacity: a prospective cohort study	Da Costa-Silva *et al.*	2011	46	4.27	Morphological Properties	Observational	Brazil
46	Evaluation of spontaneous space closure and development of permanent dentition after extraction of hypomineralized permanent first molars	Jalevik *et al.*	2007	45	3.00	Treatment	Observational	Sweden
47	Molar incisor hypomineralization: A survey of members of the Australian and New Zealand Society of Paediatric Dentistry	Crombie *et al.*	2008	44	3.21	Epidemiology	Cross-sectional	Australia
48	Managing molar-incisor hypomineralization: A systematic review	Elhennawy *et al.*	2016	43	7.33	Treatment	Systematic review	Germany
49	Prevalence of enamel defects in primary and permanent teeth in a group of schoolchildren from Granada (Spain)	Robles *et al.*	2013	43	4.78	Epidemiology	Cross-sectional	Spain
50	Epidemiologic study of molar-incisor hypomineralization in 8-year-old Spanish children	Garcia-Margarit *et al.*	2014	42	5.25	Epidemiology	Cross-sectional	Spain
51	Characterisation of developmentally hypomineralised human enamel	Crombie *et al.*	2013	42	4.67	Morphological Properties	Experimental	Australia
52	Treatment outcomes and dental anxiety in 18-year-olds with MIH, comparisons with healthy controls - a longitudinal study	Jalevik *et al.*	2012	42	4.20	Treatment	Longitudinal	Sweden
53	Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice	Ghanim *et al.*	2017	41	8.60	Diagnosis	Diagnostic study	Australia
54	Transmission electron microscope characterisation of molar-incisor-hypomineralisation	Xie *et al.*	2008	40	2.86	Morphological Properties	Experimental	Australia

Table 1. *The 100 most cited articles in MIH.* ***(cont.)***

No	Title	Authors	Year	Number of citations	Average of citations	Thematic fields	Types of studies	Country
55	The prevalence of molar incisor hypomineralization (MIH) in a group of children in a highly polluted urban region and a windfarm-green energy island	Kuscu *et al.*	2009	39	3.00	Epidemiology	Observational	Turkey
56	Prevalence of developmental enamel defects of the first permanent molars among school children in Western Australia	Arrow, P	2008	39	2.79	Epidemiology	Cross-sectional	Australia
57	Developmental Enamel Defects and Their Association with Dental Caries in Preschoolers in Jeddah, Saudi Arabia	Farsi, N	2010	37	3.08	Dental Caries	Cross-sectional	Saudi Arabia
58	Is there a positive relationship between molar incisor hypomineralisations and the presence of dental caries?	Heitmuller *et al.*	2013	35	3.89	Dental Caries	Cross-sectional	Germany
59	Aetiology of severe demarcated enamel opacities - an evaluation based on prospective medical and social data from 17,000 children	Fagrell *et al.*	2011	35	3.18	Aetiology	Longitudinal	Sweden
60	Elevated Serum 25(OH)-Vitamin D Levels Are Negatively Correlated with Molar-Incisor Hypomineralization	Kuhnisch *et al.*	2015	34	4.86	Aetiology	Longitudinal	Germany
61	Pulpal status of hypomineralized permanent molars	Rodd *et al.*	2007	34	2.27	Hypersensitivity	Experimental	United Kingdom
62	Enamel opacities and dental aesthetics	Ellwood *et al.*	1995	33	1.22	Aesthetic Perception	Cross-sectional	United Kingdom
63	Prevalence of molar-incisor hypomineralisation observed using transillumination in a group of children from Barcelona (Spain)	Gomez *et al.*	2012	32	3.20	Epidemiology	Cross-sectional	Spain
64	The prevalence and aetiology of Molar-Incisor Hypomineralisation in a group of children in Istanbul	Kuscu *et al.*	2008	32	2.29	Epidemiology	Clinical study	Turkey
65	Prevalence of Molar-Incisor-Hypomineralisation among school children in four German cities	Petrou *et al.*	2014	31	3.88	Epidemiology	Cross-sectional	Germany
66	Risk factors in the occurrence of molarincisor hypomineralization amongst a group of Iraqi children	Ghanim *et al.*	2013	31	3.44	Aetiology	Cross-sectional	Australia
67	Family-Based Genetic Association for Molar-Incisor Hypomineralization	Jeremias *et al.*	2016	30	5.00	Aetiology	Experimental	Brazil
68	Drugs related to the etiology of molar incisor hypomineralization A systematic review	Serna *et al.*	2016	28	4.67	Aetiology	Systematic review	Spain
69	Impact of molar-incisor hypomineralization on oral health-related quality of life in schoolchildren	Dantas-Neta *et al.*	2016	28	4.67	Quality of Life	Cross-sectional	Brazil
70	Onset of Molar Incisor Hypomineralization (MIH)	Fagrell *et al.*	2013	28	3.11	Aetiology	Experimental	Sweden

Table 1. *The 100 most cited articles in MIH.* ***(cont.)***

No	Title	Authors	Year	Number of citations	Average of citations	Thematic fields	Types of studies	Country
71	Structural, mechanical and chemical evaluation of molar-incisor hypomineralization-affected enamel: A systematic review	Elhennawy *et al.*	2017	27	5.40	Morphological Properties	Systematic review	Australia
72	Linking the clinical presentation of molar-incisor hypomineralisation to its mineral density	Farah *et al.*	2010	27	2.33	Morphological Properties	Experimental	New Zealand
73	Exploring the association between genetic and environmental factors and molar incisor hypomineralization: evidence from a twin study	Teixeira *et al.*	2018	26	6.50	Aetiology	Cross-sectional	Brazil
74	Prevalence, pattern and severity of molar incisor hypomineralisation in 8- to 10-year-old school children in Ile-Ife, Nigeria	Oyedele *et al.*	2015	26	3.71	Epidemiology	Cross-sectional	Nigeria
75	Proportion and extent of manifestation of molar-incisor-hypomineralizations according to different phenotypes	Kuhnisch *et al.*	2014	26	3.25	Epidemiology	Observational	Germany
76	Perception of Molar-Incisor Hypomineralisation (MIH) by Iraqi Dental Academics	Ghanim *et al.*	2011	26	2.45	Aesthetic Perception	Cross-sectional	Iraq
77	Hypomineralized Second Primary Molars as Predictor of Molar Incisor Hypomineralization	Negre-Barber *et al.*	2016	25	4.17	Epidemiology	Cross-sectional	Spain
78	Factors associated with molar incisor hypomineralization in Thai children	Pitiphat *et al.*	2014	25	3.13	Aetiology	Cross-sectional	Thailand
79	Resin infiltration of developmentally hypomineralised enamel	Crombie *et al.*	2014	25	3.13	Treatment	Experimental	Australia
80	MIH Supplementation Strategies: Prospective Clinical and Laboratory Trial	Baroni *et al.*	2011	25	2.27	Treatment	Observational	Italy
81	Developmental dental defects in children who reside by a river polluted by dioxins and furans	Holtta *et al.*	2001	25	1.19	Aetiology	Cross-sectional	Finland
82	Hypomineralised second primary molars: prevalence, defect characteristics and possible association with Molar Incisor Hypomineralisation in Indian children	Mittal *et al.*	2015	24	3.43	Epidemiology	Cross-sectional	India
83	Association between Molar Incisor Hypomineralization in Schoolchildren and Both Prenatal and Postnatal Factors: A Population-Based Study	Tourino *et al.*	2016	23	3.83	Aetiology	Cross-sectional	Brazil
84	A new type of dental anomaly: molar-incisor malformation (MIM)	Lee *et al.*	2014	23	2.88	Diagnosis	Case series	South Corea
85	Distribution and severity of molar hypomineralisation: trial of a new severity index	Oliver *et al.*	2014	23	2.88	Epidemiology	Cross-sectional	Australia

Table 1. *The 100 most cited articles in MIH.* ***(cont.)***

No	Title	Authors	Year	Number of citations	Average of citations	Thematic fields	Types of studies	Country
86	Mineralisation of Developmentally Hypomineralised Human Enamel in vitro	Crombie *et al.*	2013	22	2.44	Morphological Properties	Experimental	Australia
87	Prevalence of molar incisor hypomineralization in the city of Buenos Aires	Biondi *et al.*	2011	22	2.00	Epidemiology	Observational	Argentina
88	Molar incisor hypomineralization (MIH): conservative treatment management to restore affected teeth	Fragelli *et al.*	2015	21	3.00	Treatment	Observational	Brazil
89	An in vivo investigation of salivary properties, enamel hypomineralisation, and carious lesion severity in a group of Iraqi schoolchildren	Ghanim *et al.*	2013	21	2.33	Dental Caries	Experimental	Iraq
90	Association between use of asthma drugs and prevalence of demarcated opacities in permanent first molars in 6-to-8-year-old Danish children	Wogelius *et al.*	2010	21	1.75	Aetiology	Cross-sectional	Denmark
91	Relationship between laser fluorescence and enamel hypomineralisation	Farah *et al.*	2008	21	1.50	Diagnosis	Experimental	New Zealand
92	Genome-wide association study (GWAS) for molar-incisor hypomineralization (MIH)	Kuhnisch *et al.*	2014	20	2.50	Aetiology	Experimental	Germany
93	Molar incisor hypomineralisation (MIH) - an overview	Almuallem *et al.*	2018	19	4.75	Diagnosis	Literature review	Saudi Arabia
94	Canines are affected in 16-year-olds with molar-incisor hypomineralisation (MIH): an epidemiological study based on the Tromso study: Fit Futures	Schmalfuss *et al.*	2016	19	3.17	Epidemiology	Cross-sectional	Norway
95	Epidemiologic Study of Molar-incisor Hypomineralization in Schoolchildren in Northeastern Brazil	de Lima *et al.*	2015	19	2.71	Epidemiology	Cross-sectional	Brazil
96	Prevalence of molar incisor hypomineralization (MIH) in Singaporean children	Ng *et al.*	2015	19	2.71	Epidemiology	Cross-sectional	Singapore
97	Molar incisor hypomineralisation and dental caries among children in Slovenia	Groselj *et al.*	2013	19	2.22	Dental Caries	Cross-sectional	Slovenia
98	A systematic review and meta-analysis of systemic exposure associated with molar incisor hypomineralization	Fatturi *et al.*	2019	18	6.00	Aetiology	Systematic review	Brazil
99	Do parents and children perceive molar-incisor hypomineralization as an oral health problem?	Leal *et al.*	2017	18	3.60	Aesthetic Perception	Observational	Brazil
100	The prevalence and pattern of deciduous molar hypomineralization and molar-incisor hypomineralization in children from a suburban population in Nigeria	Temilola *et al.*	2015	18	2.57	Epidemiology	Cross-sectional	Nigeria

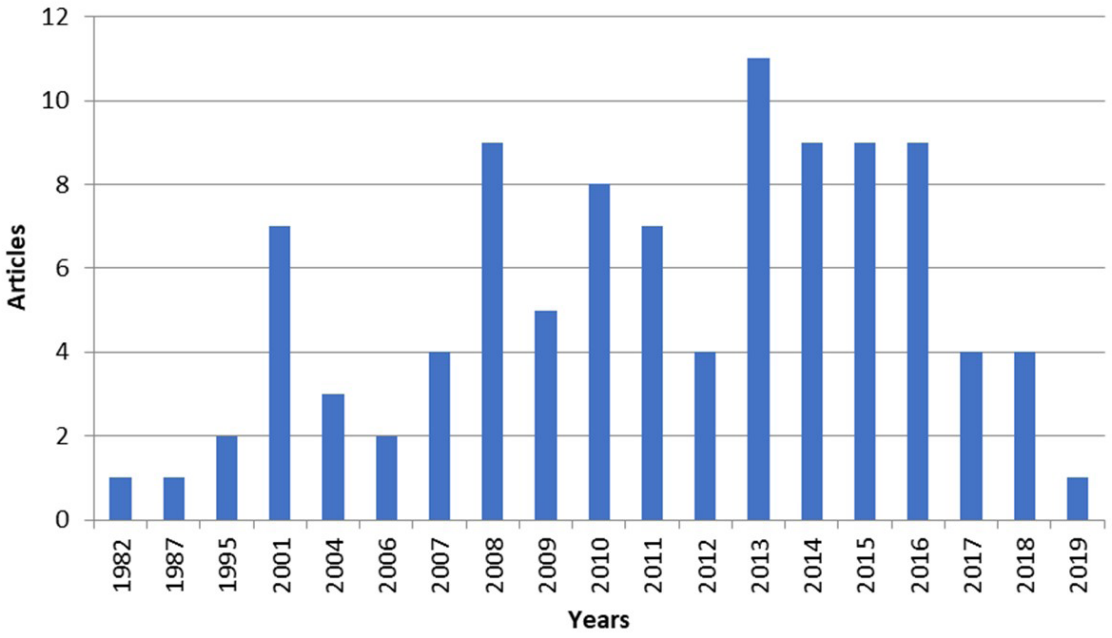


Figure 1. *Number of articles per year*

Regarding thematic fields, the majority of research was related to epidemiology (35%), followed by Etiology (25%), Morphological Properties (15%), Treatment (9%), Diagnosis (8%), Dental Caries (6%), Esthetic Perception (3%), Hypersensitivity (2%) and Quality of Life (1%). Categorization of articles in terms of MIH's etiology and management is presented in Figures 2 and 3, respectively.

Europe (43%) and Oceania (27%) were the continents with the greatest contribution to the list of the most cited articles,

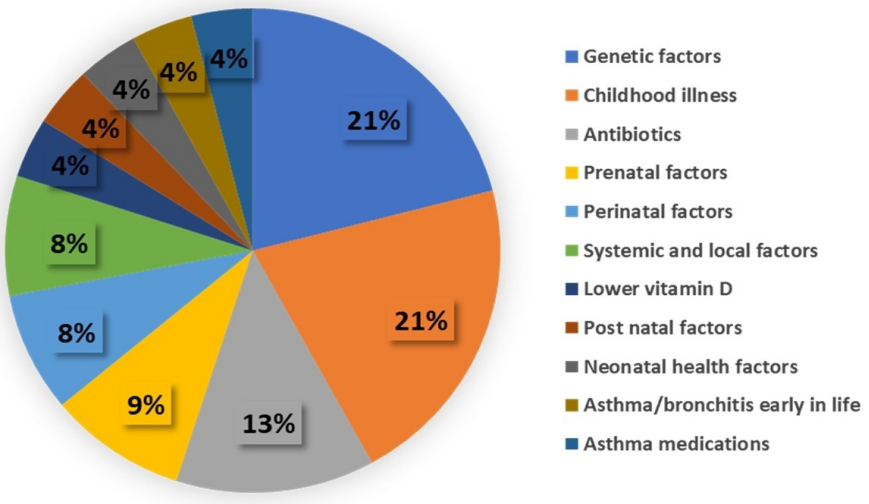


Figure 2. *Etiological factors associated with MIH studied in the articles*

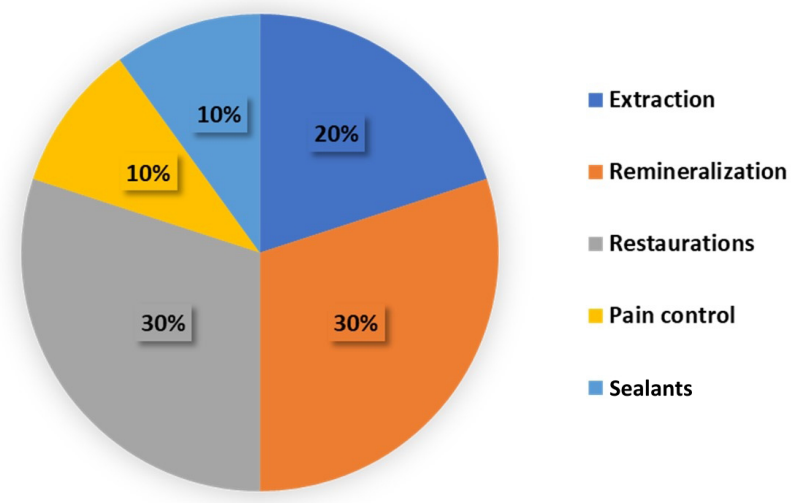
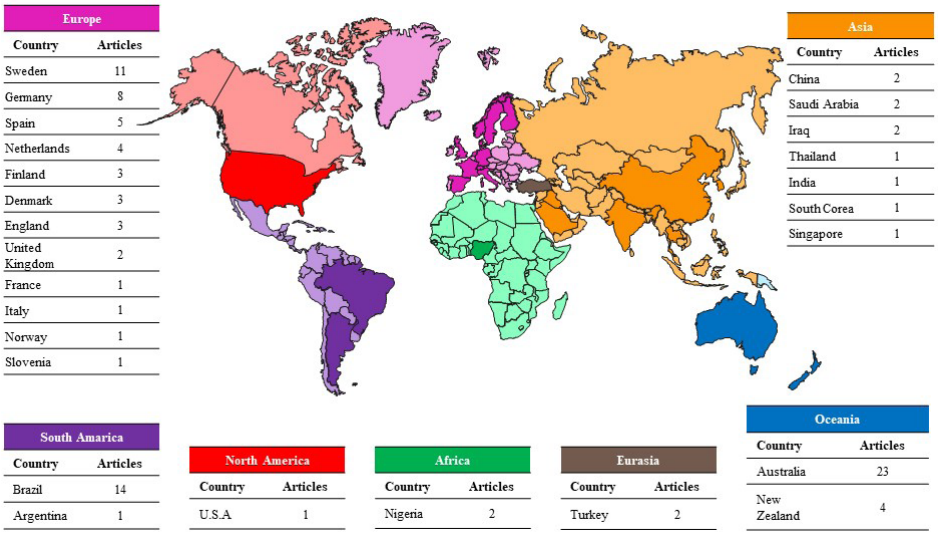


Figure 3. *Clinical management for MIH described in the articles*

followed by South America (15%) and Asia (10%). Australia was responsible for the majority of the papers included (23%), followed by Brazil (14%), Sweden (11%) and Germany (8%). Europe had the highest number of countries (46.15%) with the published articles receiving high levels of citation (Figure 4). The most cited authors (irrespective of being corresponding or co-authors) were Manton, D. J. (881 citations), Jalevik, B. (749 citations), Kilpatrick, N.M. (599 citations), Alaluusua, S. (595 citations), Weerheijm, K.L. (585 citations), Noren, J. G. (451 citations), Swain, M.V. (412 citations), Crombie, F.A. (354 citations), Jeremias, F. (341 citations) and Ghanim, A. M. (304 citations) (Table 2). Sixteen institutions contributed two or more studies included in the ranking, with the University of Melbourne in Australia presenting most



Europe

Country	Articles
Sweden	11
Germany	8
Spain	5
Netherlands	4
Finland	3
Denmark	3
England	3
United Kingdom	2
France	1
Italy	1
Norway	1
Slovenia	1

Asia

Country	Articles
China	2
Saudi Arabia	2
Iraq	2
Thailand	1
India	1
South Corea	1
Singapore	1

South Amarica

Country	Articles
Brazil	14
Argentina	1

North America

Country	Articles
U.S.A	1

Africa

Country	Articles
Nigeria	2

Eurasia

Country	Articles
Turkey	2

Oceania

Country	Articles
Australia	23
New Zealand	4

Figure 4. *The countries of origin of the 100 most cited manuscripts in MIH*

Table 2. *Authors with the largest number of articles included amongst the 100 most cited articles.*

Authors	First author	Co-author	Last author	Total	Total of citations
Manton, D. J.	-	14	4	18	881
Swain, M.V.	-	6	2	8	412
Kilpatrick, N.M.	-	5	3	8	599
Jalevik, B.	5	2	-	7	749
Ghanim, A. M.	6	1	-	7	304
Crombie, F.A.	5	2	-	7	354
Jeremias, F.	3	3	-	6	341
Noren, J. G.	-	1	5	6	451
Weerheijm, K.L.	2	3	1	6	585
Alaluusua, S.	-	-	4	4	595

collaborations (17%), followed by the São Paulo State University - UNESP in Brazil, and the University of Gothenburg in Sweden, both with five publications each (Figure 5).

Evaluation of all the author keywords and KeyWords Plus indicated that the most popular terms were “prevalence” (n = 44), “teeth” (n = 39), “children” (n = 34) and “enamel” (n = 31) (Figure 6).

With respect to study design, the majority of the studies were of the cross-sectional type (39%), followed by experimental studies (24%), observational studies (14%), systematic reviews (9%), literature reviews (6%), longitudinal studies (4%), diagnostic

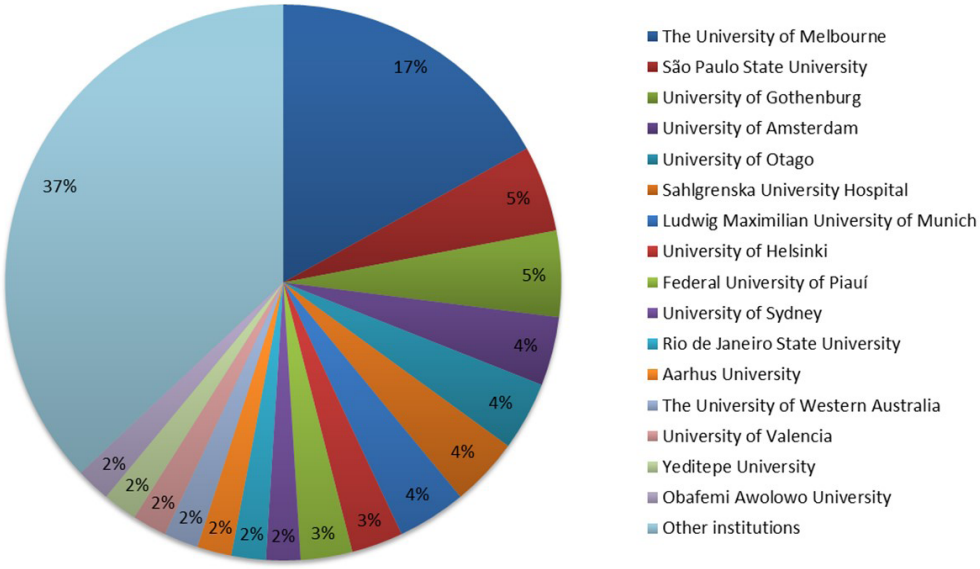


Figure 5. *Institutions that contributed the most cited articles.*

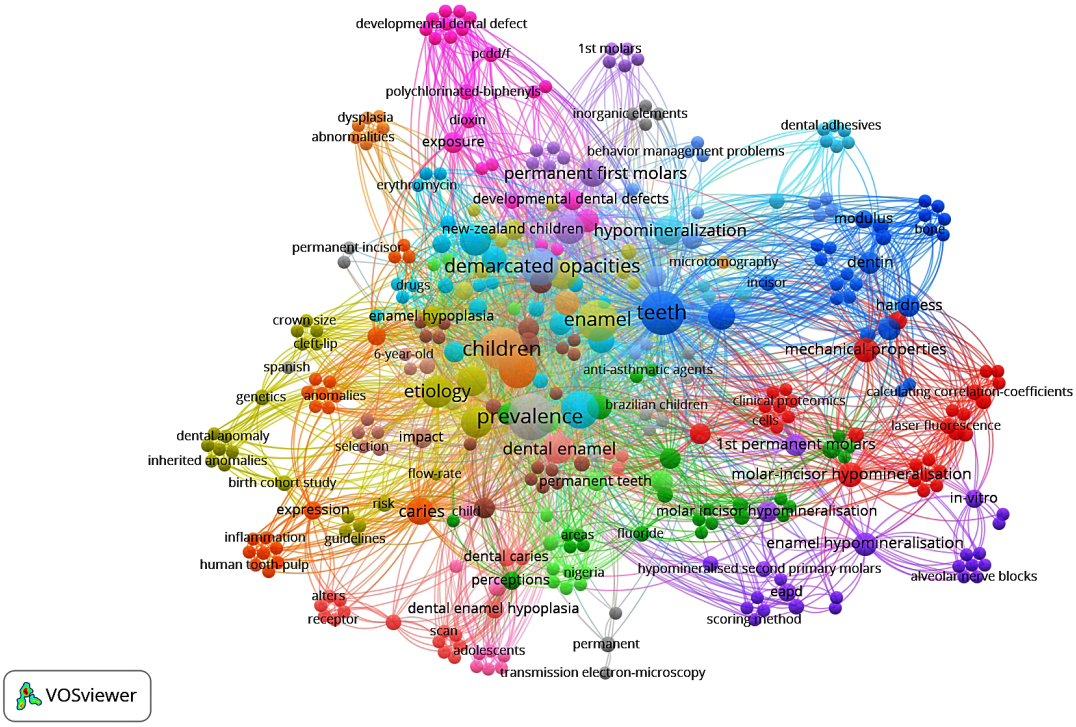


Figure 6. *Keyword co-occurrence network visualization of the 100 most highly cited articles. The size of the nodes represents the frequency of the keywords. Larger nodes indicate higher frequency. The colors of the nodes indicate the cluster to which keywords belong. The thickness and the length of the joining lines indicate the closeness of the interactions between two nodes.*

studies (2%), clinical studies (1%) and case series (1%), as described in Table 3.

Table 3. *Study design of the 100 most cited articles in MIH.*

Type of study	N
Cross-sectional study	39
Experimental study	24
Observational study	14
Systematic review	9
Literature review	6
Longitudinal study	4
Diagnostic study	2
Clinical studies	1
Case series	1

Discussion

The objective of the present study was to identify the 100 most cited articles about MIH and analyze their characteristics. To the best of the authors' knowledge, this is the first study to explore research in the area of enamel defects. The searches conducted in Web of Science and Scopus led to identification of a total of 10,196 and 8,928 articles, respectively. Our search covered a broad spectrum of enamel defects through the use of diverse keywords. This choice was influenced by the fact that the formal designation of MIH was only established in 2001,[1] Prior to which various nomenclatures were employed to describe the same clinical condition. The evolution of terminology, along with ongoing disagreements among researchers in distinguishing

hypomineralizations from hypoplasias and other enamel defects, informed our selection of keywords. Nonetheless, a careful analysis of identified articles was carried out, resulting in the exclusion of those not directly relevant to MIH. The records returned by the Scopus and Web of Science databases varied considerably. The coverage of Web of Science dated back to 1900, while the coverage of articles prior to 1996 was more limited in Scopus.[18,19] For this reason, the list of the 100 main articles was based on WOS.

Our study identified 10 articles that obtained over 100 citations. According to Heldwein, Rhoden and Morgentaler,[20] studies that receive 100 or more citations may be considered classics, because they represent historical points of reference in the development of a specific area. Of the 100 articles, 39 were of the cross-sectional type, 24 experimental and 14 observational. These types of study are more frequently used in the areas of medicine, due to being more easily conducted and have greater cost-benefit.[21]

The articles were published between the years 1982 and 2019, however MIH was first described only in 2001. Prior to this date, four articles were identified that used old terminologies for describing this condition ("Cheese Molars" and "'non-fluoride hypomineralization"). In the year 2001, seven articles were published, including the study that led the ranking of citations, and that was responsible for the contemporary denomination of MIH.[1] Naturally, it was to be expected that the pioneer study would be cited with high frequency by subsequent studies. As from this period, there was a growing number of publications in the area, especially in the year 2013, when of eleven published studies, 73% approached the etiological aspects and relations of MIH with dental caries.

Indeed, to date, the etiology of MIH is still unclear, but it is believed to be multifactorial.[22] For this reason, several papers have been published to describe factors associated with this enamel defect. Amongst the various etiological hypotheses mentioned in the most cited papers, risk factors causing disturbances have included medication use (e.g., antibiotics) and childhood illnesses [23,24] as the most published subject. However, it is difficult to differentiate whether the MIH is caused by the childhood disease or as a result of how the disease is managed (e.g., the use of antibiotics).[25] More recently, a genetic predisposition in conjunction with one or several other epigenetic factors has also been proposed.[26–28] This was expected, given that the entire process of dental enamel formation is under genetic control, and suggests that genetic causes could be at least partly responsible for MIH development.[26]

It was found that several treatments have been reported. Management of MIH can be complicated, and often requires consideration of several individual and tooth-specific factors before making a decision.[29] Most of papers of the list regarding treatment includes preventive procedures indicated only in cases where there is no structural tooth loss, or else conservative or invasive restorations with removal of the affected area.

Bibliometric studies in the area of dentistry have pointed out the United States and consequently, American authors as being

leaders in the rankings of studies with high levels of citation [30,31]. However, in the present study, countries such as Australia (23%), Brazil (14%) and Sweden (11%), were identified as being the pioneers in researches about MIH. The high prevalence of MIH found in these regions suggested that there was greater concern about conducting in-depth research.[3,32,33]

Among the authors, Ghanim, A. M. is the only collaborator to appear six times as the first author among the most cited articles, however, she is ranked tenth in the number of citations (304 citations). Although Manton, D. J. is not the first author in any of the articles, but this author has a higher number of studies in the ranking (18%) and the highest number of citations (881). Alaluusua, S. was ranked the tenth author in quantity of articles included (four), however, he was ranked fourth in the number of citations (595). There are various factors that may influence the quantity of citations of an article. Therefore, a high quantity of studies published by one and the same author may not exhibit a high rate of citations.[34]

The University of Melbourne, the University of Gothenburg and the São Paulo State University - UNESP were the institutions that produced the most studies about MIH. This is because these universities are located in the continents that most conduct researches about the topic, particularly due to the high prevalence of cases of this condition. These institutions contemplated 27% of the total number of articles and are affiliated with 93.5% of the ten most cited authors.

The studies were published in 32 different journals, the majority (40%) in specific journals of pediatric dentistry. Although the diagnosis of MIH may be more easily made by professionals in pediatric dentistry, by virtue of the time of eruption of the molar, it is interesting to note the low quantity of articles in other areas of dentistry, such as oral biology (3%) and cosmetic dentistry (6%) that could make a significant contribution to research with an approach to the etiological factors and treatments.

Analyzing the keyword co-occurrence network is a tool for mapping the domain of research in a specific field, by examining the connections among keywords. According to Figure 4, those in the largest and most centrally localized nodes were filled by terms such as “prevalence” “teeth” “children” and “enamel”. The keyword “prevalence” had a significant weight, probably due to the increase in studies for determining the prevalence of MIH in the world population. This result had been expected seeing that 35% of the studies included were considered to be of the epidemiological type.

The 100 most cited articles showed heterogeneity in their themes and study designs, in spite of the high prevalence of cross-sectional studies (39%). This type of study is frequently conducted in the area of health because it is accessible and fast to conduct when evaluating the prevalence of health problems.[35] Longitudinal studies represented only 4% of all the articles in the ranking. These studies are useful for evaluating the cause-and-effect relationships of a certain disease, in addition to the risk factors and development of some type of alteration. However, a longer time and more financial resources are required to conduct them.[36] It is important to point out that so far, no etiological factor has been directly established in the investigation of

the relations of cause and effect of MIH. Further high-quality longitudinal studies are suggested.

As is the case with other bibliometric studies, our analysis had some limitations. Firstly, a possible bias may be due to self-citation since the Web of Science does not perform automatic exclusion and this factor was not controlled in our study. Secondly, the count of citations does not directly reflect the quality of a paper but allows a quantitative evaluation of the scientific impact of an article. However, there is a risk of bias related to the time of publication, by means of which some old publications had more time to accumulate citations.

Conclusion

To the best of the author's knowledge, this is the first bibliometric study about the 100 most cited articles about MIH. There was predominance of cross-sectional studies and prevalence rates. The majority of the articles were published as from the decade of 2010, with Australia being the country with the most prolific production. The 100 most cited studies were published in a total of 32 journals, and the Europe was the continent with the greatest contribution to the list. Evaluation of the 100 most cited articles in the area of enamel defects allowed better understanding of the world scenario with reference to MIH.

References

1. Weerheijm KL, Jälevik B, Alaluusua S. Molar–Incisor Hypomineralisation. Caries Res 2001;35(5):390-391.
2. Weerheijm KL. Molar incisor hypomineralisation (MIH). Eur J Paediatr Dent 2003;4(3):114-120.
3. Jälevik B, Klingberg G, Barregård L, Norén JG. The prevalence of demarcated opacities in permanent first molars in a group of Swedish children. Acta Odontol Scand 2001;59(5):255-260.
4. Fagrell TG, Dietz W, Jälevik B, Norén JG. Chemical, mechanical and morphological properties of hypomineralized enamel of permanent first molars. Acta Odontol Scand 2010;68(4):215-222.
5. Weerheijm KL, Duggal M, Mejàre I, *et al*. Judgement criteria for molar incisor hypomineralisation (MIH) in epidemiologic studies: a summary of the European meeting on MIH held in Athens. Eur J Paediatr Dent 2003;4(3):110-113.
6. Lygidakis NA. Treatment modalities in children with teeth affected by molar-incisor enamel hypomineralisation (MIH): A systematic review. Eur Arch Paediatr Dent 2010;11(2):65-74.
7. Elhennawy K, Schwendicke F. Managing molar-incisor hypomineralization: A systematic review. J Dent 2016;55:16-24.
8. Sundfeld D, da Silva L, Kluppel O, *et al*. Molar Incisor Hypomineralization: Etiology, Clinical Aspects, and a Restorative Treatment Case Report. Oper Dent 2020;45(4):343-351.
9. Schneider PM, Silva M. Endemic Molar Incisor Hypomineralization: a Pandemic Problem That Requires Monitoring by the Entire Health Care Community. Curr Osteoporos Rep 2018;16(3):283-288.
10. Bruni A, Serra FG, Gallo V, Deregibus A, Castroflorio T. The 50 most-cited articles on clear aligner treatment: A bibliometric and visualized analysis. Am J Orthod Dentofac Orthop 2021;159(4):e343-e362.
11. Jiang Z, Wu C, Hu S, *et al*. Research on neck dissection for oral squamous-cell carcinoma: a bibliometric analysis. Int J Oral Sci 2021;13(1):13.
12. Moed HF. New developments in the use of citation analysis in research evaluation. Arch Immunol Ther Exp (Warsz) 2009;57(1):13-18.
13. Praveen G, Chaithanya R, Alla RK, Shammas M, Abdurahiman VT, Anitha A. The 100 most cited articles in prosthodontic journals: A bibliometric analysis of articles published between 1951 and 2019. J Prosthet Dent 2020;123(5):724-730.
14. Corbella S, Francetti L, Taschieri S, Weinstein R, Del Fabbro M. Analysis of the 100 most-cited articles in periodontology. J Investig Clin Dent 2017;8(3):e12222.

15. Fardi A, Kodonas K, Gogos C, Economides N. Top-cited Articles in Endodontic Journals. J Endod 2011;37(9):1183-1190.
16. Tarazona B, Lucas-Dominguez R, Paredes-Gallardo V, Alonso-Arroyo A, Vidal-Infer A. The 100 most-cited articles in orthodontics: A bibliometric study. Angle Orthod 2018;88(6):785-796.
17. Perazzo MF, Otoni ALC, Costa MS, Granville-Granville AF, Paiva SM, Martins-Júnior PA. The top 100 most-cited papers in Paediatric Dentistry journals: A bibliometric analysis. Int J Paediatr Dent 2019;29(6):692-711.
18. Falagas ME, Pitsouni EI, Malietzis GA, Pappas G. Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. FASEB J 2008;22(2):338-342.
19. Kulkarni A V. Comparisons of Citations in Web of Science, Scopus, and Google Scholar for Articles Published in General Medical Journals. JAMA 2009;302(10):1092.
20. Heldwein FL, Rhoden EL, Morgentaler A. Classics of Urology : A Half Century History of the Most. URL 2010;75(6):1261-1268.
21. Song JW, Chung KC. Observational Studies: Cohort and Case-Control Studies. Plast Reconstr Surg 2010;126(6):2234-2242.
22. Fatturi AL, Wambier LM, Chibinski AC, *et al*. A systematic review and meta-analysis of systemic exposure associated with molar incisor hypomineralization. Community Dent Oral Epidemiol 2019;47(5):407-415.
23. Lygidakis NA, Dimou G, Marinou D. Molar-Incisor-Hypomineralisation (MIH). A retrospective clinical study in Greek children. II. Possible medical aetiological factors. Eur Arch Paediatr Dent 2008;9(4):207-217.
24. Silva MJ, Scurrah KJ, Craig JM, Manton DJ, Kilpatrick N. Etiology of molar incisor hypomineralization - A systematic review. Community Dent Oral Epidemiol 2016;44(4):342-353.
25. Garot E, Rouas P, Somani C, Taylor GD, Wong F, Lygidakis NA. An update of the aetiological factors involved in molar incisor hypomineralisation (MIH): a systematic review and meta-analysis. Eur Arch Paediatr Dent 2022;23(1):23-38.
26. Jeremias F, Souza JF de, Costa Silva CM da, Cordeiro R de CL, Zuanon ÂCC, Santos-Pinto L. Dental caries experience and Molar-Incisor Hypomineralization. Acta Odontol Scand 2013;71(3-4):870-876.
27. Kühnisch J, Heitmüller D, Thiering E, *et al*. Proportion and extent of manifestation of molar-incisor-hypomineralizations according to different phenotypes. J Public Health Dent 2014;74(1):42-49.
28. Teixeira RJPB, Andrade NS, Queiroz LCC, *et al*. Exploring the association between genetic and environmental factors and molar incisor hypomineralization: evidence from a twin study. Int J Paediatr Dent 2018;28(2):198-206.
29. Lygidakis NA, Wong F, Jälevik B, Vierrou AM, Alaluusua S, Espelid I. Best Clinical Practice Guidance for clinicians dealing with children presenting with Molar-Incisor-Hypomineralisation (MIH). Eur Arch Paediatr Dent 2010;11(2):75-81.
30. Garcovich D, Marques Martinez L, Adobes Martin M. Citation classics in paediatric dentistry: a bibliometric study on the 100 most-cited articles. Eur Arch Paediatr Dent 2020;21(2):249-261.
31. Musa TH, Li W, Kawuki J, Wei P. The 100 top-cited articles on scrub typhus: a bibliometric analysis. Osong Public Heal Res Perspect 2021;12(2):126-135.
32. Arrow P. Prevalence of developmental enamel defects of the first permanent molars among school children in Western Australia. Aust Dent J 2008;53(3):250-259.
33. Soviero V, Haubek D, Trindade C, Da Matta T, Poulsen S. Prevalence and distribution of demarcated opacities and their sequelae in permanent 1st molars and incisors in 7 to 13-year-old Brazilian children. Acta Odontol Scand 2009;67(3):170-175.
34. Tahamtan I, Safipour Afshar A, Ahamdzadeh K. Factors affecting number of citations: a comprehensive review of the literature. Scientometrics 2016;107(3):1195-1225.
35. Levin KA. Study design III: Cross-sectional studies. Evid Based Dent 2006;7(1):24-25.
36. Caruana EJ, Roman M, Hernández-Sánchez J, Solli P. Longitudinal studies. J Thorac Dis 2015;7(11):E537-40.

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