

# Prevalence, pattern and distribution of MIH defects in Sudanese children

Hanna Elhassan Abdalla (✉ [Hanoya8@hotmail.com](mailto:Hanoya8@hotmail.com))

Al-Neelain University <https://orcid.org/0000-0003-2498-4502>

Amal Hussein Abuaffan

University of Khartoum

Arthur Musakulu Kemoli

University of Nairobi

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## Research article

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## Abstract

**Background:** Molar incisor hypomineralization (MIH) has serious impact on oral health-related quality of life for a child, due to its effects on tooth structure, aesthetics and behavior of the child. The current study was designed to determine the prevalence, pattern and distribution of MIH in school children in Sudan.

**Methods:** This was a descriptive, cross-sectional study involving 568 children, aged 8-11 years from schools in Khartoum State. After collecting their socio-demographic data, the children were examined for hypomineralization on the 12 MIH indexed teeth, and assessed on the MIH pattern and distribution. The data collected were analyzed to obtain descriptive statistics, and the results related to the socio-demographic and other dental-related factors of the children using chi-square test and Spearman Rank Correlation, with the significant level set at  $p<0.05$ .

**Results:** The prevalence of MIH in the study population was 20.1%. Majority of the affected teeth were permanent first molars (PFMs) (12.5%), but there was no statistical significant difference between the occurrence of hypomineralization on mandibular and maxillary molars ( $p=0.22$ ). However, in the case of incisors, there was a statistical significant difference between the maxillary incisors that had higher hypomineralization rate when related to the mandibular incisors ( $p=0.00$ ). In terms of the pattern of hypomineralization, demarcated opacities were the commonest MIH defects (69.9%) in the study group.

**Conclusions:** While the prevalence of MIH in the study population was 20.1%, both molars and incisor teeth were frequently affected in both dental arches, and the demarcated opacity type were the most frequent form of defect found in the teeth of the participants.

## Background

Molar Incisor Hypomineralization (MIH) is observed on permanent molars as demarcated opacities that vary from creamy-white or yellow to yellowish-brown discolourations (1). The condition is of systemic origin, and affects one to four permanent first molars (PFMs), and often involving the permanent incisors as well (1). MIH-like defects have also been detected on second primary molars, when they are referred to as deciduous molar hypomineralization (DMH) (2). The aetiology of MIH is unclear, but environmental and genetic factors, like child delivery complications, prematurity, dioxins in breast milk, respiratory problems, calcium and phosphate metabolic disorders or high fevers during early childhood, use of antibiotics etc. (3, 4), have been linked to this condition. What has been clear about MIH is that the offending factors come into play during the first 4 years after birth, and interferes with the calcification and/or maturation phases of amelogenesis resulting in qualitative defects of enamel or hypomineralization (5).

The diagnosis of MIH is clinically determined while the tooth is clean and wet, and distinguished from conditions that can mimic it, like enamel hypoplasia, fluorosis, amelogenesis imperfect and early carious lesions, on the basis that MIH is localized demarcated opacities affecting a third of the tooth crown (occlusally or incisally) (1).

Globally, the prevalence of MIH range from 2.9–40.2% (6), with the highest prevalence being reported in Brazil (7). In Africa, the prevalence of 2.9%, 17.7% and 13.7% have been reported from Libya (8), Nigeria (9) and Kenya (10), respectively. As there are no past studies on MIH reported from Sudan, this study was designed to determine prevalence, clinical pattern and distribution of MIH in Sudan.

## Methods

This was a descriptive, cross-sectional study undertaken in 2017, involving 8–11 year-old children from public basic schools in Khartoum state.

### **Determination of study population**

The study sample was determined using the formula, (see Formula 1 in the Supplemental Files) with  $n$  = sample size,  $z$  = critical value for achieving 95% confidence level,  $p$  = the anticipated population proportion which is always chosen from previous studies,

$q = 1-p$  and  $d$  = desired margin of error. As for  $p$  value, a Kenyan study of 2009 that reported MIH prevalence of 13.73% (10) was used. Assuming an error of 4% in applying the formula, a sample size of 568 children was arrived at.

### **Sampling technique**

Four localities out of the seven Localities forming Khartoum State, were randomly selected, and through a multi-stage cluster sampling technique, 20 basic schools were randomly selected proportionally to child population in the selected localities. Ethical approval for the study was obtained from the Research Committee of University of Khartoum - Faculty of Dentistry, besides the written approvals from the Director of primary school education for each locality and the Director of each primary school. A written informed consent was obtained from the parents/guardians of the participants, and each child also gave assent to participate in the study.

### **Data collection**

The Principal Investigator was trained by an experienced paediatric dentist at the University of Khartoum, on MIH and caries detection. The training involved the use of photographs and examination of children in the field, and who were not part of the study. During this phase and during the time of data collection, inter-examiner calibration was done and Kappa values calculated were 0.83, 0.74 and 0.67 (30 children) for MIH, DMFT and dmft respectively. The Principal Investigator assisted by a trained recording clerk, examined the 8–11 year-old participants from the 20 schools, for MIH and caries (in a field situation).

Socio-demographic data of each participant were first recorded using WHO oral health assessment Form for children, prior to the documentation of the findings of the oral examination. The oral examination took place in their respective schools, in a room prepared for the purpose.

Each child was examined while sitting in up-right position in an ordinary chair facing a natural light source. During the examination the examiner used sterile dental probes, tweezers, cotton rolls in addition to single use of clean disposable examination gloves and mouth masks for each child. The probe was initially used to remove dental plaque and food remnants from the tooth surfaces. and for detection of dental caries. The cotton rolls were for cleaning the all tooth surfaces prior to examining them for caries and MIH. The presence of Hypomineralization was also recorded for only the 12 index teeth (i.e. permanent first molars and incisors (11), in accordance with the criteria by the European Academy of Paediatric Dentistry (EAPD) (12). The index teeth were examined for MIH (while wet to distinguish the defects from incipient carious lesions), post-eruptive enamel breakdown, atypical restorations and extraction due to MIH (14). Any child who was uncooperative, had enamel lesions smaller than 2 mm (6) or other enamel defects (not MIH) or with fixed appliances, was excluded from the study.

During this oral examination, the Principal Investigator also randomly re-examined a participant after every tenth one to establish intra-examiner reliability, which was calculated as Kappa 0.84, 0.80 and 0.73 (56 children) for MIH, DMFT and dmft respectively. All children in the participating schools received free oral health education and the participants who required dental treatment were referred for appropriate management to the Pediatric Department, Faculty of Dentistry/University of Khartoum.

## Data analysis

All data gathered were entered in the Statistical Package for Social Science (SPSS) program Version 19 computer programme that was used to analyze the data. Descriptive data like frequency, means and relative distributions of MIH were displayed using Tables and Bar Charts. The Chi-square test was used to test the association between MIH and age, gender and dental caries; the difference in proportions between two groups like molars and incisors, left and right, maxillary and mandibular teeth. Spearman rank correlation was used to test the association between number of affected molars and incisors. In all these tests the p-value was pegged at  $< 0.05$ , which was considered to be significant.

## Results

The 568 children aged 8–11 years (284 boys and 284 girls with mean age = 9.5) who participated in the study had a prevalence of MIH of 20.1%. The distribution of MIH in accordance to age and gender is shown in Table 1. There were no significant statistical difference noted between the participants' ages or gender in relationship to the occurrence of MIH ( $p > 0.05$ ).

Table 1  
Distribution of MIH among different ages and gender.

Variables	Children with teeth with MIH (%)	Children with teeth without MIH (%)	Total number of children (%)	Chi-square	p value
<b>Gender</b>					
Male	59(20.7%)	225 (79.3%)	284 (50%)	0.176	0.675
Female	55(19.4%)	229 (80.6%)	284 (50%)		
Total	114 (20.1)	454 (79.1)	586(100%)		
<b>Age in years</b>					
8	18 (19.6%)	74 (80.4%)	92 (16.2%)	4.297	0.231
9	29 (16.1%)	151 (83.9%)	180(31.7%)		
10	43 (20.9%)	163 (79.1%)	206(36.3%)		
11	24 (26.7%)	66 (73.3%)	90 (15.8%)		

Of the 114 participants with MIH, 71 (12.5%) had hypomineralization changes in their permanent first molars (PFM) and permanent incisors (PI), 43 (7.6%) participants in their PFM only (MH) and 18 (3.2%) participants in their PI only (IH). (See Table 1). The number of MIH affected teeth for the 114 children with MIH were 376 with a mean of 3.3 ( $\pm 1.63$ ) teeth per child, of which 2.2 and 1.1 teeth were molars and incisors respectively. There was no

significant statistical difference in the mean number of affected teeth between boys and girls ( $p = 0.386$ ). The majority of the children (38 or 33.3%) had one molar affected, 34 (29.8%) had 2 molars, 27 (23.7%) had 3 molars while only 15 (13.2%) of the children had all the four molars affected. The mean number of affected incisors increased with increasing number of affected molars, and the differences was statistically significant ( $P$ -value  $< 0.001$ ) (Table 2).

Table 2  
Mean number of affected permanent incisors according to the number of affected PFM

No. of molars affected	Mean No. of incisors affected (95% CI)	Spearman rank correlation	P-value
1	1.16 (0.79–1.53)	0.627	< 0.001
2	0.92 (0.58–1.25)		
3	1.07 (0.61–1.54)		
4	1.67 (0.81–2.52)		

In terms of the distribution of MIH defects on the MIH index teeth, the general distribution was as shown in Table 3. Although the maxillary teeth were more frequently affected with MIH than mandibular teeth ( $p = 0.017$ ), the PFM had a significantly higher rate of occurrence (65.8%) than the incisors (34.2%), and the difference was statistically significant ( $p = 0.000$ ). However, there was no significant statistical difference between in MIH occurring on the right (50.5%) and left side (49.5%) of the dental arches ( $p = 0.837$ ), although the left mandibular FPM (17.6%) and the right maxillary central incisors (11.2%) were the most affected teeth. The mandibular molars (34.4%) were slightly more affected than maxillary molars (31.4%), but the difference was not significant statistically ( $p = 0.218$ ). The maxillary incisors (24.2%) were significantly more affected than the mandibular incisors (11.2%), ( $p = 0.000$ ), with the central incisors (21.3%) being also significantly more affected than lateral incisors (3%) ( $p = 0.000$ ). In the lower anterior region the mandibular lateral incisors (6.7%) were more affected than central incisors (4.5%), but the difference was not significant statistically ( $p = 0.103$ ).

Table 3

Distribution of hypomineralization features in index teeth of MIH-affected children according to EAPD diagnostic criteria (2003).

Index tooth	White/creamy demarcated opacities & no PEB (N & %)	White/creamy demarcated opacities with PEB (N & %)	Yellow/brown demarcated opacities & no PEB (N & %)	Yellow/brown demarcated opacities with PEB (N & %)	Atypical restoration (N & %)	Missing due to MIH (N & %)	Total (N & %)
16	32 (51.6%)	15 (24.2%)	8 (12.9%)	7 (11.3%)	-	-	62 (100%)
12	4 (100%)	-	-	-	-	-	4 (100%)
11	39 (92.8%)	2 (4.8%)	-	1 (2.4%)	-	-	42 (100%)
21	32 (94.2%)	1 (2.9%)	-	1 (2.9%)	-	-	34 (100%)
22	7 (100%)	-	-	-	-	-	7 (100%)
26	32 (57.1%)	10 (17.9%)	8 (14.3%)	6 (10.7%)	-	-	56 (100%)
36	26 (42.3%)	16 (25.4%)	6 (9.5%)	12 (19.0%)	1 (1.6%)	2 (3.2%)	63 (100%)
32	9 (90.0%)	-	1 (10%)	-	-	-	10 (100%)
31	9 (100%)	-	-	-	-	-	9 (100%)
41	8 (100%)	-	-	-	-	-	8 (100%)
42	14 (93.3%)	-	1 (6.7%)	-	-	-	15 (100%)
46	23 (34.8%)	30 (45.5%)	4 (6.1%)	4 (6.1%)	2 (3.0%)	3 (4.5%)	66 (100%)
<b>Total</b>	<b>235 (62.5%)</b>	<b>74 (19.7%)</b>	<b>28 (7.4%)</b>	<b>31 (8.2%)</b>	<b>3 (0.8%)</b>	<b>5 (1.3%)</b>	<b>376 (100%)</b>

When the pattern of MIH defects was assessed on the MIH index teeth (Table 3), the demarcated opacities were the most common defects in both molars and incisors, at 69.9% of all hypomineralized teeth, and this was statistically significant ( $p = 0.000$ ). The white/creamy discolouration was more frequent than the yellow brown demarcated opacities. The post-eruptive breakdown was the second most common finding, being observed in 27.9% of all the affected teeth. Atypical restorations and extractions among PFMs were found in only 0.8% and 1.3% of the children, respectively. Demarcated opacities in PFMs was found in 59.5% of all affected molars, while PEB was the second most frequent defect with 92 out of 247 (37.2%) of the affected molars, with extractions being less frequent. In the case of incisors, only 5 out of 129 (3.9%) of the affected teeth had PEB (only maxillary central incisors affected), 96.1% of the affected incisors had demarcated opacities only and there were no cases

of AR or missing incisors due to MIH (see Fig. 1). Overall, post-eruptive breakdown was more frequent in girls than boys (See Table 4) but the difference was not significant statistically ( $p = 0.662$ ), and neither was it different with age ( $p = 0.598$ ).

Table 4  
Post-eruptive breakdown frequency in terms of age and gender

	White/ creamy demarcated opacities with PEB	Yellow/ brown demarcated opacities with PEB	Total	Chi - square	p- Value
<b>Gender</b>					
Boys	30	14	44		
Girls	44	17	65	0.192	0.662
Total	74	31	105		
<b>Age</b>					
8	10	2	12		
9	13	8	21		
10	28	11	39	1.877	0.598
11	22	11	33		
Total	73	32	105		
<b>Figures and Legends</b>					

## Discussion

The best age for the examination of MIH has been given as 8 years when the permanent first molars and permanent incisors have all erupted (15). However, the current study used 8–11 year-olds, like in other previous studies (8, 9) had done, and only included opacities 2 mm or greater for the diagnosis of MIH (16).

### Prevalence of MIH

The prevalence of MIH in the current study was 20.1%, which was higher than the global average prevalence of 16% (9), but comparable to results reported of 19.3% from Finland (17), 21.8% from Spain (18), and 20.0% from Thailand (19). Alternatively, when the current results were related to those reported from other African countries, they were higher than the 17.7% from Nigeria (9), 13.7% from Kenya (10), and the 2.9% from Libya (8). Globally, the researches that has reported the least prevalence of MIH were from Hong Kong (8) and Libya (20) of less than 3%, and the highest were from Brazil (11) and Denmark (23).

### Association of MIH with Age and gender

The current study has shown no significant statistical difference with the occurrence of MIH in relation to age ( $p = 0.231$ ), which is consistent with results reported by Yodeled *et al.* (9), and Ghanim *et al.*, (21), but not for results by Koch *et al.* (22), and Da costa-Silva *et al.* (23) that showed significant increase with age. In terms of gender, the current study showed boys had slightly higher MIH prevalence than girls, although this was not statistically

significant ( $p = 0.675$ ), just as some studies have indicated before (24, 29) and contrary to results from other studies where the prevalence were high for girls (10, 20, 24,) and for boys (8, 25).

### **Number and distribution of MIH-affected teeth**

The mean number of MIH-affected teeth in a child in the current study was 3.3, consistent with that reported for Denmark of 3.6 (11), Brazil with 3.3 (26) and Nigeria with 3.5 (27), but lesser than that reported in China of 2.6 (20) and Italy of 2.0 (28), and contrasted those recorded in Bosnia and Herzegovina of 5.59 (24), Germany with 4.8 (25) and India with 4.31 (29). The variations in the mean number of affected teeth could suggest that regardless of the MIH prevalence in the population, the mean number of teeth affected appear to be almost similar, a denotation of a common characteristic of the defect. The majority of the children in the current study had one and two molars affected rather than three or four molars, the same finding was reported in a study in Finland (17) and in Ankara, Turkey (30). In contrast other studies have reported most of children have four molars affected (7, 11).

The risk of incisor involvement in the current study appeared to increase significantly with the number of molars affected, a situation similar to the findings in a studies conducted by Wogelius et. al. (11) and Da costa-Silva et. al. (23), but in contrast to the that found that the risk was insignificant (18).

In the current study population, the permanent first molars were more frequently affected than incisors, just as reported in other studies (14, 32), but this result was lower than that obtained in Denmark in 2008, where the affected incisors were more than the molars (11). Further, in the current study, the affected maxillary teeth were more than the mandibular teeth, a situation consistent with the findings by Leppaniemi et al. in 2001 (17) and Temilola et al. in 2015(27). Nonetheless, studies by Cho *et al* (20) in 2008, Ghanim et al in 2011 (13), found equal distribution of defects in the upper and lower jaws. The current study also showed that the mandibular and maxillary molars were equally affected ( $P = 0.218$ ), in line with what Weerheijm et al reported in 2001 (33) and Cho et al in 2008 (20), but contrary to the results from Sweden (32), Lithuania (14), Jordan(34) and Gujarat, India (35) that found more mandibular than maxillary molars being affected. Greek (24) and Iraqi (13) studies found more maxillary than mandibular molars were affected.

The maxillary incisors in the current study were more frequently affected, a result that mirrored the findings by Parikh et al in 2012 (13), Ghanim et al in 2011 (29) and Muratbegovic et al in 2007) (35), but contrary to th results of a Turkish study by Sönmez et al in 2013 (30), who reported more mandibular than maxillary incisors being affected. The current study also showed the upper central incisors (right: 11.2%, left: 9.0%) were the most frequent affected as was also reported by Lygidais et al in 2008 (24), Zawaideh et al in 2011 (14), Jasulaityte et al in 2008 (34) Allazzam et al in 2014 (31).

### **Pattern of MIH defect in hypomineralized teeth**

The current study found that the most common pattern of MIH defects were demarcated opacities. The white/creamy demarcated opacities were more frequent than yellow/brown opacities, which was in agreement with previous studies by Wogelius et al in 2008 (11) and Mitta et al in 2015 (36), but just the opposite to the findings by Ghanim et al in 2014 (21) which revealed that yellow/brown opacities were the most common form of MIH defects. The prevalence of post-eruptive breakdown in the present study was 28% which was comparable to the 28.2% obtained from Lithuania (14) but higher than the 8.4% reported in Finland (17) and 2.0% FROM Brazil (7). This variation may be explained by the inclusion of older age group children in the current study, as demarcated opacities may tend to break down over time (11). The most severe MIH defects (PEB, AR and

extractions due to MIH) were present on the first permanent molars, unlike the permanent incisors where PEB was rare possibly due to less masticatory forces placed on these teeth (13, 37, 23)

## Conclusions

1. The prevalence of MIH in the Sudanese school children from Khartoum State was 20.1%, with no gender difference.
2. While both molars and incisors were frequently affected by MIH, the mandibular molars and Maxillary incisors showed higher numbers of MIH defects than the maxillary molar and mandibular incisors, respectively.
3. The most prevalent form of MIH defect was the demarcated opacities type. And more so, the white/creamy form, followed by the post-eruptive breakdown, with the least common types being the atypical restorations and missing because of MIH.

## List Of Abbreviations

**AR** – Atypical restoration

**IH** – Incisor hypomineralization

**MH** – Molar hypomineralization

**MIH** – Molar incisor hypomineralization

**PEB** – Post eruption breakdown

**PFM** – Permanent first molars

**PI** – permanent incisors

**SPSS**- Statistical Package for Social Sciences

## Declarations

### Ethics approval and consent to participate

Prior to commencement of the study, ethical clearance for the study was sought and obtained from the Research Committee of the University of Khartoum - Faculty of Dentistry (Reference: HREC assigned number 5/2015). The parent/guardian and child provided written informed consent and assent, respectively, after full disclosure of the study was given to them. Permission to carry out the research at the schools was also obtained from Directors of Primary School Education for the relevant authorities and also the Director of each primary school.

### Consent for publication

Not applicable.

### Availability of data and material

The data providing for the results presented in this study is available by contact to the corresponding author, but restrictions apply to the availability of these data and to a certain time period, as the data were used under license for the current study, and so are not publicly available.

### **Competing interests**

The authors declare no potential conflicts of interest in respect to the authorship nor the Publication of the present article.

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This work was not funded, other than money spent on the research from the researcher herself.

### **Author contributions**

HEA identified and designed the study, recruited the participants, collected the data, analyzed the data and presented results for the original larger study, as part of the interdisciplinary research initiative.

AHA assisted in identifying the research and was involved in the initial design and planning of the larger study, as part of the interdisciplinary research initiative.

AMK conceptualized and designed the initial draft of the current research MS, verified the data acquisition and analysis, as adapted from the original larger study, in collaboration with HEA and AHA, as part of the interdisciplinary research initiative.

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### **Authors' information**

Not applicable.

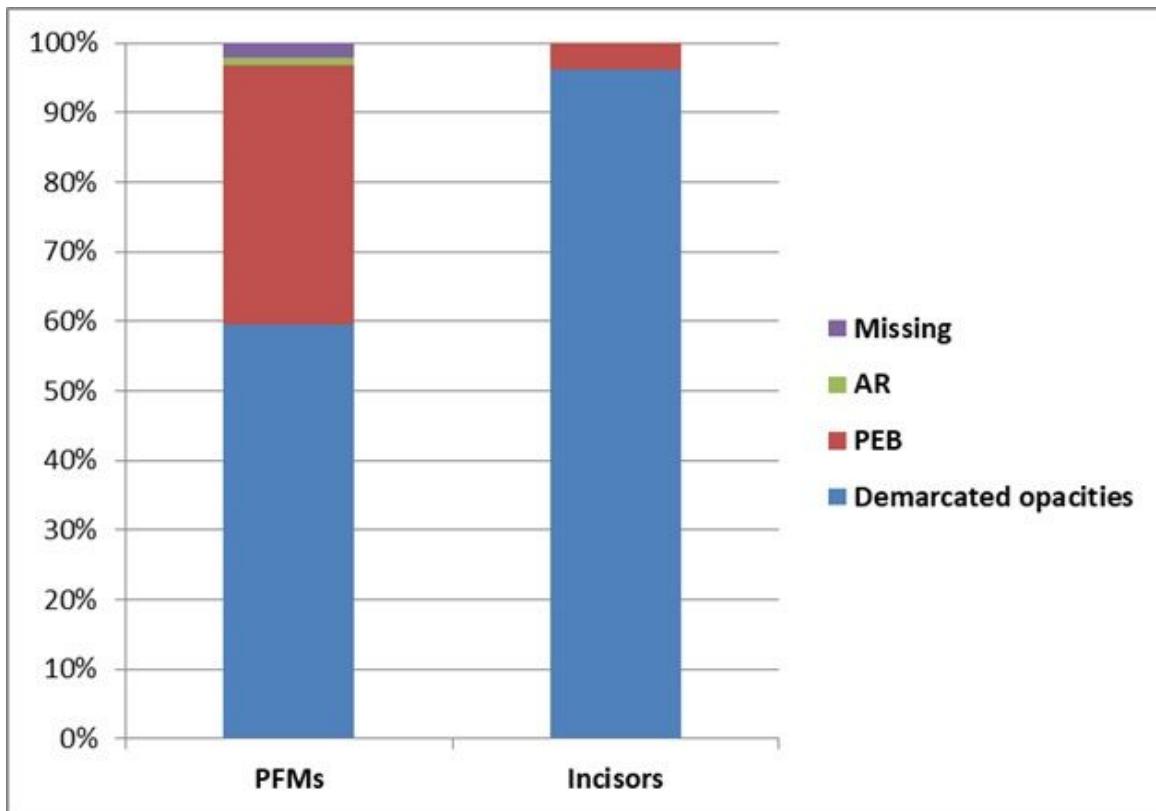
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## Figures



**Figure 1**

Pattern of MIH defect for each group of hypomineralized teeth.

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