

# “Ethnic disparities in the prevalence of Molar–Incisor–Hypomineralisation (MIH) and caries among 6–12-year-old children in Catalonia, Spain”



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## Abstract

**Background** In recent years, there has been uneven improvement in school children's oral health, highlighting inequalities in access to dental care and health outcomes, particularly among ethnic minorities. The most prevalent oral disease in childhood, caries, is preventable, as its risk factors are well known. However, MIH, a common condition affecting the enamel of permanent incisors and/or molars, has no established aetiology or preventive measures.

**Aim** To study the prevalence of MIH and caries in 6- and 12-year-old schoolchildren and their association with ethnic disparities and other relevant factors.

**Methods** A cross-sectional study among schoolchildren was conducted in 725 children from Masnou (Barcelona, 2013) and in 577 children from Sant Andreu de Llavaneres (Barcelona, 2018–2020). Data collection was carried out by means of clinical examination and a self-referenced questionnaire. Oral health outcomes included: presence of dental caries, presence of MIH, hypomineralised second primary molars (HSPM). All variables were analysed according to ethnic disparities and other variables such as socioeconomic, diet, hygiene habits, plaque and access to dental services. We performed multivariate Poisson regression models with robust variance to examine ethnic disparities in MIH and caries.

**Results** The overall prevalence of MIH and caries was 12.2% and 30.5%, respectively. The prevalence of MIH was lower in immigrants than in native children, although not statistically significant (10% vs. 12.8%,  $p=0.24$ ). The prevalence of caries was higher among immigrant than native children (40.8% vs 28.5%,  $p<0.001$ ). The multivariate analysis demonstrated that ethnicity, child's age, and plaque accumulation were associated with the prevalence of caries. No significant associations were observed for MIH. Children with HSPM were more likely to develop MIH (PR=2.6).

**Conclusions** This cross-sectional study based in Catalonia, Spain showed that there are ethnic disparities in caries as observed with other child's diseases; however, they do not seem to follow the same pattern for MIH. More studies are needed (i) to explore how MIH behaves among populations in terms of inequality; (ii) to study the aetiological factors of MIH; and (iii) to identify potential factors associated with MIH and caries that have not been studied and that may contribute to the observed ethnic disparities.

**KEYWORDS** Ethnicity, Molar–Incisor–Hypomineralisation, dental caries, children, health status disparities, public health dentistry.

## Introduction

In the recent decades, there has been a significant interest in improving children's oral health. However, not all of the hu-man population has benefited equally. There is remarkable literature documenting disparities in access to care and in oral health outcomes, mainly based on a marked social gradient [Watt et al., 2016; Van der Tas et al., 2017] and ethnic minorities [Van Der Tas et al., 2016; Rouxel and Chandola, 2018; Valdez et al., 2022]. Oral health disparities can be defined as the difference in levels of oral health that are avoidable and are considered unfair, unaccepted, and unjust. Furthermore, ethnicity can be defined as a category of people who identify with each other based on similarities, such as common language, social, cultural, or national experience. Ethnic identity as a minority condition has been defined as an important risk factor for poor oral health [Rouxel and Chandola, 2018]. A higher level of dental disease, underutilisation of dental care, and less treatment have been reported among immigrants compared to their native-born counterparts [Shi et al., 2018]. Additionally, oral health behaviours [Valdez et al., 2022], dietary habits [Dondi et al., 2020], levels of social support within the host country [Dahlan et al., 2019], racism and discrimination [Evans and Smith, 2021] try to explain this described poor oral health.

The Global Burden of Disease (GBD) study showed that the prevalence of dental caries in permanent teeth ranked first globally for prevalence among all Level 4 causes, with 2.03 billion of cases in 2019. Although risk factors of dental caries are widely known and are largely preventable, it remains the most important oral disease in childhood.

Dental caries is a disease of unequal distribution, with social disadvantages attributable to within certain ethnic groups [Ferrazzano et al., 2019; Diamanti et al., 2022] and the lower socioeconomic level [Schwendicke et al., 2015]. According to aepidemiological research carried out in Spain in the last decades, the prevalence of caries is 40–50% higher in immigrant children than in their native counterparts [Bravo Pérez et al., 2016].

Extensive evidence support that dental caries has an economic gradient [Schwendicke et al., 2015]. Children with a lower socio-economic status have a lower prevalence than their high socio-economic counterparts. Dental caries negatively affects children's oral health-related quality of life, causing disturbances such as pain, impaired speaking, eating and sleeping disruptions and poor school performance [Alsumait et al., 2015].

The situation is different for Molar-Incisor-Hypomineralisation (MIH). It currently has an unknown aetiology, it is difficult to prevent, and it does not follow the pattern of oral diseases in terms of social and ethnic disparities. MIH is a common defect in the mineralisation of one to four first permanent molars, frequently associated with affected incisors, which appears as opacities that vary in terms of severity and extent. They may be white, yellow, or brown, and can develop into post-eruptive enamel breakdown and extensive atypical caries, which may require extraction. The hypomineralised enamel substructure can also predispose patients to plaque stagnation, enamel breakdown, thermal sensitivity causing pain and discomfort, and problems with retention of restoration and a decreased oral health-related quality of life. Treatment of MIH can be complex and challenging in young patients with variable prognosis [Giuca et al, 2020]. In the last decades the prevalence of MIH increased. Currently, the overall prevalence of MIH is estimated to be 14% [Zhao et al., 2018]. While the aetiology of MIH is unclear, multifactorial factors involving genetic, epigenetic, environmental and lifestyle factors have been proposed to explain the occurrence of enamel hypomineralisation. The most important window of exposure appears to be the latter stages of amelogenesis, when the enamel matrix proteins are degraded and the matrix is mineralised. Perinatal hypoxia, prematurity, incubator, low birth weight, high fever, respiratory and gastrointestinal infections, medication [amoxicillin] and vitamin D deficiency of mother increase the risk of having MIH [Serna et al., 2016; van der Tas et al., 2018; Børsting et al., 2022; Garot et al., 2022]. Despite this evidence, none of these factors seem to explain MIH recent emergence nor its selective enamel lesions on the first mineralising permanent teeth. Recently, it has been suggested that also genetic predisposition [Hočevár et al., 2020] and the role of epigenetic factors [MJ et al., 2022] can be an important player to truly understand MIH aetiology. The objective of this study was to examine the prevalence and relationship of MIH and caries with ethnic disparities and other variables among 6–12-year-old schoolchildren, during the school year 2013 in the areas of Masnou and Sant Andreu de Llavaneres, Barcelona, Spain from 2018 to 2020.

## Materials and Methods

### Study design

This cross-sectional study was conducted in a convenience sample of 6–12-year-old schoolchildren enrolled in public elementary schools in Sant Andreu de Llavaneres (n=725, Barcelona, 2018-2020) and in Masnou (n=577, Barcelona, 2013). Sant Andreu had a population of 10,877 inhabitants, with an immigration rate of 9.30%, and Masnou had a population of 22,595 inhabitants, with an immigration rate of 8.14%. MIH and dental caries were measured among 1,302 students aged between 6 and 12 years. We excluded 9% of the total students (1,419) without informed consent from the parents. The study protocol adhered to the ethical guidelines of the 1975 Declaration of Helsinki and received approval

from the Medical Ethical Committee of IDIAP Jordi Gol (22/067-P). Confidentiality and anonymity of the data were guaranteed. Data collection was carried out by means of clinical examination and a self-reported questionnaire. An informed consent form was sent to the parents in advance. The examination took place in a conditioned room of school after the children had brushed their teeth. Access of saliva on the teeth was removed with dental cotton rolls. For the inspection, flashlights and mirrors were used by a single calibrated examiner.

The self-questionnaire was collected before the clinical examination (in a file coded with an ID code) within the framework of the annual school-based dental examinations between September and December of every year. Schoolchildren completed questions on socio-economic status (FAS), immigration, oral hygiene habits, fluoride use, dietary habits and access to dental services under parental supervision.

### MIH

The MIH-related hypomineralisation diagnoses were recorded according to the diagnostic criteria of the European Academy of Paediatric Dentistry (EAPD); demarcated opacity, post-eruptive enamel breakdown, atypical restoration, extraction due to MIH [Weerheijm et al., 2003]. In cases of demarcated opacities only being present in incisors and not in first permanent molars, these teeth were not diagnosed as being affected by MIH. The evaluation of Hypomineralized Second Primary Molars (HSPM) was also conducted.

### Dental caries

Dental caries was diagnosed following the guidelines of the WHO 4th edition. Furthermore, the DMFT index was estimated (the index of caries in permanent teeth, which is determined by the total number of permanent teeth with decay (D), missing teeth due to decay (M) and filled teeth (F)), and the restoration index (proportion of permanent filled teeth (F) compared to all decayed (D), missing (M) and filled (F) teeth).

### Ethnicity

The main independent variable is the migratory fact. However, given the lack of consensus in the definition, two categories were formulated according to the background situation of the mother regardless of the schoolchild's country of origin. 'Immigrant' was defined as the schoolchild of a mother originating from outside of the EU (excluding North America), and 'native' as the schoolchild of a mother from within the community (the EU15 and North America). The EU15 corresponds to the 15-member states of the European Union between 1995 and 2004 (France, Germany, Italy, the Netherlands, Luxembourg, Belgium, Denmark, Greece, United Kingdom, Spain, Portugal, Finland, Sweden and Austria). This criterion was chosen following the variable defined in our previous articles in order to be able to compare them.

### Other variables

In terms of the independent variables, in addition to the school year, age and gender, intermediate variables such as self-reported oral hygiene habits (derived from the criterion of the Catalan Health Survey), the use of dental floss, the consumption of sugars (grouped into 4 categories; very high, high, low and very low), adherence to the Mediterranean diet (iqdm) (derived from the criterion of the KIDMED question-

	N	%
<b>Age (years)</b>		
6 year	246	18.89
12 years	1056	81.11
Missings	0	0.00
<b>Gender</b>		
Male	680	52.23
Female	622	47.77
Missings	0	0.00
<b>Place of residence and birth</b>		
Masnou	725	55.68
Sant Andreu de Llavaneres	577	44.32
Missings	0	0.00
<b>Country of origin of mother</b>		
Catalonia	996	76.50
Spain	95	7.30
EU15	39	3.00
Central / Eastern EU	20	1.54
North America	3	0.23
Latin America	84	6.45
Middle Est	1	0.77
Rest of Asia	17	1.31
North Africa	39	3.00
Rest of Africa	8	0.61
Missings	0	0.00
<b>Ethnicity<sup>1</sup></b>		
Native	1091	83.79
Immigrant	211	16.21
Missings	0	0.00
<b>Education<sup>2</sup></b>		
Low	24	1.84
Middle	206	15.82
High	592	45.47
Missings	480	36.87
<b>Plaque build-up<sup>3</sup></b>		
Yes	967	74.27
Missings	0	0.00
<b>Tooth brushing &gt; Once per day</b>		
Yes	1210	92.93

	N	%
Missings	0	0.00
<b>Use of dental floss</b>		
Yes	188	14.44
Missings	0	0.00
<b>Diet<sup>4</sup></b>		
iqdm (>4)	1164	0.89
Missings	0	0.00
<b>Sugars<sup>5</sup></b>		
Very low	320	24.58
Low	343	26.34
Medium	336	25.81
High	303	23.27
Missings	0	0.00
<b>Dental caries</b>		
Yes	397	0.30492
DFMT index (mean. SD)	1302	0.73 (1.41)
Restoration index (mean. SD)	1298	11.44 (29.97)
<b>MIH</b>		
Yes	161	12.37
Missings	0	0.00
<b>HSPM</b>		
Yes	18	1.38
Missings	0	0.00
<b>Access to dental services</b>		
No checking	402	30.88
Public dental service	205	15.75
Private dental service	659	50.61
Both services	36	2.77
Missings	0	0.00

<sup>1</sup> According to the mother's immigration status, regardless of schoolchild's country of origin  
<sup>2</sup> According to the Family Affluence Scale  
<sup>3</sup> Derived from the modification of the Silness-Löe Index  
<sup>4</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire  
<sup>5</sup> "High", "medium", "low" and "very low" according to weekly consumption of cariogenic foods

**TABLE 1** Distribution of the different variables in schoolchildren 6-12 years of age, Maresme 2013-2020, total group (n = 1302).

naire)[Mariscal-Arcas et al., 2009], access to a dentist during the past year, and the intake of fluoride as dichotomous variable. The social class was obtained through the Family Affluence Scale (FAS), a socio-economic indicator designed to be answered by children and adolescents, with a total of 4 questions. A score on the FAS scale was calculated for each student. Plaque accumulation was clinically evaluated using the Silness-Löe Plaque Index.

### Statistical analysis

We performed descriptive univariate analyses with frequencies for categorical variables and mean and standard deviation for numerical variables. All analyses were stratified for immigrant and native. In addition, we used Chi-Squared or Exact Fisher tests to check for differences among categorical variables, while mean differences for numerical variables between the two groups were tested using Student's or U Mann-Whitney tests depending on variables distributions and

p-values are added. To determine risk factors associated with the presence of MIH and caries, Prevalence Ratios (PR) were calculated using Poisson models of regression with robust variance with their confidence intervals (CI95%) and p-values associated. The independent variables for entry in the model were all those that were significant in the bivariate analysis linking with the presence of MIH and caries. Additionally, to compare the data concerning the prevalence of MIH and caries in the Masnou (2013) with those of the Sant Andreu de Llavaneres (2018-2020), the Chi-square test was computed. All Data analysis was performed with the STATA (version 14). The level of significance that was used in the hypothesis contrasts was 5%.

## Results

### Participant characteristics

Characteristics of the study participants are shown in

	Masnou		Sant Andreu Llaveneres		p value
	n	%	n	%	
<b>Age (years)</b>					
6 years	0	0.00	246	42.63	<0.001*
12 years	725	100.00	331	57.37	
Missings	0	0.00	0	0.00	
<b>Gender</b>					
Male	371	51.17	309	53.55	0.393
Female	354	48.83	268	46.45	
Missings	0	0.00	0	0.00	
<b>Country of origin of mother</b>					
Catalonia	555	76.55	441	76.43	0.082
Spain	61	8.41	34	5.89	
EU15	15	2.07	24	4.16	
Central / Eastern EU	12	1.66	8	1.39	
North America	2	0.28	1	0.17	
Latin America	43	5.93	41	7.11	
Middle Est	0	0.00	1	0.17	
Rest of Asia	6	0.83	11	1.91	
North Africa	27	3.72	12	2.08	
Rest of Africa	4	0.55	4	0.69	
<b>Ethnicity <sup>1</sup></b>					
Native	616	84.97	475	82.32	0.199
Immigrant	109	15.03	102	17.68	
Missings	0	0.00	0	0.00	
<b>Education <sup>2</sup></b>					
Low	16	2.21	8	1.39	<0.001*
Middle	163	22.48	43	7.45	
High	532	73.38	60	10.40	
Missings	14	1.93	466	80.76	
<b>Plaque build-up <sup>3</sup></b>					
Yes	688	94.90	279	48.35	<0.001*
Missings	0	0.00	0	0.00	
<b>Tooth brushing &gt; Once per day</b>					
Yes	667	92.00	543	94.11	0.140
Missings	0	0.00	0	0.00	
<b>Use of dental floss</b>					
Yes	107	14.76	81	14.04	0.713
Missings	0	0.00	0	0.00	
<b>Diet <sup>4</sup></b>					
iqdm (>4)	626	86.35	538	93.24	<0.001*
<b>Sugars <sup>5</sup></b>					
Very low	179	24.69	141	24.44	0.613
Low	189	26.07	154	26.69	
Medium	196	27.03	140	24.26	
High	161	22.21	142	24.61	
<b>Dental caries</b>					
Yes	249	34.35	148	25.65	0.001*
<b>DFMT index (mean. SD)</b>	725	0.88 (1.60)	577	0.54 (1.09)	<0.001*
<b>Restoration index (mean. SD)</b>	721	16.34 (34.80)	577	5.31 (21.01)	<0.001*
<b>MIH</b>					
Yes	51	7.03	110	19.06	<0.001*
<b>Access to dental services</b>					
No checking	210	28.97	192	33.28	0.002*
Public dental service	135	18.62	70	12.13	
Private dental service	366	50.48	293	50.78	
Both services	14	1.93	22	3.81	
Missings	0	0.00	0	0.00	
<b>HSPM</b>					
Yes	0	0.00	559	96.88	NA

<sup>1</sup> According to the mother's immigration status, regardless of schoolchild's country of origin <sup>2</sup> According to the Family Affluence Scale <sup>3</sup> Derived from the modification of the Silness-Löe Index <sup>4</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire <sup>5</sup> "High", "medium", "low" and "very low" according to weekly consumption of cariogenic foods \* Statistically significant p\_value

**TABLE 2** Distribution of the different variables according to the place of residence of the children studied between 6-12 years of age, total group (n = 1305).

Table 1. A total of 1,367 children were examined, of whom 725 (55.6%) lived in the rural area of Masnou, Barcelona in 2013 and 577 (44.3%) in the Sant Andreu de Llaveneres area, Barcelona in 2018-2020. The age range of the children examined were between 6 and 15 years old. In total, 680 boys (52.2%) and 622 girls (47.8%) were examined. Of the total number of children, 83.8% (n= 1091) were native and 16.2% (n= 211) immigrants. The overall prevalence was 12.4% for MIH, 30.5% for caries, and the DMFT index was 0.73 ±1.4. Half of the children (50.6%) visited a private dental clinic in the last year.

Specific sample characteristics for the different years matching to place of residence is shown in Table 2. We observed significant differences in several variables of study (Table 2). Therefore, all models of the study were adjusted by place of residence to account for differences between the two areas. Table 3 shows the distribution of general population stratified by the ethnicity. The two ethnic groups were not different regarding gender, place of residence and age distribution, but show significant difference in prevalence of caries, DFMT and accessibility to dental services.

### Immigration and MIH and caries

Overall, the prevalence of MIH was lower in immigrants (9.9%) than in native participants (12.8%) although this difference was not significant (p=0.245) (Table 3). None of the other variables studied was significantly associated with the prevalence of MIH by ethnicity group (Table 4).

Among immigrant children, there was a higher prevalence of caries (40.76% vs 28.51%, p<0.001) and a greater DFMT index (1.16±1.9 vs 0.64±1.3, p<0.001) compared to native children (Table 3). Significant differences were observed in the Masnou schoolchildren population, specifically in male sex, average socioeconomic level, poor oral hygiene, high sugar intake, and lack of dental check-ups (Table 5). Sample distribution of MIH and dental caries according to ethnic disparities variables stratified by place of residence are shown in Tables 5 and 6.

### Risk factors of MIH and caries

A Poisson regression analysis with multivariate robust variance was conducted to establish which variables are associated with a lower or greater risk of MIH and caries (Tables 7 and 8). In the case of MIH, no significant associations to ethnic inequalities were observed in a total group (Table 7). We only note in schoolchildren of Llaveneres (Table 9) that suffering from HSPM had a Prevalence Ratio (PR) of 2.44 (CI 95% CI= 1.41-4.20, p=0.001) for having MIH as well. In the case of caries (Table 8), the risk of caries increased in immigrant schoolchildren (PR = 1.43, CI 95% = 1.19-1.72, p<0.001). We observed that age and having plaque also increases caries risk (PR = 4.15, 95% CI =2.67-6.44, p<0.001) and (PR = 1.27, 95% CI =1.00-1.62, p=0.047).

### Comparison of MIH data from 2013 to 2018/2020

When assessing the differences of factors influencing MIH between the cohort analysed in 2013 and the cohort analysed 2018-2020, we observed some significant differences. In the 2018-2020 cohort we observed that schoolchildren tended to have a higher prevalence of MIH (19.1% vs 7%, p<0.001), less caries (25.6% vs 34.3%, p<0.001), lower CAOD (0.54 vs 0.88, p<0.001), and a

better diet with an adherence to the Mediterranean diet (93.2% vs 86.3%,  $p < 0.001$ ), than in the 2013 analysis (Table 2).

## Discussion

The results of this study show that ethnic disparities in childhood caries are present in our study population. The immigrant population in our sample tended to have higher caries rates compared to native populations (40.4% versus 28.7%,  $p = 0.001$ ). Several studies [Bastos et al., 2018; Mock-Muñoz de Luna et al., 2019; Bastos et al., 2020; Valdez et al., 2022] have supported the association between ethnicity and oral health outcomes and ethnicity and caries of children [Guarnizo-Herreño and Wehby, 2012; Mock-Muñoz de Luna et al., 2019], despite differences in the determination of ethnic background. In our case, the definition has been based on previous Catalan oral health surveys and studies of our territory, in order to be able to compare results.

In the case of MIH, although a significant ethnic association is not observed, we see a trend towards higher MIH prevalence (12.8%) among natives compared to immigrants (9.95%). However, in both models this association is not significant. Nonetheless, a distinction was observed when comparing the cohort collected in 2013 with the cohort collected in 2018, where the former indicated that ethnicity acted as a stronger, though not significant, protective factor in relation to MIH. To date, exploration of the impact of ethnicity on MIH has been limited [Elfrink et al., 2014], making this study one of the few to assess this association.

Socioeconomic factors are also strong determinants of caries, as documented in the international literature [Schwendicke et al., 2015]. Our study does not show the socioeconomic variable because in the data collected in 2018-2020, there are 80.8% of missing's, due to parents' refusal to answer this questionnaire. Regarding the risk factors associated with the MIH, we observed that children with HSPM have a 2.6 times higher change of developing MIH. Several studies supported this interrelation [Negre-Barber et al., 2016; Garot et al., 2018]. Other systematic review and meta-analysis [Costa et al., 2017] have evaluated the association between developmental defects of enamel [DDE] and dental caries, and found that children with DDE have a higher prevalence of dental caries. The MIH prevalence data of the present study (7% in 2013, 19% in 2018, and 12.2% overall prevalence) were comparable with the results of other MIH prevalence studies [Zhao et al., 2018].

We know that certain behaviours are important risk factors for caries [Shqair et al., 2022]. The results of our study show that there were significant ethnic disparities for caries in plaque accumulation, age, gender, sugar intake and accessibility to regular dental check-ups. These results have already been described in literature on inequalities in oral health [Van Meijeren-van Lunteren et al., 2019]. Still, it is interesting to note that in our study, after adjusting for these behaviours, ethnic disparities in caries remain. These results suggest that there are other social, genetics and environmental determinants that may be driving ethnic disparities in caries that are not accounted for in our study or other studies. Maternal health, age, marital status, neighbourhood safety, social capital, and residence status are factors associated with racial disparities in children's dental health [Guarnizo-Herreño and Wehby, 2012]. Additionally, psychosocial factors such as 'self-efficacy', 'intention', 'social influences', 'coping planning', and

'action planning' have been linked to higher brushing frequency [Scheerman et al., 2016]. The variable 'sense of coherence' [SOC] has also been identified as a risk factor influencing hygienic and dietary habits, including toothbrushing frequency and dentist seeking. Notably, higher SOC levels in mothers correlate with improved preventive oral health practices for their children [Elyasi et al., 2015]. Social support for immigration has also been shown to play an important role in improving their oral health outcomes [Dahlan et al., 2019]. Lastly, current research is examining the impact of racism and race as potential risk factors for oral health outcomes [Evans and Smith, 2021].

Therefore, the literature indicates the need to develop research on other social, biological, economic, cultural, and environmental factors affecting oral health that are not being taken into consideration in order to reduce ethnic inequalities. In the case of MIH, many studies suggest that environmental factors and behaviours during the pregnancy and epigenetic modulation are important in the aetiology of enamel defects [Kühnisch et al., 2021; MJ et al., 2022].

The results of this study also show that ethnic disparities in the accessibility of oral care were present in our population. These disparities are widely described in the literature. A significant percentage of immigrant children with cavities have not had access to annual dental check-ups (6.9% natives vs. 14.69% immigrants). A recent study assess the determinants of health associated with low accessibility [Klein and Von Dem Knesebeck, 2018]. The association between social support and utilization of dental care with oral health has been one of the most addressed factors among recent studies [Dahlan et al., 2019]. Our study also has some limitations. First, these data are cross-sectional, so no conclusions can be drawn about the causal relationship. Second, another limitation of our study is the sample size, which was limited in the MIH analysis. The sample size is usually calculated before the study to identify the minimum sample size to reject the null hypothesis power and statistical significance. However, in our study, the database collected for the analysis of caries inequalities from a previous study was reused and there was no predetermined hypothesis for the MIH, this study being exploratory in nature. Thirdly, we know that the EAPD recommends 5 years-old for the diagnosis of HSPM and 8 years-old for the diagnosis of MIH since the first permanent molars and most of the permanent incisors have already erupted. Our study is a secondary analysis of data collected for another purpose and annual school reviews of the 6-7 and 12-15-year cohorts were performed. Likewise, the intra-examiner reproducibility was also not assessed, although the adoption of EAPD calibration training for MIH seems to be recommended. Despite these limitations, our results still give strong indication on the differences in the prevalence of MIH and caries between native and immigrant populations. One of the strengths of the study is its novelty: we are not aware of any other published study that evaluates ethnic disparities in the two childhood dental diseases that are of most concern in dental public health; caries because of its prevalence, and MIH because it is increasingly common and of unknown cause.

## Conclusions

This cross-sectional study based on the Catalan child population showed that there are ethnic disparities in caries, and that there may be ethnic disparities in MIH, with a distinct pattern from most of the childhood diseases. More research is needed to explore

	Native		Immigrants		p value*
	N	%	N	%	
<b>Age (years)</b>					
6 year	203	18.61	43	20,38	0,547
12 years	888	81.39	168	79,62	
Missings	0	0.00	0	0,00	
<b>Gender</b>					
Male	578	52.98	102	48,34	0,217
Female	513	47.02	109	51.66	
Missings	0	0.00	0	0.00	
<b>Place of residence and birth</b>					
Masnou	616	56.46	109	51.66	<0.001 *
Sant Andreu de Llavaneres	475	48.34	102	47.34	
<b>Country of origin of mother</b>					
Catalonia	996	91.29	0	0.00	NA
Spain	95	8.71	0	0.00	
EU15	0	0.00	39	18.48	
Central / Eastern EU	0	0.00	20	9.48	
North America	0	0.00	3	1.42	
Latin America	0	0.00	84	39.81	
Middle Est	0	0.00	1	0.47	
Rest of Asia	0	0.00	17	8.06	
North Africa	0	0.00	39	18.48	
Rest of Africa	0	0.00	8	3.79	
Missings	0	0.00	0	0.00	
<b>Education<sup>1</sup></b>					
Low	10	0.92	14	6.64	<0.001 *
Middle	154	14.12	52	24.65	
High	536	49.13	56	26.54	
Missings	391	35.84	89	42.18	
<b>Plaque build-up<sup>2</sup></b>					
Yes	804	73.69	163	77.25	0.279
Missings	0	0.00	0	0.00	
<b>Tooth brushing &gt; Once per day</b>					
Yes	1007	92.30	203	96.21	0.043
Missings	0	0.00	0	0.00	
<b>Use of dental floss</b>					
Yes	147	13.47	41	19.43	0.024
Missings	0	0.00	0	0.00	
<b>Diet<sup>3</sup></b>					
iqdm (>4)	982	90.01	182	86.26	0.105
<b>Sugars<sup>4</sup></b>					
Very low	272	24.93	48	22.75	0.397
Low	294	26.95	49	23.22	
Medium	273	25.02	63	29.86	
High	252	23.10	51	24.17	
<b>Dental caries</b>					
Yes	311	28.51	86	40.76	<0.001 *

<b>DFMT index (mean. SD)</b>	1091	0.64 (1.28)	211	1.16 (1.88)	<0.001*
<b>Restoration index (mean. SD)</b>	1088	11.65 (30.45)	210	10.31 (27.39)	0.055
<b>MIH</b>					
Yes	140	12.83	21	9.95	0.245
<b>Access to dental services</b>					
No checking	329	30.16	73	34.60	<0.001*
Public dental service	155	14.21	50	23.70	
Private dental service	577	52.89	82	38.86	
Both services	30	2.75	6	2.84	
Missings	0	0.00	0	0.00	
<b>HSPM</b>					
Yes	460	42.16	99	46.92	0.909
<sup>1</sup> According to the Family Affluence Scale					
<sup>2</sup> Derived from the modification of the Silness-Löe Index					
<sup>3</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire					
<sup>4</sup> "High", "medium", "low" and "very low" according to weekly consumption of cariogenic foods.					
* Statistically significant p_value					

**TABLE 3** Distribution of the different variables according to ethnic disparities of the children studied between 6-12 years of age, total group (n = 1305).

	MIH			Dental caries		
	Native	Immigrant	p-value	Native	Immigrant	p-value
<b>Age (years), n (%)</b>						
6 years	38 (8.00%)	6 (5.88%)	0.459	16 (3.37%)	5 (4.90%)	0.425
12 years	54 (11.37%)	12 (11.76%)	0.932	105 (22.11%)	22 (21.57%)	0.851
<b>Gender, n (%)</b>						
Male	47 (9.89%)	11 (10.78%)	0.575	58 (12.21%)	16 (15.69%)	0.174
Female	45 (9.47%)	7 (6.86%)	0.255	63 (13.26%)	11 (10.78%)	0.283
<b>Hygiene, n (%)</b>						
Plaque build-up <sup>3</sup>	44 (9.26%)	11 (10.78%)	0.762	65 (13.68%)	18 (17.65%)	0.962
Tooth brushing > Once per day	87 (18.32%)	17 (16.67%)	0.545	113 (23.79%)	27 (26.47%)	0.758
Use of dental floss	13 (2.74%)	6 (5.88%)	0.262	20 (4.21%)	7 (6.86%)	0.571
<b>Diet, n (%)</b>						
iqdm <sup>4</sup>	87 (18.32%)	15 (14.71%)	0.414	116 (24.42%)	25 (24.51%)	0.925
<b>Sugars, n (%)</b>						
Very low	16 (3.37%)	4 (3.92%)	0.756	23 (4.84%)	7 (6.86%)	0.925
Low	31 (6.53%)	7 (6.86%)	0.965	32 (6.74%)	6 (5.88%)	0.660
Medium	21 (4.42%)	5 (4.90%)	0.924	30 (6.32%)	6 (5.88%)	0.733
High	24 (5.05%)	2 (1.96%)	0.524	36 (7.58%)	8 (7.84%)	0.081
<b>Access to dental services, n (%)</b>						
No checking	30 (6.32%)	5 (4.90%)	0.881	27 (5.68%)	5 (4.90%)	0.928
Public dental service	9 (1.89%)	3 (2.94%)	0.950	20 (4.21%)	6 (5.88%)	0.698
Private dental service	50 (10.53%)	10 (9.80%)	0.806	70 (14.74%)	15 (14.71%)	0.977
Both services	3 (0.63%)	0 (0.00%)	1.000	4 (0.84%)	1 (0.98%)	0.637
HSPM	86 (18.11%)	16 (15.69%)	0.554	121 (25.47%)	27 (26.47%)	0.843
Yes	6 (1.26%)	2 (1.96%)	0.396	0 (0.00%)	0 (0.00%)	–

<sup>1</sup> According to the Family Affluence Scale

<sup>2</sup> Derived from the modification of the Silness-Löe Index

<sup>3</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire

<sup>4</sup> "High" or "medium" or "low" or "very low" according to weekly consumption of cariogenic foods

\* Statistically significant p\_value

**TABLE 4** Sample distribution of MIH and dental caries according to ethnic disparities and other variables in schoolchildren 6-12 years of age, Maresme 2013-2020, total group (n = 1302).

	MIH			Dental caries		
	Native	Immigrant	p-value	Native	Immigrant	p-value
<b>Age (years). n (%)</b>						
6 year	0 (0.00%)	0 (0.00%)	.	0 (0.00%)	0 (0.00%)	.
12 years	48 (7.79%)	3 (2.75%)	0.058	190 (30.84%)	59 (54.13%)	<0.001*
<b>Gender. n (%)</b>						
Male	22 (3.57%)	1 (0.92%)	0.177	93 (15.10%)	29 (26.61%)	<0.001*
Female	26 (4.22%)	2 (1.83%)	0.169	97 (15.75%)	30 (27.52%)	0.006
<b>Education. n (%)<sup>1</sup></b>						
Low	0 (0.00%)	0 (0.00%)	.	5 (0.81%)	9 (8.26%)	0.696
Middle	9 (1.46%)	0 (0.00%)	0.064	35 (5.68%)	29 (26.61%)	<0.001*
High	38 (6.17%)	3 (2.75%)	0.786	148 (24.03%)	19 (17.43%)	0.290
<b>Hygiene. n (%)<sup>2</sup></b>						
Plaque build-up	45 (7.31%)	3 (2.75%)	0.079	188 (30.52%)	57 (52.29%)	<0.001*
Tooth brushing > Once per day	44 (7.14%)	3 (2.75%)	0.075	174 (28.25%)	54 (49.54%)	<0.001*
Use of dental floss	8 (1.30%)	0 (0.00%)	0.124	21 (3.41%)	8 (7.34%)	0.350
<b>Diet. n (%)<sup>3</sup></b>						
iqdm	42 (6.82%)	3 (2.75%)	0.139	160 (25.97%)	47 (43.12%)	<0.001*
<b>Sugars. n (%)<sup>4</sup></b>						
Very low	10 (1.62%)	0 (0.00%)	0.308	44 (7.14%)	9 (8.26%)	0.014
Low	15 (2.44%)	0 (0.00%)	0.154	59 (9.58%)	12 (11.01%)	0.049
Medium	12 (1.95%)	2 (1.83%)	0.649	46 (7.47%)	15 (13.76%)	0.170
High	11 (1.79%)	1 (0.92%)	0.242	41 (6.66%)	23 (21.10%)	<0.001*
<b>Access to dental services. n (%)</b>						
No checking	10 (1.62%)	1 (0.92%)	0.321	48 (7.79%)	26 (23.85%)	<0.001*
Public dental service	8 (1.30%)	1 (0.92%)	0.358	30 (4.87%)	18 (16.51%)	0.005
Private dental service	29 (4.71%)	1 (0.92%)	0.311	108 (17.53%)	13 (11.93%)	0.212
Both services	1 (0.16%)	0 (0.00%)	1.000	4 (0.65%)	2 (1.83%)	0.347

<sup>1</sup> According to the Family Affluence Scale

<sup>2</sup> Derived from the modification of the Silness-Löe Index

<sup>3</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire

<sup>4</sup> "High" or "medium" or "low" or "very low" according to weekly consumption of cariogenic foods

\* Statistically significant p\_value

**TABLE 5** Sample distribution of MIH and dental caries according to ethnic disparities and other variables in schoolchildren 12 years of Masnou, Maresme 2013 (n=725).

possible factors associated with caries that have not been studied and that may contribute to disparities and, more prospective studies are warranted assessing risk factors for MIH.

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### Credit authorship contribution statement

Ester Cots: Investigation, Data curation, Methodology, Formal analysis, Writing original draft. Maribel Casas: Writing, review & editing. Maria Gregoriano: Investigation. Xavier Busquet-Duran: Writing, review & editing. Jofre Bielsa: writing-review & editing. Carla Chacon: writing-review & editing. Lea Kragt: Writing-review & editing. Pere Torán: Writing-review & editing, Conceptualisation, Resources, Supervision, Funding acquisition. Francisco Guinot: Writing-review & editing, Conceptualisation, Resources, Supervision, Funding acquisition.



	MIH			Dental caries		
	Native	Immigrant	p-value	Native	Immigrant	p-value
<b>Age (years), n (%)</b>						
6 year	38 (8.00%)	6 (5.88%)	0.459	16 (3.37%)	5 (4.90%)	0.425
12 years	54 (11.37%)	12 (11.76%)	0.932	105 (22.11%)	22 (21.57%)	0.851
<b>Gender, n (%)</b>						
Male	47 (9.89%)	11 (10.78%)	0.575	58 (12.21%)	16 (15.69%)	0.174
Female	45 (9.47%)	7 (6.86%)	0.255	63 (13.26%)	11 (10.78%)	0.283
<b>Hygiene, n (%)</b>						
Plaque build-up <sup>1</sup>	44 (9.26%)	11 (10.78%)	0.762	65 (13.68%)	18 (17.65%)	0.962
Tooth brushing > Once per day	87 (18.32%)	17 (16.67%)	0.545	113 (23.79%)	27 (26.47%)	0.758
Use of dental floss	13 (2.74%)	6 (5.88%)	0.262	20 (4.21%)	7 (6.86%)	0.571
<b>Diet, n (%)</b>						
iqdm <sup>2</sup>	87 (18.32%)	15 (14.71%)	0.414	116 (24.42%)	25 (24.51%)	0.925
<b>Sugars, n (%)<sup>3</sup></b>						
Very low	16 (3.37%)	4 (3.92%)	0.756	23 (4.84%)	7 (6.86%)	0.925
Low	31 (6.53%)	7 (6.86%)	0.965	32 (6.74%)	6 (5.88%)	0.660
Medium	21 (4.42%)	5 (4.90%)	0.924	30 (6.32%)	6 (5.88%)	0.733
High	24 (5.05%)	2 (1.96%)	0.524	36 (7.58%)	8 (7.84%)	0.081
<b>Access to dental services, n (%)</b>						
No checking	30 (6.32%)	5 (4.90%)	0.881	27 (5.68%)	5 (4.90%)	0.928
Public dental service	9 (1.89%)	3 (2.94%)	0.950	20 (4.21%)	6 (5.88%)	0.698
Private dental service	50 (10.53%)	10 (9.80%)	0.806	70 (14.74%)	15 (14.71%)	0.977
Both services	3 (0.63%)	0 (0.00%)	1.000	4 (0.84%)	1 (0.98%)	0.637
<b>HSPM</b>						
Yes	86 (18.11%)	16 (15.69%)	0.554	121 (25.47%)	27 (26.47%)	0.843
	6 (1.26%)	2 (1.96%)	0.396	0 (0.00%)	0 (0.00%)	–

<sup>1</sup> Derived from the modification of the Silness-Löe Index

<sup>2</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire

<sup>3</sup> "High" or "medium" or "low" or "very low" according to weekly consumption of cariogenic foods

**TABLE 6** Sample distribution of MIH and dental caries according to ethnic disparities and socioeconomic variables in schoolchildren 6-12 years of Sant Andreu de Llavaneres. Maresme 2018-2020 (n=577).

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	Prc	CI95%	p value	PRadja	CI95%	p value
<b>Place of residence and birth</b>						
Masnou	1.00			1.00		
Sant Andreu de Llavaneres	2.71	(1.98 - 3.71)	<0.001*	2.86	(1.99 - 4.13)	<0.001*
<b>Ethnicity<sup>1</sup></b>						
Native	1.00					
Immigrant	0.78	(0.50 - 1.20)	0.252			
<b>Age (years)</b>						
6 years	1.00			1.00		
12 years	0.62	(0.45 - 0.85)	0.003*	1.11	(0.78 - 1.57)	0.562
<b>Gender</b>						
Male	1.00					
Female	1.08	(0.81 - 1.44)	0.603			
<b>Hygiene habits</b>						
<b>Plaque build-up<sup>2</sup></b>						
No	1.00			1.00		
Yes	0.62	(0.46 - 0.83)	0.001*	1.03	(0.74 - 1.43)	0.866
<b>Tooth brushing &gt; Once per day</b>						
Yes	1.00					
No	0.87	(0.48 - 1.59)	0.654			
<b>Use of dental floss</b>						
Yes	1.00					
No	0.84	(0.57 - 1.23)	0.365			
<b>Diet<sup>3</sup></b>						
<b>iqdm</b>						
>4	1.00					
<4	0.80	(0.48 - 1.35)	0.408			
<b>Sugars<sup>4</sup></b>						
Very low	1.00					
Low	1.65	(1.08 - 2.51)	0.020			
Medium	1.27	(0.81 - 1.99)	0.296			
High	1.34	(0.85 - 2.10)	0.207			
<b>Dental services</b>						
No	1.00					
Yes	0.90	(0.65 - 1.23)	0.501			

<sup>1</sup> According to the mother's immigration status, regardless of schoolchild's country of origin

<sup>2</sup> Derived from the modification of the Silness-Löe Index

<sup>3</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire

<sup>4</sup> "High", "medium", "low" and "very low" according to weekly consumption of cariogenic foods

\* Statistically significant p\_value

<sup>a</sup> Note: Variables with a p-trend value<0.20 are included

**TABLE 7** Ethnic, socioeconomic and dental variables associated with presence MIH in schoolchildren 6-12 years of age, Maresme 2013-2020, total group (n = 1302).

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	PRc	CI95%	p value	PRadj*	CI95%	p value
<b>Place of residence and birth</b>						
Masnou	1.00			1.00		
Sant Andreu de Llavaneres	0.75	(0.63 - 0.89)	0.001*	1.18	(0.97 - 1.42)	0.090
<b>Ethnicity</b>						
Native	1.00			1.00		
Immigrant	1.43	(1.18 - 1.73)	<0.001*	1.43	(1.19 - 1.72)	<0.001*
<b>Age (years)</b>						
6 years	1.00			1.00		
12 years	4.17	(2.75 - 6.33)	<0.001*	4.15	(2.67 - 6.44)	<0.001*
<b>Gender</b>						
Male	1.00			1.00		
Female	1.12	(0.95 - 1.32)	0.172*	1.15	(0.98 - 1.35)	0.088
<b>Hygiene habits</b>						
<b>Plaque build-up</b>						
No	1.00			1.00		
Yes	1.65	(1.31 - 2.07)	<0.001*	1.27	(1.00 - 1.62)	0.047*
<b>Tooth brushing &gt; Once per day</b>						
Yes	1.00					
No	1.04	(0.76 - 1.42)	0.823			
<b>Use of dental floss</b>						
Yes	1.00					
No	1.03	(0.81 - 1.30)	0.821			
<b>Diet</b>						
<b>iqdm</b>						
>4	1.00			1.00		
<4	1.19	(0.93 - 1.51)	0.163*	1.10	(0.87 - 1.39)	0.410
<b>Sugars</b>						
Very low	1.00			1.00		
Low	1.23	(0.96 - 1.56)	0.099*	1.20	(0.95 - 1.52)	0.127
Medium	1.11	(0.87 - 1.43)	0.401	1.01	(0.79 - 1.28)	0.963
High	1.37	(1.08 - 1.75)	0.009*	1.23	(0.98 - 1.55)	0.074
<b>Dental services</b>						
No	1.00			1.00		
Yes	0.82	(0.68 - 0.98)	0.034*	0.89	(0.74 - 1.06)	0.20
<b>MIH</b>						
No	1.00					
Yes	1.09	(0.86 - 1.38)	0.468			

<sup>1</sup> According to the mother's immigration status, regardless of schoolchild's country of origin

<sup>2</sup> Derived from the modification of the Silness-Löe Index

<sup>3</sup> According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire

<sup>4</sup> "High", "medium", "low" and "very low" according to weekly consumption of cariogenic foods

\* Statistically significant p\_value

<sup>o</sup> Note: Variables with a p-trend value < 0.20 are included

**TABLE 8** Ethnic, socioeconomic and dental variables associated with presence of caries in schoolchildren 6-12 years of age, Maresme 2013-2020, total group (n = 1302).

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	Prc	CI95%	p value	PRadja	CI95%	p value
<b>Ethnicity<sup>1</sup></b>						
Native	1,00					
Immigrant	0,91	(0.58 - 1.44)	0.690			
<b>Age (years)</b>						
6 years	1,00					
12 years	1,11	(0.79 - 1.57)	0.536			
<b>Gender</b>						
Male	1,00					
Female	1,03	(0.74 - 1.45)	0.847			
<b>Hygiene habits</b>						
<b>Plaque build-up<sup>2</sup></b>						
No	1,00					
Yes	1,07	(0.76 - 1.50)	0.701			
<b>Tooth brushing &gt; Once per day</b>						
Yes	1,00					
No	0,92	(0.44 - 1.94)	0.830			
<b>Use of dental floss</b>						
Yes	1,00					
No	0,78	(0.51 - 1.21)	0.269			
<b>Diet<sup>3</sup></b>						
iqdm						
>4	1,00					
<4	1,08	(0.57 - 2.06)	0.810			
<b>Sugars<sup>4</sup></b>						
Very low	1,00					
Low	1,74	(1.06 - 2.84)	0.027			
Medium	1,31	(0.77 - 2.23)	0.323			
High	1,29	(0.76 - 2.20)	0.349			
<b>Dental services</b>						
No	1,00					
Yes	0,94	(0.65 - 1.34)	0.719			
<b>HSPM</b>						
No	1,00			1,00		
Yes	2,44	(1.41 - 4.20)	0.001*	2,44	(1.41 - 4.20)	0.001*

<sup>1</sup>According to the mother's immigration status, regardless of schoolchild's country of origin

<sup>2</sup>Derived from the modification of the Silness-Löe Index

<sup>3</sup>According to the index of adherence to a Mediterranean diet derived from the criterion of the KIDMED questionnaire

<sup>4</sup>"High", "medium", "low" and "very low" according to weekly consumption of cariogenic foods

\*Statistically significant p\_value a Note: Variables with a p-trend value<0.20 are included

**TABLE 9** Ethnic, socioeconomic and dental variables associated with presence of MIH in schoolchildren 6-12 years of Sant Andreu de Llavaneres, Maresme 2018-2020 (n=577).

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