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

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BACKGROUND: Molar incisor hypomineralization (MIH) is a frequently encountered oral condition that varies from mild opacities to post-eruptive 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. 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. Systemic factors include prenatal and perinatal complications, low birth weight, frequent use of antibiotics, respiratory tract infections, calcium-phosphate metabolic disorders, and hypoxia. A genetic interaction with systemic and environmental factors leading to MIH is also reported.

The severity of MIH varies from mild opacities to post eruptive enamel breakdown. 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. The global prevalence of MIH varies from 2.8% to 40% depending on the population studied and diagnostic criteria used to identify MIH. A few point prevalence studies conducted in Saudi Arabia among children without special needs have reported an MIH prevalence of 8.6% to 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. Previously studies have reported a variable prevalence of developmental defects of the enamel in CSHCN, but none specifically for MIH. CSHCN are more prone to develop dental caries because of their physical, mental, neurological, or behavioral impairment. Previous studies have reported a positive association between MIH and increased caries prevalence. 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. 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 and modified to improve the validity based on a pilot interview with 25 parents (Cronbach alpha = 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. 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 = post eruptive 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, Alazzam 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.\(^{4,11,19-24}\) 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 to the age distribution of CSHCN. However, a larger sample size is required to confirm the findings.

### 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)\(a\) | 88 (55.0)\(a\) | 16 (10.0) | 7 (4.4)                          | 5 (3.1)                                    |
| 12-16 (n=240)    | 68 (28.3)\(a\) | 38 (15.8)\(a\) | 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) | 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) | 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: \(^aP<.05, ^{aP}<.001\)
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  |                          |
| 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  | .016                     |
| 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)* | .29 – .71  | 12 (50.0)  | .29 – .71  |                          |
| **Prenatal factors**             |             |            |            |            |                          |
| Yes (n=240)                      | 69 (28.7)*  | .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)*  | .15 – .26  | 153 (80.1) | .74 – .86  |                          |
| **Postnatal factors**            |             |            |            |            |                          |
| Childhood illness and history of antibiotics |             |            |            |            |                          |
| Yes (n=301)                      | 83 (27.6)*  | .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  |                          |
| 12-18 months (n=97)              | 27 (27.8)   | .19 – .38  | 70 (72.2)  | .62 – .81  | .030                     |
| >18 months (n=42)                | 17 (40.5)*  | .26 – .57  | 25 (59.5)  | .43 – .74  |                          |

Data are number (%). Pairwise comparisons (Z test) with Bonferroni correction: *P<.05. *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
to the possibility of carious lesion masking MIH among older children.\textsuperscript{5,23,24} In agreement with the previous studies,\textsuperscript{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.\textsuperscript{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,\textsuperscript{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.\textsuperscript{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.\textsuperscript{40,41} The dioxins may disturb tooth development leading to a greater risk of MIH.\textsuperscript{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\textsuperscript{10} and Kılınç et al,\textsuperscript{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.\textsuperscript{14,16,20,21,24,25} The prevalence of post eruptive enamel breakdown, atypical restoration, and tooth loss were slightly higher compared to the previous studies.\textsuperscript{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 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   |

FREQUENCY OF MIH AMONG CSHCN

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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 | 95% CI 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  | .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 R²=0.180 Cox and Snell R²=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.

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