original article

Frequency of molar incisor hypomineralization and associated factors among children with special health care needs

Roshan Noor Mohamed, Sakeenabi Basha, Yousef Al-Thomali, Fatma Salem Al Zahrani, Amal Adnan Ashour, Ammar Saleh Al Shamrani, Nada Eid Almutair

From the Faculty of Dentistry, Taif University, Taif, Saudi Arabia

Correspondence: Dr. Roshan Noor Mohamed · Pediatric Dentistry, Faculty of Dentistry, Taif University, Taif 21944, Saudi Arabia · roshan.noor@tudent.edu.sa · ORCID: https://orcid.org/0000-0001-9722-6740

Citation: Mohamed RN, Basha S, Al-Thomali Y, Al Zahrani FS, Ashour AA, Al Shamrani AS, et al. Frequency of molar incisor hypomineralization-and associated factors among children with special health care needs. Ann Saudi Med 2021; 41(4): 238-245. DOI: 10.5144/0256-4947.2021.238

Received: January 12, 2021

Accepted: April 16, 2021

Published: August 22, 2021

Funding: None.

BACKGROUND: Molar incisor hypomineralization (MIH) is a frequently encountered oral condition that varies from mild opacities to posteruptive enamel breakdown. No previous published studies have investigated the frequency of MIH and associated risk factors among children with special health care needs (CSHCN) to our awareness.

OBJECTIVES: Assess the frequency of MIH and associated risk factors among CSHCN.

DESIGN: Cross-sectional.

SETTING: Schools in provincial city of Saudi Arabia.

PATIENTS AND METHODS: The study was conducted among 400 (180 boys and 220 girls) special needs children. Diagnosis of MIH was according to the European Academy of Paediatric Dentistry criteria.

MAIN OUTCOME MEASURE: Result of logistic regression analysis that assessed the association between MIH prevalence and associated prenatal, perinatal, and postnatal factors.

SAMPLE SIZE: 400 (180 boys and 220 girls) special needs children.

RESULTS: Among 400 CSHCN, 98 (24.5%) presented with MIH. Children with multiple disabilities had a 3.89 times greater risk of MIH (95% CI: 1.91–6.19, *P*=.002). Children with positive prenatal factors had an adjusted odds ratio (aOR) of 2.31 times for MIH (95% CI: 1.22–4.73, *P*=.012). Children with a childhood infection history had an aOR of 2.43 times for MIH (95% CI: 1.31–5.85, *P*=.014). Children with a breastfeeding history >18 months had an aOR of 3.73 for MIH (95% CI: 1.62–8.60, *P*=.002). Permanent maxillary first molars were the most frequently affected teeth, and demarcated opacity was the most frequent MIH type.

CONCLUSION: MIH should be recognized as one of the prevalent oral health problems among CSHCN to prevent tooth mortality.

LIMITATIONS: A cross-sectional study cannot establish a causal relationship.

CONFLICT OF INTEREST: None.

Molar incisor hypomineralization (MIH) is a frequently encountered oral condition among children worldwide. The MIH most often affects permanent first molar and incisors, which presents as demarcated, qualitative enamel defects either symmetrical or asymmetrical in distribution.[1,2] It is a multifactorial condition resulting from the influence of systemic and or environmental factors during a late secretory phase or early maturation stage of amelogenesis.[3,4] Systemic factors include prenatal and perinatal complications, low birth weight, frequent use of antibiotics, respiratory tract infections, calcium-phosphate metabolic disorders, and hypoxia.[3-11] A genetic interaction with systemic and environmental factors leading to MIH is also reported.[12,13]

The severity of MIH varies from mild opacities to posteruptive enamel breakdown.[2,14] A noticeable esthetic problem and associated hypersensitivity, susceptibility to dental caries, enamel disintegration, and or loss of tooth structure may affect the quality of life.[15-18] The global prevalence of MIH varies from 2.8% to 40% depending on the population studied and diagnostic criteria used to identify MIH.[5-11,19-25] A few point prevalence studies conducted in Saudi Arabia among children without special needs have reported an MIH prevalence of 8.6% to 25%.[5,25]

Children with special health care needs (CSHCN) have physical, mental, or behavioral conditions that limit them from normal daily activities and often require health care interventions.[26] Previously studies have reported a variable prevalence of developmental defects of the enamel in CSHCN,[27,28] but none specifically for MIH. CSHCN are more prone to develop dental caries because of their physical, mental, neurological, or behavioral impairment.[29,30] Previous studies have reported a positive association between MIH and increased caries prevalence.[15,16] The present study aimed to assess the prevalence of MIH among children with CSHCN, associated risk factors for MIH among CSHCN, and specify which type of disability is the most significant.

PATIENTS AND METHODS

A descriptive cross-sectional study was conducted among 400 (180 boys and 220 girls) CSHCN, Taif City, Makkah Province, Saudi Arabia. The National Demographic Survey, Saudi Arabia, 2016, reported a prevalence of 2.7% for childhood disability among 0-19 year olds with 2670 affected children per hundred thousand.[31] Based on the pilot study, a sample of 400 was finalized with an anticipated population proportion of 0.40, at type I error rate of 5% and a power of 80%. The study followed a two-stage random sampling method. At the first stage, thirty public schools with CSHCN were randomly selected by lottery numbers from the five zones of the city (five to seven schools from each zone) to meet the required sample size. In the second stage, CSHCN were selected by probability proportional to size by random sampling technique. Using lottery numbers, six to 25 children from each school proportionate to the number of available CSHCN (a total of 675 CSHCN in selected schools) were selected. The institutional review board approved the study (Ethical clearance number – 39-11007-0029). The authors obtained written informed consent from the parents/guardians of the participants. Ten children who displayed aggressive behavior (with temper tantrums, physical aggression such as hitting or biting) and inability to cooperate were excluded. Other special needs children were randomly selected in their place. The investigators collected relevant information from parents/guardians of CSHCN through a face-to-face interview using a pretested structured inquiry items: sociodemographic details (age, gender, parental education, family income), prenatal factors (mothers medical history, infection during pregnancy, medication history, vitamin D deficiency or hypocalcemia, gestational diabetes, hypertension, pre-eclampsia), perinatal factors (vaginal or cesarean delivery, premature birth, birth weight, prolonged delivery), postnatal factors (childhood infection and illness like asthma, urinary tract infection, otitis media, chickenpox, respiratory tract infection, rubella, tonsillitis, high fever, allergies, epilepsy, renal failure, cardiac problems, antibiotic usage, breastfeeding period during the first four years of life). The inquiry items were adopted from published literature[3-9] and modified to improve the validity based on a pilot interview with 25 parents (Cronbach alpha α=0.84).

All the CSHCN included in the study were examined by the single examiner under natural light using sterile mouth mirrors and CPI probes. A diagnosis of MIH was made according to the European Academy of Paediatric Dentistry criteria.[32] Permanent first molars (PFMs) and permanent incisors were examined in clean and wet conditions for the lesions larger than 1 mm for recording as MIH. The MIH was coded as follows: 0=no defect, 1=demarcated opacity, 2=posteruptive breakdown, 3=atypical restorations, 4=tooth loss due to MIH (permanent first molars extracted due to MIH). Children were considered to be affected by MIH if one or more PFMs were involved with or without permanent incisor involvement. The examiner was trained to diagnose MIH using photographs of varying severity of the condition. The intra-examiner reproducibility was assessed

for MIH criteria by examining 15% of subjects twice, on successive days (Kappa value of 0.92, *P*<.05). Enamel defects on all teeth, teeth with dental fluorosis, enamel defects on permanent incisors without the involvement of PFMs were excluded from MIH. All disability types, including physically/mentally challenged or those with sensory/motor issues among CSHCN, were taken from school records and categorized into six groups as per the World Health Organization Criteria: Intellectual disability (ID), Autistic disorder, cerebral palsy, Down syndrome, deafness or blindness, or both, multiple disabilities or patients with syndromes. The children with multiple disabilities included those with a physical disability combined with a sensory and or cognitive disability.[33]

The difference in proportion was tested using the chi-square test followed by pairwise comparisons (Z tests) with Bonferroni correction. Multiple logistic regression analysis with forward entry was performed to assess the association between the MIH prevalence (yes/no) and the influence of prenatal, perinatal, and postnatal factors, age, gender, and type of disability. Goodness-of-fit was tested by the chi-square test. The R^2 was calculated using Cox-Snell and McFadden's measures. The data was normally distributed. The analysis was performed using the IBM SPSS Statistics, version 17 (IBM Corp.in Armonk, NY). All statistical tests were two-sided, and the significance level was set at *P*<.05.

RESULTS

Among 400 CSHCN, 123 (30.8%) children presented with intellectual disability, 107 (26.8%) with autism, and 70 (17.5%) with Down syndrome (**Table 1**). Ninety-eight (24.5%) children presented with MIH. The frequency of MIH was 50% among children with multiple disabilities (*P*=.016) (**Table 2**). The MIH frequency was 28.7% in children with prenatal factors (*P*=.018). Eighty three (27.6%) children with childhood infection had MIH (*P*=.013). Seventeen (40.5%) children with breastfeeding period >18 months had MIH (*P*=.03). Of 291 teeth with MIH lesions, 122 teeth were affected with demarcated opacity, and 40 teeth were lost due to MIH. One hundred thirteen permanent maxillary first molars and 108 permanent mandibular first molars were affected with MIH (**Table 3**).

Children with multiple disabilities presented a 3.89 times greater risk of MIH (95% CI: 1.91 – 6.19, *P*=.002). Children with positive prenatal factors presented with an adjusted odds ratio (aOR) of 2.31 times for MIH (95% CI: 1.22 – 4.73, *P*=.012). Children with a childhood infection history presented with an aOR of 2.43 for MIH (95% CI: 1.31 – 5.85, *P*=.014). Children with breastfeeding history >18 months had an aOR of 3.73 times for MIH (95% CI: 1.62 – 8.60, *P*=.002) (**Table 4**).

DISCUSSION

The present study is the first to investigate the frequency of MIH and associated risk factors among CSHCN. A total of 400 CSHCN were included based on the pilot study, which also satisfies the minimum required study population criteria in MIH frequency studies.[34] The overall prevalence of MIH in the present study was 24.5%, as similarly reported by Rizk et al,[25] although among normal Saudi children. In contrast to this, Allazzam et al[5] showed a prevalence of 8.6% MIH among 8 to 12-year-old children visiting the Pediatric Dental Clinic. However, the global prevalence of MIH among normal children varied from 2.4% to 40.2%, depending upon the population studied, age group involved, and diagnostic criteria for MIH.[6-11,19-24] In the present study, children were aged from 6-16 years, and the prevalence of MIH was slightly higher among 6-11-year-old CSHCN compared to 12-16 years. This finding might be due

Table 1. Disability types according to age and gender distribution.

Variables	Autism	Cerebral palsy	Intellectual disability	Down syndrome	Deafness or Blindness or both	Children with multiple disability/ syndrome
Age (years)						
6-11 (n=160)	39 (24.4)[a]	5 (3.1)[b]	88 (55.0)[a]	16 (10.0)	7 (4.4)	5 (3.1)
12-16 (n=240)	68 (28.3)[a]	38 (15.8)[b]	35 (14.6)[a]	54 (22.5)	26 (10.8)	19 (7.9)
Gender						
Boys (n=180)	49 (27.2)[a]	18 (10.0)	82 (45.6)[a]	18 (10.0)[a]	8 (4.4)[a]	5 (2.8)[a]
Girls (n=220)	58 (26.4)[a]	25 (11.4)	41 (18.6)[a]	52 (23.6)[a]	25 (11.4)[a]	19 (8.6)[a]

Data are number (%). Chi-square test for age groups and gender: *P*<.001. Pairwise comparisons (Z test) with Bonferroni correction: [a] *P*<.05, [b]*P*<.001

Table 2. Frequency of molar incisor hypomineralization by demographic and clinical variables.

Variables	MIH Present	95% CI	MIH Absent	95% CI	Chi-square test, *P* value
Age (years)					
6-11 (n=160)	46 (28.7)	.22 – .35	114 (71.3)	.64 – .78	.123
12-16 (n=240)	52 (21.7)	.17 – .27	188 (78.3)	.73 – .83	
Gender					
Boys (n=180)	33 (18.3)	.13 – .25	147 (81.7)	.75 – .87	.070
Girls (n=220)	65 (29.5)	.23 – .36	155 (70.5)	.64 – .76	
Type of disability					
Autistic disorder (n=107)	21 (19.6)	.13 – .28	86 (80.4)	.72 – .87	.016
Cerebral palsy (n=43)	13 (30.2)	.17 – .46	30 (69.8)	.54 – .83	
Intellectual disability (n=123)	23 (18.7)	.12 – .27	100 (81.3)	.73 – .88	
Down syndrome (n=70)	19 (27.1)	.17 – .39	51 (72.9)	.61 – .83	
Deafness or Blindness, or both (n=33)	10 (30.3)	.16 – .49	23 (69.7)	.51 – .84	
Multiple disabilities or with syndromes (n=24)	12 (50.0)[a]	.29 – .71	12 (50.0)	.29 – .71	
Prenatal factors[b]					
Yes (n=240)	69 (28.7)[a]	.23 – .35	171 (71.3)	.65 – .77	.018
No (n=160)	29 (18.1)	.13 – .25	131 (81.9)	.75 – .88	
Perinatal factors					
Delivery type					
Normal (n=237)	52 (21.9)	.17 – .28	185 (78.1)	.72 – .83	.158
C-section (n=163)	46 (28.2)	.22 – .36	117 (71.8)	.64 – .79	
PTLBW or FTLBW					
Yes (n=209)	60 (28.7)	.23 – .35	149 (71.3)	.65 – .78	.041
No (n=191)	38 (19.9)[a]	.15 – .26	153 (80.1)	.74 – .86	
Postnatal factors					
Childhood illness and history of antibiotics					
Yes (n=301)	83 (27.6)[a]	.23 – .33	218 (72.4)	.67 – .78	.013
No (n=99)	15 (15.2)	.09 – .24	84 (84.8)	.76 – .91	
Breastfeeding period					
0–12 months (n=261)	54 (20.7)	.16 – .26	207 (79.3)	.74 – .84	.030
12-18 months (n=97)	27 (27.8)	.19 – .38	70 (72.2)	.62 – .81	
>18 months (n=42)	17 (40.5)[a]	.26 – .57	25 (59.5)	.43 – .74	

Data are number (%). Pairwise comparisons (Z test) with Bonferroni correction: [a]*P*<.05. [b]Prenatal factors: positive mothers medical history during pregnancy (infection, medication, vitamin D deficiency or hypocalcaemia, gestational diabetes, hypertension, pre-eclampsia), PTLBW: Preterm low-birth weight, FTLBW: Full term low birth weight, MIH: Molar incisor hypomineralization

Table 3. MIH types according to teeth affected (permanent first molars and permanent incisors).

Type of MIH	Maxillary molars (n=713)	Maxillary incisors (n=821)	Mandibular molar (n=703)	Mandibular incisors (n=833)	Total
Demarcated opacity	31	48	26	17	122
Posteruptive breakdown	31	3	34	0	68
Atypical restorations	33	2	26	0	61
Tooth loss due to MIH	18	0	22	0	40
Total	113	53	108	17	291

to the possibility of carious lesion masking MIH among older children.[5,23,24] In agreement with the previous studies,[14,21] the present study showed a slightly higher prevalence of MIH among girls than boys; however, the difference was not statistically significant.

The current result showed a significantly higher prevalence of MIH among children with multiple disabilities than other children. Regression analysis showed these children were 3.89 times greater risk of having MIH. Comparing the present result to previous studies was not possible because of a similar study not precisely measuring MIH among CSHCN.

Some previous studies have focused on possible systemic, genetic, and environmental factors that influence MIH prevalence.[3-13] These studies showed health problems during the prenatal, perinatal, or postnatal period, hypoxia in amelogenesis stage, dioxin present in breast milk, childhood infection or illness, use of antibiotics during the first four years of life are possible etiological factors for MIH prevalence leading to a localized form of enamel hypomineralization. In agreement with the previous studies,[5-11] the present study result showed a 2.31 times greater risk of having MIH among children with a positive prenatal history of a maternal medical problem. Children with a history of childhood infection presented with an odds ratio of 2.43 times greater risk of having MIH. Childhood infections can disturb ameloblasts during the late secretory or early maturation stage either directly or indirectly through malnutrition, an increase in temperature, pH shifts, hypoxia, or hypocalcemia.[35-39] Children with a breastfeeding history of >18 months presented with 3.73 times greater MIH risk. Prolonged breastfeeding may increase exposure to dioxins, which are widely spread environmental pollutants. Dioxins accumulate in the food chain and are secreted in human milk.[40,41] The dioxins may disturb tooth development leading to a greater risk of MIH.[42,43] The present study showed no association between MIH and the type of delivery, preterm birth, or low-birth-weight. This finding may be due to the small sample size so statistical power might not have been sufficient to detect the differences. However, a contrasting observation was reported by Koruyucu et al[10] and Kılınç et al,[22] showing a significant association between MIH prevalence and birth type and birth weight.

The present study result showed that upper permanent first molars were the most frequently affected teeth, and demarcated opacity was the most frequent type of MIH as reported by previous studies.[14,16,20,21,24,25] The prevalence of posteruptive enamel breakdown, atypical restoration, and tooth loss were slightly higher compared to the previous studies.[6,9] This may be due to the inclusion of older age children in the present study. Regression analysis showed no association between the presence of MIH in PFMs alone and with the involvement of MIH in the permanent incisor.

The present study's limitation may be its cross-sectional nature with a limited study population where the chance of recall bias might influence establishing a casual relationship between MIH and associated risk factors. The present study's scope did not include the categorization of childhood infection. The accuracy and limited information present in the school records influence the identification and categorization of the disabilities. Using natural light for diagnosis of MIH may under-or over-estimate its prevalence even after achieving intraexaminer consistency. Future research covering a broad spectrum of risk factors associated with MIH through a longitudinal study with the inclusion of a control population with no special health care needs can substantiate the present study results.

To conclude, the present study showed a 24.5% prevalence of MIH among CSHCN. Children with multiple disabilities presented with a significantly higher prevalence of MIH. The MIH prevalence was significantly associated with a positive prenatal maternal medical problem. A childhood infection and prolonged span of breastfeeding presented with a greater risk of MIH

Table 4. Multiple logistic regression analysis of factors associated with presence of molar incisor hypomineralization.

Variables	B	Standard error	Wald	Sig. (*P* value)	Adjusted odds ratio	95% CI	
						Lower	Upper
Intercept	.49	.64	.59	.439			
Age (years)							
6-11	.66	.31	1.26	.065	.39	.21	.71
12-16	#						
Gender							
Boys	#						
Girls	.71	.34	1.86	.218	1.115	.11	2.20
Disability types							
Autistic disorder	#						
Cerebral palsy	.64	.35	1.43	.073	1.84	.94	2.01
Intellectual disability	1.01	0.55	3.33	.064	2.75	.98	3.01
Down's syndrome	.75	.52	1.58	.208	2.11	.66	6.72
Deafness or Blindness, or both	.61	.45	1.53	.074	1.74	.96	4.01
Multiple disabilities or with syndromes	1.78	.58	9.54	.002	3.89	1.91	6.19
Prenatal factors							
Yes	.91	.30	9.09	.012	2.31	1.22	4.73
No	#						
Perinatal factors							
Normal delivery	#						
C-Section delivery	.45	.34	1.04	.218	.09	.02	.31
Preterm or full-term low birth weight	.53	.33	1.12	.321	.93	.14	2.48
Full-term low birth weight	#						
Postnatal factors							
Childhood infection							
Yes	.84	.64	5.99	.014	2.43	1.31	5.85
No	#						
Breast feeding							
0-12 months	#						
12-18 months	.68	.45	2.28	.131	1.97	.82	4.75
>18 months	1.32	.43	9.56	.002	3.73	1.62	8.60
MIH in permanent first molars							
MIH in incisors	.46	.31	.98	.221	.87	.06	2.11
No MIH in incisors	#						

#Reference level, chi-square likelihood ratio=80.309, df=12, *P*<.001, chi-square goodness of fit=243.580, *P*=.001, McFadden R^2=0.180 Cox and Snell R^2=0.182.

postnatally. The recommendations for the management of MIH should focus on early diagnosis of the lesion, creating awareness among caregivers, and motivating dental practitioners both in private and public sectors to provide preventive and restorative services for MIH lesions in CSHCN. Although the Saudi government encourages an integrated approach for delivering health care services for CSHCN, there is a need to identify MIH as one of the prevalent oral health problems among CSHCN to prevent tooth mortality.

Acknowledgment

The present research work is supported by Taif University Researchers Support Project Number (TURSP-2020/102), Taif University PO Box 11099, Taif-21944, Saudi Arabia.

REFERENCES

1. Tkachenko TB, Savushkina NA, Karpova LS. Acquired malformations of hard dental tissue: Molar-Incisor-Hipomineralisation (review of literature). The Scientific Notes of the Pavlov University 2020;26:18-22.
2. Weerheijm KL. Molar incisor hypomineralization (MIH): clinical presentation, etiology and management. Dent Update 2004;31:9-12.
3. Silva MJ, Scurrah KJ, Craig JM, Manton DJ, Kilpatrick N. Etiology of molar incisor hypomineralization–A systematic review. Community Dent Oral Epidemiol. 2016;44:342-53.
4. Alaluusua S. Etiology of molar-incisor hypomineralisation: A systematic review. Eur. Arch. Paediatr. Dent. 2010;11(2):53-58.
5. Allazzam SM, Alaki SM, El Meligy OA. Molar incisor hypomineralization, prevalence, and etiology. Int J Dent. 2014;2014:234508.
6. Dantas-Neta NB, Soares Figueiredo M, Lima CCB, Bendo CB, Matos de Andrade ÉM, Lima MDM, et al. Factors associated with molar-incisor hypomineralisation in schoolchildren aged 8-10 years: a case-control study. Int J Paediatr Dent 2018;28(6):570-577.
7. Sönmez H, Yıldırım G, Bezgin T. Putative factors associated with molar incisor hypomineralisation: an epidemiological study. Eur Arch Paediatr Dent. 2013;14(6):375-80.
8. Souza JF, Costa-Silva CM, Jeremias F, Santos-Pinto L, Zuanon AC, Cordeiro RC. Molar incisor hypomineralisation: possible aetiological factors in children from urban and rural areas. Eur Arch Paediatr Dent. 2012;13(4):164-70.
9. Rai A, Singh A, Menon I, Singh J, Rai V, Aswal GS. Molar Incisor Hypomineralization: Prevalence and Risk Factors Among 7-9 Years Old School Children in Muradnagar, Ghaziabad. Open Dent J. 2018;12:714-722.
10. Koruyucu M, Özel S, Tuna EB. Prevalence and etiology of molar-incisor hypomineralization (MIH) in the city of Istanbul. J Dent Science. 2018;13:318-328.
11. Lygidakis N A, 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;9:207-217.
12. Teixeira RJPB, Andrade NS, Queiroz LCC, Mendes FM, Moura MS, Moura LFAD, 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.
13. Jeremias F, Koruyucu M, Küchler EC, Bayram M, Tuna EB, Deeley K, et al. Genes expressed in dental enamel development are associated with molar-incisor hypomineralization. Arch Oral Biol. 2013;58(10):1434-42.
14. Buchgraber B, Kqiku L, Ebeleseder KA. Molar incisor hypomineralization: proportion and severity in primary public school children in Graz, Austria. Clin Oral Investig. 2018;22(2):757-762.
15. Gambetta-Tessini K, Mariño R, Ghanim A, Calache H, Manton DJ. The impact of MIH/HSPM on the carious lesion severity of schoolchildren from Talca, Chile. Eur Arch Paediatr Dent. 2019;20(5):417-423.
16. da Costa-Silva CM, Jeremias F, de Souza JF, Cordeiro RDCL, Santos-Pinto L, uanon ACC. Molar incisor hypomineralization: prevalence, severity and clinical consequences in Brazilian children. Int J Paediatr Dent. 2010;20:426-434.
17. Portella PD, Menoncin BLV, de Souza JF, de Menezes JVNB, Fraiz FC, Assunção LRDS. Impact of molar incisor hypomineralization on quality of life in children with early mixed dentition: A hierarchical approach. Int J Paediatr Dent. 2019;29(4):496-506.
18. Raposo F, de Carvalho Rodrigues AC, Lia ÉN, Leal SC. Prevalence of Hypersensitivity in Teeth Affected by Molar-Incisor Hypomineralization (MIH). Caries Research. 2019;53(4):424-430.
19. Jälevik B. Prevalence and Diagnosis of Molar-Incisor- Hypomineralisation (MIH): A systematic review. Eur Arch Paediatr Dent. 2010;11(2):59-64.
20. Petrou MA, Giraki M, Bissar AR, Basner R, Wempe C, Altarabulsi MB, et al. Prevalence of Molar-Incisor-Hypomineralisation among school children in four German cities. Int J Paediatr Dent. 2014;24(6):434-40.
21. Saber F, Waly N, Moheb D. Prevalence of molar incisor hypomineralisation in a group of Egyptian children using the short form: a cross-sectional study. Eur Arch Paediatr Dent. 2018;19(5):337-345.
22. Kılınç G, Çetin M, Köse B, Ellidokuz H. Prevalence, aetiology, and treatment of molar incisor hypomineralization in children living in Izmir City (Turkey). Int J Paediatr Dent. 2019;29:775-782.
23. Bhaskar SA, Hegde S. Molar-incisor hypomineralization: Prevalence, severity and clinical characteristics in 8- to 13-year-old children of Udaipur, India. J Indian Soc Pedod Prev Dent. 2014;32:322-9.
24. Amend S, Nossol C, Bausback-Schomakers S, Wleklinski C, Scheibelhut C, Pons-Kühnemann J, et al. Prevalence of molar-incisor-hypomineralisation (MIH) among 6–12-year-old children in Central Hesse (Germany). Clin Oral Invest. 2020;35.
25. Rizk H, Al-Mutairi MM, Habibullah MA. The prevalence of molar-incisor hypomineralization in primary schoolchildren aged 7–9 years in Qassim Region of Saudi Arabia. J Interdisciplinary Dent. 2018;8:44-8.
26. American Academy of Pediatric Dentistry. Management of dental patients with special health care needs. The Reference Manual of Pediatric Dentistry. Chicago, Ill.: American Academy of Pediatric Dentistry. 2020:275-80.
27. Lin X, Wu W, Zhang C, Lo EC, Chu CH, Dissanayaka WL. Prevalence and distribution of developmental enamel defects in children with cerebral palsy in Beijing, China. Int J Paediatr Dent. 2011;21:23-8
28. Erika V, Modric, Verzak Ž, Karlovic Z. Developmental defects of enamel in children with intellectual disability. Acta Stomatol Croat. 2016;50:65-71
29. Nqcobo CB, Yengopal V, Rudolph MJ, M Thekiso M, Z Joosab Z. Dental caries prevalence in children attending special needs schools in Johannesburg, Gauteng Province, South Africa. SADJ 2012;67: 308-13.
30. Shah AH, Bindayel NA, AlOlaywi FM, Sheehan SA. Oral Health Status of a group at a Special needs centre in AlKharj Saudi Arabia. J Disability Oral Health. 2015;16:79-85
31. Bindawas SM, Vennu V. The National and Regional Prevalence Rates of Disability, Type, of Disability and Severity in Saudi Arabia-Analysis of 2016 Demographic Survey Data. Int J Environ Res Public Health. 2018;28:15(3):419.
32. Werheijm KL, Duggal M, Mejare , Papagiannoulis L. Judgment criteria for molar incisor hypomineralization (MIH) in epidemiologic studies: a summary of the European meeting on MIH held in Athens, 2003. Eur J Paediatr Dent. 2003;4:110-113.
33. World Health Organization. International Classification of Functioning, Disability and Health, Version for Children and Youth (ICF-CY). Geneva: WHO, 2007.
34. 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):247-255.
35. Muñoz CS, Silva AP, Solano F, Castells MT, Vicente A, Ruiz AJO. Effect of antibiotics and NSAIDs on cyclooxygenase-2 in the enamel mineralization. Sci Rep. 2018;8:4132.
36. Tung K, Fujita H, Yamashita Y, Takagi Y. Effect of turpentine-induced fever during the enamel formation of rat inciso. Archives of Oral Biology. 2006;51:464-470.
37. Yamaguti PM, Arana-Chavez VE, Acevedo AC. Changes in amelogenesis in the rat incisor following short-term hypocalcaemia. Archives of Oral Biology. 2005;50:185-188.
38. Robinson C, Connell S, Brookes J, Kirkham J, Shore RC, Smith DAM. Surface chemistry of enamel apatite during maturation in relation to pH: implications for protein removal and crystal growth. Archives of Oral Biology. 2005;50:267-270.
39. Sidaly R, Risnes S, Khan QE, Stiris T, Sehic A. The effect of hypoxia on the formation of mouse incisor enamel. Arch Oral Biol. 2015;60(11):1601-12.
40. Todaka T, Hirakawa H, Kajiwara J, Hori T, Tobiishi K, Onozuka D, et al. Concentrations of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and dioxin-like polychlorinated biphenyls in blood and breast milk collected from 60 mothers in Sapporo City, Japan. Chemosphere. 2008;72(8):1152-8.
41. van den Berg M, Kypke K, Kotz A, Tritscher A, Lee SY, Magulova K, et al. WHO/UNEP global surveys of PCDDs, PCDFs, PCBs and DDTs in human milk and benefit-risk evaluation of breastfeeding. Arch Toxicol. 2017;91(1):83-96.
42. Kuscu OO, Caglar E, Aslan S, Durmusoglu E, Karademir A, Sandalli N. The prevalence of molar incisor hypomineralization (MIH) in a group of children in a highly polluted urban region and a windfarm-green energy island. Int J Paediatr Dent. 2009;19(3):176-85.
43. Laisi S, Kiviranta H, Lukinmaa PL, Vartiainen T, Alaluusua S. Molar-incisor-hypomineralisation and dioxins: new findings. Eur Arch Paediatr Dent. 2008;9(4):224-7.