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ORIGINAL SCIENTIFIC ARTICLE

Prevalence, distribution, characteristics and associated factors of molar-incisor hypo-mineralisation among Libyan schoolchildren: a cross-sectional survey

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Abstract

Background and aim This study aimed to assess the prevalence and clinical status of molar incisor hypomineralisation (MIH) and other enamel defects and associated factors in Libyan children.

Methods A cross-sectional survey of a randomly selected sample of 8- to 10-year-old Libyan school children was conducted in the city of Benghazi, Libya in 2019. The children were assessed for the presence of MIH and enamel defects according to EAPD evaluation criteria. The survey was supplemented by a questionnaire, completed by parents, about potential associated factors occurring before, around and after birth. Association with risk indicators was assessed using chi-square and Mann–Whitney *U* tests.

Results One thousand forty-seven children returned complete questionnaires and attended the clinical examination, with 87% response rate. MIH was the most common form of enamel defects, affecting 162 (15.5%) children. The average number of MIH affected teeth was 3.54 (SD = 1.82). There were no statistically significant associations between the prevalence of MIH and health or demographic characteristics except for the history of early childhood health problems ($P = 0.047$).

Conclusions In Libyan children, MIH appeared to be the most prevalent type of enamel defects affecting 15.5% of the participants. Although not statistically significant, MIH appeared to be associated with prenatal, perinatal and post-natal challenges.

Keywords Molar incisor hypomineralisation (MIH) · Enamel defects · Libya · Children · Prevalence · Epidemiologic studies

Introduction

Molar incisor hypomineralisation (MIH) refers to demarcated enamel defects of systemic origin affecting one or more first permanent molars often, but not necessarily, combined with affected incisors (Weerheijm et al. 2001a, b). MIH varies clinically from white, yellow or brown demarcated discoloration to complete breakdown of enamel soon after eruption (Weerheijm et al. 2003). These lesions are a manifestation of decreased mineralisation of tooth enamel, which is believed to be caused by disturbance of enamel formation during prenatal, natal and early childhood periods (Crombie et al. 2009). The etiology of MIH is not fully understood. However, several studies have linked MIH to multiple systemically acting environmental factors such as chronic childhood illness, preterm birth, low birth weight, respiratory tract infection, perinatal complications and antibiotic use during gestation or breast feeding, as well as genetic factors (Crombie et al. 2009; Almuallem and Busuttil-Naudi 2018). In recent years, MIH has received much attention as a challenging clinical condition that creates problems for both dentists and patients (Weerheijm and Mejare 2003; Crombie et al. 2008; Americano et al. 2017). The management of MIH is an onerous task for dentists because of clinical difficulties to provide effective restorative treatment and pain control (Leppaniemi et al. 2001; Crombie et al. 2008; Almuallem and Busuttil-Naudi 2018).

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For patients, MIH may have significant impact on the quality of life (Almuallem and Busuttil-Naudi 2018), causing pain, plaque retention, dental caries and eventually tooth loss (Jalevik and Klingberg 2002).

MIH is considered a relatively common condition (Crombie et al. 2009; Almuallem and Busuttil-Naudi 2018). However, wide variations in MIH prevalence have been reported in different countries, ranging from as low as 2.8% in Hong Kong (Cho et al. 2008) to 40.2% in Brazil (Soviero et al. 2009). Although this could reflect real disparities in MIH prevalence between different countries, many commentators put this down to variations in indices, diagnostic criteria, age groups and examination protocols used to measure MIH, and hence, under or over estimation of MIH prevalence in various locations (Jalevik 2010; Ghanim et al. 2017). In an attempt to standardize MIH assessment, the European Academy of Paediatric Dentistry (EAPD) established MIH assessment criteria which have been supported by a training manual for use in clinical practice and epidemiological surveys (Ghanim et al. 2015). However, despite the popularity of EAPD assessment criteria for MIH assessment in developed and western European countries, there is still a paucity of data on MIH in some regions such as Africa and the Middle East (Elfrink et al. 2015).

Libya is one of the Arab League countries located on the north coast of Africa. Reviewing the dental literature revealed only one study that has examined enamel defects in Libyan children and demonstrated that 2.9% had MIH (Fteita et al. 2006). However, the findings of this study cannot be generalised to the Libyan population since it was conducted on a small convenience sample of children. In addition, no attempts were made to investigate factors associated with MIH in Libyan children. Therefore, additional studies targeting Libyan children are needed to provide reliable information comparable with international data. In addition, the country is now suffering from political unrest starting since the so-called February uprising of 2011, and hence it is important to assess the burden of dental diseases to inform oral health polices and services planning. Therefore, the present study aimed to assess the prevalence and distribution of MIH and other enamel defects using EAPD criteria and to investigate MIH associated factors in a representative sample of Libyan children.

Materials and methods

Ethical approval was obtained from the Ethics Committee of Faculty of Dentistry, University of Benghazi (UOB-2018-DPH1) and necessary permissions were obtained from local authorities before commencing the study. Informed consent was obtained in advance from parents and guardians. Only children whose parents provided written consent and completed questionnaires were included in the study.

Study design and setting

A cross-sectional study using paper-based, self-administered questionnaires along with oral clinical examinations was conducted. Data were collected between December 2018 and May 2019, in Benghazi, Libya. Benghazi is the second largest city in Libya, the capital of its eastern province, with around 811,000 inhabitants representing 12% of the total population in the country (IndexMundi 2019). Benghazi is considered the melting pot of the country since its residents are descendants of the full spectrum of Libyan tribes, regions and races, and, therefore, the population of Benghazi is deemed representative of all Libyans.

Participants and sampling

The study targeted 8- to 11-year-old school children represented by those who were registered in primary schools for the 2018/19 academic year in Benghazi, Libya. This age span has been recommended as the preferred age to investigate MIH prevalence in children (Weerheijm et al. 2003). According to the Ministry of Education records, 12,761 children, with almost equal male and female ratio, were registered in 60 state-run as well as private schools, distributed over the three main districts of Benghazi. It has been suggested that MIH studies should involve at least 300 participants for prevalence and 1000 participants for etiological studies (Elfrink et al. 2015). We estimated non-response of about 20% and, therefore, aimed to recruit 1200 participants.

The participants were recruited by using a two-stage cluster random sampling technique. At the first stage, a proportional sample of schools was randomly selected to reflect the distribution of state-run and private schools (3:1) in the three main districts in the city. At the second stage, classes were randomly selected from each school. All children in each included class were invited to take part in the study. The inclusion criteria were children living in Benghazi, aged 8–10 years of age, enrolled in primary schools in the area, physically and intellectually fit and with parental consent. Exclusion criteria were children having intrinsic staining and receiving orthodontic treatment at the time of examination or those whose first permanent molars were so broken down that it was difficult to identify the cause of destruction (Ghanim et al. 2011).

Data collection

Paper-based, self-administered questionnaires as well as clinical oral examination were used for data collection. The questionnaires comprised mainly two sections. The first section collected participant's sociodemographic information (gender, date of birth and parents' educational level). The second section asked questions related to potential causes of MIH (Crombie et al. 2009), including history of medication during pregnancy, delivery pattern (normal, caesarian or preterm) as well as body weight (normal, low or overweight), currently having chronic disease and history of having medical problem during early childhood. The questionnaires were sent through the schools' central administration to the parents as part of study package including information sheet and written consent. The questionnaire was pre-tested for face validity by five dentists not involved in the study. In addition, clarity was assessed by ten parents whose children were attending pediatric dentistry clinics of the Faculty of Dentistry, University of Benghazi.

The children were examined for the presence of MIH and dental caries. MIH was assessed using MIH index or long form recording sheet (Ghanim et al. 2015)(Ghanim et al. 2017). The occlusal, facial and palatal as well as lingual surfaces of permanent first molars and incisors (index teeth) were examined for the presence of enamel defects including MIH using 10-point scoring system of EAPD evaluation criteria. The extent of the defect in each affected tooth was also categorized according to the involved surface area as follows: (1) < 1⁄3; (2) At least 1⁄3 but < 2⁄3; and (3) At least 2⁄3 of a tooth surface affected. Dental caries experience was assessed according to the World Health Organization (WHO) diagnostic criteria using the Decayed, Missing and Filled Teeth (DMFT) index (WHO 1997). Oral clinical examinations were performed using a disposable diagnostic kit and head lamp while the child was seated on an ordinary chair in the classroom. No other examination tools such as radiographs or magnification tools were used. All examinations were carried out by three trained and calibrated dentists. The training sessions were provided at the Department of Community and Preventive Dentistry, Faculty of Dentistry, University of Benghazi. Intra- and inter-examiner reliability were ensured before data collection. This involved two sessions of clinical examination of 20 children, performed at a 3-week interval. Furthermore, 10% of the children participating in the main survey were randomly selected and reassessed for enamel defects and dental caries after 2 weeks. Kappa coefficient ranged from 0.88 to 0.96.

Data analysis

The Statistical Package for Social Sciences, version 24 (IBM Corp., Armonk, N.Y., USA) was used for data management and analysis. Descriptive statistics were calculated for sample characteristics and prevalence as well as distribution of MIH and other enamel defects. Chi square and Fisher exact tests were used to compare the proportion of children who have MIH by their demographic and health characteristics (gender, age, presence of caries in permanent teeth, child's delivery type, body weight status at birth, health status during early childhood and history of medication during pregnancy). Mann–Whitney *U* test and Kruskal Wallis test were used to compare mean numbers of MIH- affected teeth by participants' demographic and health characteristics. Statistical significance was set at ≤ 0.05.

Results

Out of 1200 children recruited to join the study from15 state-run and 5 private schools, 1047 children returned complete questionnaires and attended the clinical examination, giving a response rate of 87%. Gender was almost equally distributed (496, 47.4% males and 549, 52.4% females). Most participants were 9-year-olds (425, 40.4%), from state schools (786, 75.1%) and had caries-free permanent teeth (741, 70.8%). Figure 1 depicts the prevalence of different enamel defects observed in the current study. Overall, 287 (27.4%) had some forms of enamel defects, of which MIH was the most prevalent condition affecting 162 (15.5%) children. Demarcated opacities in incisors only and diffuse opacities were reported in 76 (7.3%) and 40 (3.8%) participants, respectively. No amelogenesis imperfecta or combined lesions were detected.

Table 1 describes the distribution, extension and clinical status of MIH according to EAPD criteria. The average number of MIH-affected teeth was 3.54 (SD = 1.82), ranging from 1 to 10 teeth. Half of the affected children had only affected molars (82, 50.6%) with 2.55 (SD = 1.19) affected teeth on average. In the remaining children with MIH (80, 49.4%), molars and incisors were MIH-affected [mean (SD) = 0.50 (1.42)]. MIH affecting more than one PFM was more common than that affecting one PFM only (76.5% and 23.5%).

According to extension, hypomineralisation of less than 1/3 of the tooth was more common (81.5%) than hypomineralisation affecting between 1/3 and 2/3 of the tooth (54.4%), with an average of 2.37 (SD = 1.89) and 1.09 (SD = 1.73) teeth, respectively. Hypomineralisation affecting more than 2/3 of the tooth was the least common form, observed in 11.5% of MIH cases. Most hypomineralisation lesions were white creamy demarcated (82.1%), whereas post-eruptive breakdown was observed in 18.5% of MIH cases and affected 0.31 (SD = 0.82) teeth on average. No atypical restoration or atypical extraction was observed. Figure 2 shows the proportion of hypomineralised lesions in each index tooth. Permanent first molars (PFMs) (112, 69.1% and 106, 65.4%, for right and left respectively) and maxillary central incisors were the most frequently affected teeth, whereas lower left lateral incisors were the least affected (7, 4.3%).

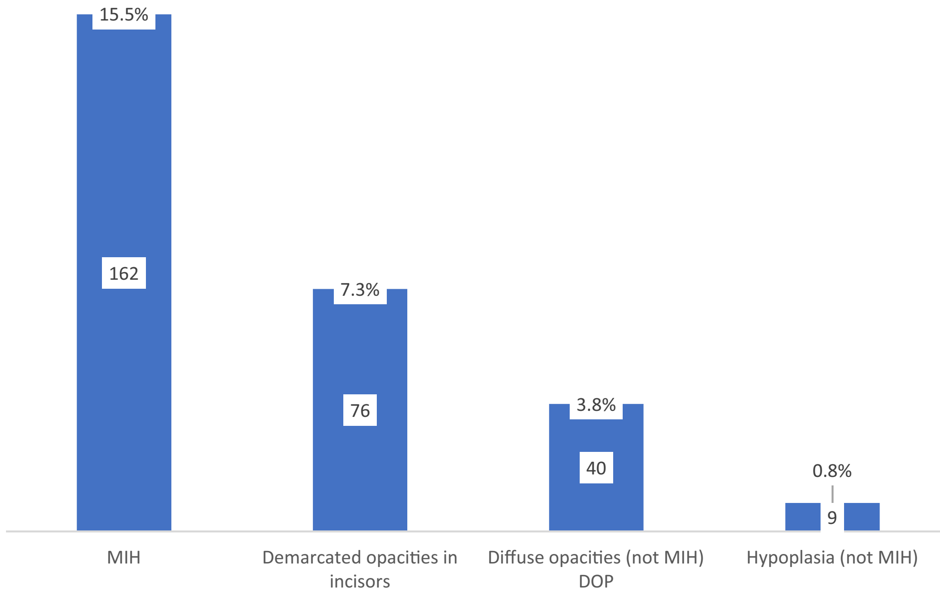

Fig. 1 Prevalence of enamel defects ($n = 1047$)

Table 1 Prevalence and distribution of MIH according to EAPD diagnostic criteria ($N = 162$, $n = 238$)

Variable	*N* (%)	Mean (SD)	Min–Max
MIH distribution			
All MIH	162 (15.5)	3.54 (1.82)	1–10
Molars Hypomineralisation (MH)	82 (50.6)	2.55 (1.19)	1–4
Molar and incisors hypomineralisation (MIH)	80 (49.4)	0.50 (1.42)	2–10
One PFM affected	38 (23.5)	–	–
More than one PFM affected	124 (76.5)	–	–
Lesion extension			
Less than 1/3 of tooth surface	132 (81.5)	2.37 (1.89)	1–10
At least 1/3 but less than 2/3 of tooth surface	72 (54.4)	1.09 (1.73)	1–10
At least 2/3 of tooth surface	17 (11.5)	0.24 (0.99)	1–8
Clinical status			
Demarcated creamy-white opacity	133 (82.1)	2.44 (1.84)	1–7
Yellow/brown demarcated opacities	39 (24.1)	0.53 (1.13)	1–5
Post Eruptive Breakdown	30 (18.5)	0.31 (0.82)	1–6

N number of children, *n* number of teeth, *PFM* permanent first molar

Table 2 compares MIH prevalence and numbers of affected teeth by participants' demographic and health-related characteristics. Apart from the association with the history of early childhood health problems ($P = 0.047$), there were no statistically significant associations between the prevalence of MIH and health or demographic characteristics. Higher percentage of MIH was observed among children who had health problems up to 3 years of age than those without health problems (51.5% and 48.5%). No statistically significant associations were observed when the numbers of MIH-affected teeth were compared by demographic and medical attributes of the participants. However, higher mean number of MIH-affected teeth was observed in children who were males, had caries in permanent teeth, with history of complicated delivery, with early childhood health problems and those whose mothers had medication during pregnancy.

Discussion

The findings show that one in four children had enamel defects and 15.5% had MIH, mostly in more than one PFM. The occurrence of MIH was significantly associated with early childhood diseases while the number of teeth affected with MIH was greater in children whose mothers used medication during delivery, those with complicated delivery, those with early childhood disease and those with more teeth affected with caries presence. The present study fills a

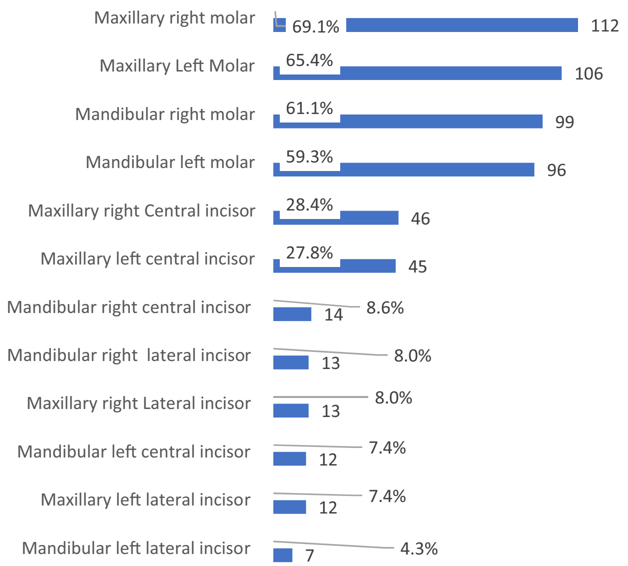

Fig. 2 Distribution of MIH-affected teeth according to EAPD diagnostic criteria ($n = 238$)

knowledge gap by assessing the prevalence and distribution of MIH among a group of children in North Africa using the standardised criteria of EAPD thus shedding light on the epidemiology and associated factors of a non-caries, dental hard tissue condition that is mostly addressed in studies from developed countries. The prevalence of MIH in the present study was within the global range of MIH reported in dental literature (2.3–40.2%) and similar to other countries in the Middle East such as Jordan (17.6%) (Zawaideh et al. 2011) and Iraq (18.6%) (Ghanim et al. 2011) and in Europe: Sweden (18.4%) (Jalevik et al. 2001) and Finland (19.3%) (Leppaniemi et al. 2001) but higher than the global prevalence of MIH in Africa (10.3%) (Dave and Taylor 2018). However, epidemiological surveys of MIH often vary in evaluation criteria, sampling methods, age of participants and how risk factors are assessed, and hence comparing data from different countries should be approached with caution. In line with this, the present study showed higher prevalence and number of MIH-affected teeth than the MIH prevalence (2.9%) and number of affected teeth (mean = 1.5) previously reported in a group of Libya children using small and convenience sampling and different evaluation criteria (Fteita et al. 2006).

The prevalence of MIH was higher in maxillary than mandibular teeth, especially the incisors, with concomitant involvement of molars and incisors. This corroborates the findings of previous studies (Leppaniemi et al. 2001; Arrow 2008; Ghanim et al. 2011). However, other studies reported higher prevalence of MIH in mandibular than maxillary teeth (Jalevik et al. 2001), and in incisors more than molars (Wogelius et al. 2008). The present study showed that MIH among Libyan children is generally mild and presents as white creamy demarcated lesions and few post-eruptive

Table 2 Association between MIH Prevalence and demographic and health-related factors of study participants ($n = 1047$)

Factor		All *N* (%)	MIH *N* (%)	*P* value	MIH teeth Mean (SD)	*P* value
Gender	Male	497 (47.5)	84 (16.9)	0.229	0.64 (1.60)	0.175
	Female	550 (52.5)	78 (14.2)		0.48 (1.34)	
Caries in permanent teeth	Absent	741 (70.8)	109 (14.7)	0.228	0.50 (1.35)	0.233
	Present	306 (29.2)	53 (17.3)		0.68 (1.72)	
Age	8 Years	312 (29.8)	76 (24.4)	0.600	0.62 (1.47)	0.390
	9 Years	425 (40.4)	97 (28.2)		0.57 (1.55)	
	10 Years	310 (29.6)	65 (21.0)		0.46 (1.37)	
Child delivery	Normal	778 (74.3)	113 (14.5)	0.1.49	0.49 (1.37)	0.097
	complicated	269 (23.4)	49 (18.2)		0.73 (1.68)	
Child weight at delivery	Normal	997 (95.2)	155 (15.5)	0.945	0.56 (1.47)	0.729
	Low weight	30 (2.9)	4 (13.3)		0.36 (1.06)	
	Overweight	20 (1.9)	3 (15.0)		0.55 (1.57)	
Chronic disease	No	920 (87.9)	145 (15.8)	0.488	0.55 (1.46)	0.457
	Yes	127 (12.1)	17 (13.4)		0.50 (1.50)	
Had health problem at age 3	No	508 (48.5)	67 (13.2)	0.047*	0.48 (1.43)	0.051
	Yes	539 (51.5)	95 (17.6)		0.61 (1.51)	
Medication During pregnancy	No	1006 (96.1)	154 (15.3)	0.466	0.54 (1.43)	0.372
	Yes	41 (3.9)	8 (19.5)		0.92 (2.16)	

Chi-Squared test was used to compare percentages/Mann–Whitney *U* test and Kruskal–Wallis test were used to compare mean numbers of MIH-affected teeth

*Statistically significant at $P < 0.05$

breakdown lesions with no atypical restoration or extraction. This finding is consistent with the results of many previous studies (Arrow 2008; Wogelius et al. 2008; Ghanim et al. 2011). The clinical presentation of MIH is related to the timing, combination and severity of insult affecting enamel formation at a critical age (Crombie et al. 2009; Almuallem and Busuttil-Naudi 2018).

Among many factors investigated in our study, a history of health problems during the first 3 years of life was significantly associated with higher prevalence and more teeth affected with MIH. This agrees with a recent systemic review which concluded that early childhood illness, particularly fever, asthma and pneumonia, was implicated as an etiological factor in MIH (Silva et al. 2016). Pre- peri- and neonatal problems were reported to be associated with developmental enamel defects although most evidence was inconsistent and of poor quality (Crombie et al. 2009).

The interpretation of our findings should be approached with caution for many reasons. First, the present study used cross-sectional design which cannot establish cause–effect relationship, though it is useful for baseline surveys, planning and evaluation purposes (Levin 2006). Second, the use of self-administered questionnaires to collect retrospective data by parents as proxies for their children has the risk of recall bias (Althubaiti 2016). However, to collect data about early childhood exposure in the absence of comprehensive individualised health records, no other method can be used. Also, the low prevalence of some risk indicators such as the use of medication during pregnancy and the low and overweight at birth produced unreliable regression estimates and, therefore, we could not conduct multivariable analysis. Future research using a longitudinal study design with greater number of participants is, therefore, required to provide valid data on potential risk factors of enamel defects among Libyan children.

This study has shown that children with caries in permanent teeth had higher MIH prevalence and greater number of MIH affected teeth than their caries-free peers. This agrees with a recently published systematic review that demonstrated a significant positive association between MIH and dental caries prevalence and severity measured using DMF index (Americano et al. 2017). A possible explanation of this association between caries and MIH might be attributed to the greater sensitivity of MIH-affected teeth resulting in avoidance of tooth brushing, poor oral hygiene and plaque accumulation which promote caries (Weerheijm et al. 2001a, b). Another possible explanation could be that MIH-affected teeth are more porous and hence it may be easier for bacterial acids to penetrate the tooth surface causing caries (Weerheijm 2003; Mahoney et al. 2004). Dental caries among Libyan school children has decreased markedly in the wake of the civil war and financial crisis flooding the country in recent years with high sugar intake and poor oral hygiene being identified as main risk factors (Arheiam et al. 2020). Although not statistically significant, the present finding supports the notion that MIH may be a risk factor for caries in children (Americano et al. 2017).

The present findings have implications for policies and modifications related to the provision of dental care for Libyan children and for dental education. The prevalence of enamel defects (mostly MIH) was almost equal to that of caries in permanent teeth at the age of children included in the study. This condition, together with previous reports documenting lower caries prevalence after the war in Libya, suggests the need for modifications of existing dental curricula to prepare dentists to address the changes in the epidemiology of oral diseases. The same applies to stakeholders in charge of planning oral health care in the post-war period. In addition to preventive and therapeutic options to address the problems of caries and health education activities to control its spread, similar efforts may be needed to address enamel defects in general and MIH in particular. Further studies addressing the burden of this condition in various age groups versus that of caries may offer a more comprehensive perspective on the extent of the problem at the population level.

Conclusions

The present study shows that among a representative group of Libyan children, MIH was the most prevalent type of enamel defects affecting 15.5% of the participants. The condition affected PFMs more than other teeth and was mostly mild in extension and clinical status. MIH was associated with prenatal (medication during pregnancy), peri-natal (method of delivery) and post-natal (early childhood illness) challenges that might have affected enamel development. MIH was also associated with the presence of caries in permanent teeth.

Author contributions AA contributed in study design, data analysis and writing up. SA, LB, EB and SR, contributed in study design and data collection. ME contributed to writing up and critical appraisal of the manuscript.

References

Almuallem Z, Busuttil-Naudi A. Molar incisor hypomineralisation (MIH)—an overview. Br Dent J. 2018;225(7):601–9.
Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. J Multidiscip Healthc. 2016;9:211–7.
Americano GC, Jacobsen PE, Soviero VM, Haubek D. A systematic review on the association between molar incisor hypomineralisation and dental caries. Int J Paediatr Dent. 2017;27(1):11–21.

Arheiam AA, Harris RV, Baker SR. Changes in dental caries and sugar intake before and during the conflict in Libya: a natural experiment. Commun Dent Oral Epidemiol. 2020;48(3):201–7.

Arrow P. Prevalence of developmental enamel defects of the first permanent molars among school children in Western Australia. Aust Dent J. 2008;53(3):250–9.

Cho SY, Ki Y, Chu V. Molar incisor hypomineralisation in Hong Kong Chinese children. Int J Paediatr Dent. 2008;18(5):348–52.

Crombie FA, Manton DJ, Weerheijm KL, Kilpatrick NM. Molar incisor hypomineralisation: a survey of members of the Australian and New Zealand Society of Paediatric Dentistry. Aust Dent J. 2008;53(2):160–6.

Crombie F, Manton D, Kilpatrick N. Aetiology of molar-incisor hypomineralisation: a critical review. Int J Paediatr Dent. 2009;19(2):73–83.

Dave M, Taylor G. Global prevalence of molar incisor hypomineralisation. Evid Based Dent. 2018;19(3):78–9.

Elfrink ME, Ghanim A, Manton DJ, Weerheijm KL. Standardised studies on Molar Incisor Hypomineralisation (MIH) and Hypomineralised Second Primary Molars (HSPM): a need. Eur Arch Paediatr Dent. 2015;16(3):247–55.

Fteita D, Ali A, Alaluusua S. Molar-incisor hypomineralisation (MIH) in a group of school-aged children in Benghazi, Libya. Eur Arch Paediatr Dent. 2006;7(2):92–5.

Ghanim A, Morgan M, Marino R, Bailey D, Manton D. Molar-incisor hypomineralisation: prevalence and defect characteristics in Iraqi children. Int J Paediatr Dent. 2011;21(6):413–21.

Ghanim A, Elfrink M, Weerheijm K, Marino R, Manton D. A practical method for use in epidemiological studies on enamel hypomineralisation. Eur Arch Paediatr Dent. 2015;16(3):235–46.

Ghanim A, Silva MJ, Elfrink MEC, Lygidakis NA, Marino RJ, Weerheijm KL, Manton DJ. Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice. Eur Arch Paediatr Dent. 2017;18(4):225–42.

IndexMundi (2019) Libya Demographics Profile 2019. World Factbook. From https://www.indexmundi.com/libya/demographics_profile.html. Accessed on 28 Jun 2020

Jalevik B. Prevalence and diagnosis of molar-incisor—hypomineralisation (MIH): a systematic review. Eur Arch Paediatr Dent. 2010;11(2):59–64.

Jalevik B, Klingberg GA. Dental treatment, dental fear and behaviour management problems in children with severe enamel hypomineralisation of their permanent first molars. Int J Paediatr Dent. 2002;12(1):24–32.

Jalevik B, Klingberg G, Barregard L, Noren JG. The prevalence of demarcated opacities in permanent first molars in a group of Swedish children. Acta Odontol Scand. 2001;59(5):255–60.

Leppaniemi A, Lukinmaa PL, Alaluusua S. Nonfluoride hypomineralisations in the permanent first molars and their impact on the treatment need. Caries Res. 2001;35(1):36–40.

Levin KA. Study design III: cross-sectional studies. Evid Based Dent. 2006;7(1):24–5.

Mahoney EK, Rohanizadeh R, Ismail FS, Kilpatrick NM, Swain MV. Mechanical properties and microstructure of hypomineralised enamel of permanent teeth. Biomaterials. 2004;25(20):5091–100.

Silva MJ, Scurrah KJ, Craig JM, Manton DJ, Kilpatrick N. Etiology of molar incisor hypomineralisation—a systematic review. Commun Dent Oral Epidemiol. 2016;44(4):342–53.

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):170–5.

Weerheijm KL. Molar incisor hypomineralisation (MIH). Eur J Paediatr Dent. 2003;4(3):114–20.

Weerheijm KL, Mejare I. Molar incisor hypomineralisation: a questionnaire inventory of its occurrence in member countries of the European Academy of Paediatric Dentistry (EAPD). Int J Paediatr Dent. 2003;13(6):411–6.

Weerheijm K, Jälevik B, Alaluusua S. Molar–incisor hypomineralisation. Caries Res. 2001a;35(5):390–1.

Weerheijm KL, Jalevik B, Alaluusua S. Molar-incisor hypomineralisation. Caries Res. 2001b;35(5):390–1.

Weerheijm KL, Duggal M, Mejare I, Papagiannoulis L, Koch G, Martens LC, Hallonsten AL. Judgement criteria for molar incisor hypomineralisation (MIH) in epidemiologic studies: a summary of the European meeting on MIH held in Athens, 2003. Eur J Paediatr Dent. 2003;4(3):110–3.

WHO. Oral health surveys : basic methods. Geneva: World Health Organization; 1997.

Wogelius P, Haubek D, Poulsen S. Prevalence and distribution of demarcated opacities in permanent 1st molars and incisors in 6 to 8-year-old Danish children. Acta Odontol Scand. 2008;66(1):58–64.

Zawaideh FI, Al-Jundi SH, Al-Jaljoli MH. Molar incisor hypomineralisation: prevalence in Jordanian children and clinical characteristics. Eur Arch Paediatr Dent. 2011;12(1):31–6.