





# Risk factors associated with occlusal caries in first permanent molars in a school program: longitudinal study

Bianca Mattos dos Santos Guerra<sup>1</sup> , Patrícia Papoula Gorni dos Reis<sup>1,2</sup> , Roberta Costa Jorge<sup>1,2</sup> , Vera Mendes Soviero<sup>1,2\*</sup> 

<sup>1</sup> Department of Preventive and Community Dentistry, State University of Rio de Janeiro (UERJ), RJ, Brazil.

<sup>2</sup> School of Dentistry, University Center Arthur Sá Earp Neto (UNIFASE), Petrópolis, RJ, Brazil.

## Corresponding author:

Vera Mendes Soviero  
Department of Preventive and Community Dentistry, State University of Rio de Janeiro (UERJ), RJ, Brazil  
School of Dentistry, Arthur Sá Earp Neto University (UNIFASE), Petrópolis, RJ, Brazil  
verasoviero@gmail.com;  
vera.soviero@uerj.br

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**Aim:** Evaluate the longitudinal status of dental caries in the occlusal surface of first permanent molars (FPM) and to identify risk factors for the progression to cavitated caries lesions in a school oral health program. **Methods:** Children who were enrolled in the program between September 2017 and October 2019, 5 to 10 years-old, presenting the four FPM were included. Four calibrated examiners assessed dental caries according to Nyvad criteria. Descriptive analysis included frequency, mean, and standard deviation calculations. Chi-square test was used in the bivariate analysis and, logistic regression adjusted for cluster effect was used to identify significant risk factors for cavity among the following independent variables: gender, age in the baseline, deft, upper/lower molar, initial caries score, Molar Incisor Hypomineralization (MIH), fluorosis, occlusal sealing. Odds ratio (OR) and respective confidence intervals (CI) are presented. **Results:** From 174 children enrolled in the program between 2017/2019, 120 were reevaluated in 2022. Eleven (2.6%) FPM in 11 children (9.2%) presented cavitated caries in the follow up examination. Significant risk factors for cavity were caries experience in the primary teeth (OR = 5.59; CI: 1.4 – 22.3) and the presence of MIH (OR = 5.33; CI: 1.6 – 18.1). Most of the active lesions in the follow up were considered active in the baseline examination. **Conclusions:** The progression to cavity was relatively low, significantly influenced by past caries experience and MIH.

**Keywords:** Dental caries. Molar. Molar hypomineralization.



## Introduction

Dental caries is the result of an imbalance in the process of demineralization and remineralization of dental hard tissues, leading to progressive mineral loss of these structures. The cavitated carious lesion is the advanced clinical sign of a chronic greater mineral loss than gain influenced by the constant pH decrease in the dental biofilm accumulated on the tooth surface<sup>1,2</sup>. This process is influenced by factors that interfere both directly and indirectly in the biofilm/tooth relationship. Among the directly related factors, the consumption of sucrose, the quality and quantity of saliva, the composition of the biofilm, the frequency of contact with fluoridated products and the frequency and quality of toothbrushing stand out. Regarding indirect factors, we can mention the socioeconomic condition, educational level, knowledge, among others, which result in attitudes and behaviors that can be more or less favorable to health<sup>3</sup>.

According to the World Health Organization, more than a third of the world's population live with untreated dental caries. The estimated global prevalence of caries in the primary dentition is 43% and in the permanent dentition is 29%<sup>4</sup>. From the 1970s onwards, a significant reduction in caries rates in permanent teeth began to be observed in developed countries. In addition to the reduction in prevalence and rates of caries, epidemiological studies have shown a process of polarization of the disease, showing that high rates of caries have become concentrated in population groups with low socioeconomic status<sup>5</sup>. According to data from the last national oral health survey carried out in Brazil, 53.4% of 5-year-old children experience caries in the primary dentition, with a dmft of 2.43. In the 12-year-old children age group, 56.5% had at least one permanent tooth affected by caries, with a DMFT of 2.07. Both dmft and DMFT scores were mainly composed of teeth with untreated carious lesions. Although the prevalence of caries is still considered high, a decline in DMFT values has been observed in Brazil in recent decades, attributed mainly to access to fluoridated water and toothpaste and the implementation of collective oral health programs. At 12 years of age, the mean DMFT has decreased from 6.7 in 1986 to 2.78 in 2003 and 2.07 in 2010<sup>6</sup>.

Analysis of the distribution of carious lesions in the dentition indicate that the occlusal surfaces of the first permanent molars (FPM), followed by the second permanent molars, are the sites most frequently affected by caries<sup>7</sup>. FPM are the first permanent teeth to erupt in the oral cavity and the initial period after eruption is at greater risk of developing a carious lesion. The absence of masticatory contact during eruption and the anatomy of FPM are factors that favor the accumulation of dental biofilm on the occlusal surface and, consequently, the development of carious lesions<sup>3,7-11</sup>. The period of eruption of FPM, comprised between the moment of gingival breakup until functional occlusion, can vary from 5 to 32 months<sup>12</sup>. Theoretically, FPM that take longer to reach functional occlusion will remain for a longer time at risk of developing a carious lesion by favoring biofilm stagnation. The situation can be aggravated if risk factors that contribute to increase the cariogenic potential of the biofilm or to reduce the resistance of the dental enamel are present<sup>7</sup>. Studies evaluating the caries risk in FPM are rather scarce in the literature. Moreover, few

studies assessed potential risk factors for caries development and progression in FPM longitudinally.

The aim of this study was to evaluate the factors associated with the occurrence of dentin caries on the occlusal surface of FPM in a school program of atraumatic restorative treatment.

## Materials and Methods

### Type of study, location and ethical aspects

This is a longitudinal study, carried out at public elementary school, located in Petrópolis, RJ. The school has an atraumatic restorative treatment program and children and adolescents are treated at the school, in a room adapted with dental materials and school desks that are used for dental care. The study was approved by the Research Ethics Committee of the Pedro Ernesto University Hospital (n° 450.138), parents signed an informed consent and children agreed to participate in the study.

### Sample

Children who entered the program, between September 2017 and October 2019, aged between 5 and 10 years old, presenting the four erupted FPM were considered eligible for the study. Exclusion criteria were the presence of FPM with cavitated caries in the initial examination, treated outside the school program and FPM with orthodontic band.

### Data collection

The Nyvad et al. (1999)<sup>13</sup> was used to detect and classify carious lesions at the level of the tooth surface. In the initial examination, the children were evaluated by two examiners calibrated by an experienced pediatric dentist. In April 2022, a new examination was carried out by two other examiners also calibrated by the same experienced pediatric dentist. In addition to testing for dental caries, the criteria by Ghanim et al. (2017)<sup>14</sup> was used to assess FPM for the presence of demarcated opacities (compatible with a diagnosis of MIH) and diffuse opacities (compatible with a diagnosis of fluorosis).

The examinations were performed at the school with the child lying on a table and the dentist positioned behind the patient's head, under the light of a headlamp. Prophylaxis was performed with a toothbrush, fluoride toothpaste and dental floss, relative isolation and drying of the teeth with a cotton roll and inspection with an explored probe n° 5 and a mouth mirror.

The dependent variable was occlusal dentin caries in FPM represented by a cavitated carious lesion exposing dentin. As potential risk factors, individual and tooth aspects were considered. In relation to the individual, it was considered: dmft in the initial examination, age, and gender. Regarding FPM, the following were considered: initial occlusal caries score, enamel hypomineralization compatible with MIH, diffuse opacity compatible with fluorosis, sealing of pits/fissures, and upper or lower FPM.

## Training and Calibration

Training was carried out prior to the two data collections and followed the same steps, consisting of reading and discussion of the criteria established for each dental caries score<sup>13</sup> and enamel development defects<sup>14</sup> followed by examination and discussion of the scores assigned to a group of patients among which there were patients who had carious lesions at different stages of progression and activity, MIH and fluorosis. The inter- and intra-examiner agreement was evaluated using the Kappa coefficient based on the data from the examination and reexamination of 20 patients, carried out independently, for dental caries, and of a set of photographs, for MIH and fluorosis, with an interval of one month. The inter- and intra-examiner kappa coefficient values for each of the examiners regarding dental caries and enamel defects (MIH and fluorosis) were equal or greater than 0.80, ranging from 0.80 to 0.86 for caries and from 0.82 to 0.89 for enamel defects.

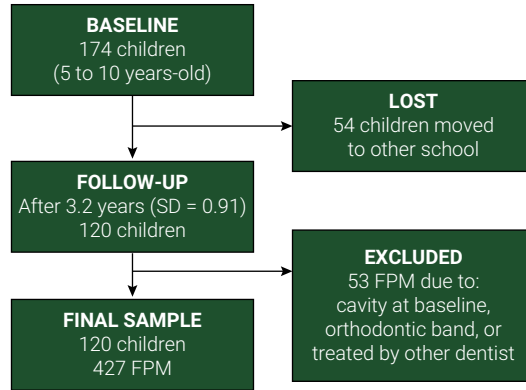
## Statistical analysis

Data were stored in an Excel spreadsheet (Microsoft Excel, version 16.6) and analyzed in SPSS (IBM Corp. version 25). The initial descriptive analysis was based on calculating percentage frequencies for categorical variables and calculating the mean and standard deviation for numerical variables. Age at initial examination was classified into two categories: 5 to 7 years and 8 to 10 years. Nyvad criteria scores were grouped to represent caries experience in the primary dentition as dmft and was analyzed as a continuous numeric variable and as a categorical variable using the following cut-off points: dmft = 0; dmft  $\geq$  1; and dmft  $\geq$  3. From the bivariate analysis of association between the independent variables and the dependent variable, using the chi-square and Mann-Whitney tests, the variables that would compose the logistic regression model were defined. The variables that showed a significant association with the dependent variable, which presented p value < 0.2 and variables considered relevant from a clinical point of view. As each individual contributed with more than one FPM to the study, the analysis was adjusted for the cluster effect.

## Results

Of the 174 children enrolled in the program between 2017/2019, with a mean age of 7.64 years (SD = 1.26), 120 (70%) were reassessed in 2022, 63 (52.5%) girls and 57 (47.5%) boys, with a mean age 11.5 (SD = 1.5). The interval between baseline and follow-up was 3.2 years (SD = 0.9). Of the 480 FPM evaluated in 2022, 25 (5.2%) were excluded because they were already cavitated at baseline, 4 (0.83%) covered by an orthodontic band and 24 (5.0%) because they were treated by another dentist out of school. The final sample consisted of 427 FPM in 120 children (figure 1). At baseline, 281 (65.8%) FPM were healthy and 146 (34.2%) had initial active caries. At follow-up, 346 (81%) were healthy, 70 (16.4%) had active initial caries and 11 (2.6%) had cavitated caries. Baseline active carious lesions tended to be active at follow-up examination more frequently ( $p < 0.001$ ) but did not show a greater rate of progression to cavitation ( $p = 0.52$ ) compared to healthy surfaces. Eleven (2.6%) FPM in 11 children (9.2%) had cavitated caries at follow-up examination. Significant risk factors for occlusal dentin

caries in FPM were caries experience in deciduous teeth (OR = 5.59; CI: 1.4 – 22.3) and presence of MIH (OR = 5.33; CI: 1.6 – 18.1) (table 1).



**Figure 1.** Sample flowchart. SD: standard deviation; FPM: first permanent molars.

**Table 1.** Bivariate analysis of the association between the dependent variable (occlusal dentin caries) and the independent variables and logistic regression analysis to calculate the odds ratio and respective confidence interval of the variables included in the model (n = 427).

Independent variables	Occlusal caries in dentin							
	Bivariate analysis				Logistic regression*			
	Yes		No		p	RC (IC)	Sig	
n	(%)	n	(%)					
Gender	Female	6	(1.4)	225	(52.7)	1.0		
	Male	5	(1.2)	191	(44.7)			
Age (years)	5 - 7	7	(1.6)	204	(47.8)	0.37	1.89 (0.57-6.22)	NS
	8 - 10	4	(0.9)	212	(49.6)			
dmft	0	1	(0.2)	173	(40.5)	0.32		
	≥1	10	(2.3)	243	(56.9)			
dmft>3	No	3	(0.7)	290	(67.9)	0.005	5.59 (1.4-22.25)	S
	Yes	8	(1.9)	126	(29.5)			
Caries lesion at baseline	No	7	(1.6)	310	(72.5)	0.48		
	Yes	4	(0.9)	106	(24.8)			
Sealant	No	5	(1.2)	270	(63.2)	0.21	0.52 (0.14-1.92)	NS
	Yes	6	(1.4)	146	(34.2)			
Demarcated opacities (MIH)	No	6	(1.4)	352	(82.4)	0.02	5.33 (1.56-8.09)	S
	Yes	5	(1.2)	64	(14.9)			
Diffuse opacities (fluorosis)	No	11	(2.6)	358	(83.8)	0.37		
	Yes	0	(0)	58	(13.6)			
Tooth	Upper	3	(0.7)	209	(48.9)	0.21	3.12 (0.59-6.48)	NS
	Lower	8	(1.8)	207	(48.5)			

Note: \*Logistic regression adjusted for cluster effect. OR: odds ratio; CI: confidence interval; Sig: significance; S: significant; NS: not significant.

## Discussion

The present study evaluated the factors associated with the occurrence of dentin caries on the occlusal surface of FPM in a school program of atraumatic restorative treatment. Caries experience in the primary dentition and MIH were significant risk factors for the occurrence of occlusal dentin caries in FPM. These findings are in line with the literature since the experience of caries in the primary dentition has been considered the main risk factor for caries in the permanent dentition<sup>15</sup> and that MIH has demonstrated a significant association with dental caries<sup>16</sup>.

It is reasonable that past caries experience predicts future caries because caries experience results from multiple risk factors combined. Hence, an individual who has or had advanced caries lesions certainly has been exposed to several caries risk factors e.g. high sugar consumption, low frequency of brushing and others. However, in general, the studies fail in showing a significant role of single potential predictors alone<sup>15</sup>. The impact of MIH on caries increment, mainly in FPM, might be explained by the lower strength of the hypomineralized enamel which has disorganized crystals and enlarged interprismatic spaces. In comparison with normal enamel, the hypomineralized enamel is not only more prone to breakdown due to the masticatory forces, but also to undergo rapidly demineralization when exposed to acid challenge of a cariogenic biofilm due to its higher solubility<sup>17</sup>.

The manifestation of occlusal caries in dentin in the present study can be considered low when compared to national<sup>6</sup> and local<sup>18</sup> data on dental caries. Only 9.2% of the children and 2.6% of the FPM evaluated developed occlusal dentin caries over an average period of three years, between 7 and 11 years of age on average. In addition, of the FPM that presented dentin caries, none showed signs of pulpal involvement as a complication of severe untreated dental caries.

In the 2010 national survey<sup>6</sup>, at age 12, more than half of the children had at least one permanent tooth affected by a cavitated carious lesion. Although the final report does not detail which permanent teeth were affected, it is assumed that they were mainly the FPM, as the literature points out that these are the permanent teeth most affected by caries at this age<sup>7</sup>. Still, FPM showed advanced carious lesion in need of endodontic treatment or were extracted due to caries in about 10% of children at 12 years old, emphasizing that FPM were severely affected<sup>19</sup>.

Data collected in 2018<sup>18</sup>, in the same municipality where the present study was carried out, identified 28.9% 8-year-olds with cavitated permanent teeth and that, for 12 year-olds, this percentage increased to 60%. Likewise, it is understood that the FPM were the most affected teeth. Therefore, children in the present study exhibited much lower rates of FPM involvement, at least during the follow-up period. Other longitudinal studies that evaluated incidence and cross-sectional studies that evaluated the prevalence of caries in FPM in the mixed dentition phase, in populations with high caries experience, also observed higher rates than the present study<sup>20-25</sup>.

Despite the interstice caused by the COVID-19 pandemic, which suspended classes at school in 2020 and 2021, it is believed that the fact that the children being included in a school program of atraumatic restorative treatment has influenced the lower incidence of occlusal caries in dentin in the FPM. In addition to

the restorative treatment of teeth with cavitated carious lesions and application of sealants, the program includes practices to reinforce oral hygiene instruction and, through its actions, maintains oral health present in the school routine. Another important reflection would be in relation to the follow-up time and whether it was sufficient to assess cavitated dentin caries as the main outcome. Considering the rate of progression of carious lesions in permanent molars, three years of follow-up in this age group seems to be sufficient to detect progression to cavities. Previous studies, which evaluated the effectiveness of measures for the prevention and control of occlusal caries, detected a significant difference between the test and control groups, with cavitated caries in dentin as the outcome, in periods from two years of follow-up<sup>10,26-28</sup>.

The presence of an active initial lesion at baseline was not a risk factor associated with progression to cavity, indicating that many initial carious lesions identified in the first examination became arrested over time. This demonstrates the dynamic character of the carious process, in which initial carious lesions can progress or become arrested depending on the interference of many factors that influence the relationship between tooth and dental biofilm. As the children are followed in an atraumatic restorative treatment program at school, some of the occlusal surfaces that showed initial carious lesions received glass ionomer cement sealant. However, the sealant showed no significant association with progression to dentin caries.

In the classic study by Dirks (1966)<sup>29</sup> it was observed that white spots, which correspond to the first sign of a caries lesion, may be a transitory clinical manifestation inherent to the ubiquitous nature of the carious process. The author suggested that the initiation of carious lesions on the buccal surface of newly erupted molars would be associated with the immaturity of the dental enamel, and that the arrestment of the lesions would result from the modification of the areas of biofilm accumulation as the eruption process evolves<sup>29</sup>. Advances in the understanding of the carious process have made it possible to understand that, in fact, the enamel of newly erupted teeth is not immature, and that post-eruptive enamel maturation will not occur<sup>7</sup>. In fact, the increase in surface hardness of tooth enamel is a consequence of repeated cycles of de- and remineralization which, in the presence of fluorine ions, result in the formation and deposition of fluorapatite in the outermost layer of enamel<sup>3</sup>. Thus, both initiation and cessation of carious lesions in the study by Dirks (1966)<sup>29</sup> would be related, in fact, to variations in local conditions predisposing to biofilm accumulation.

The changes in the biofilm stagnation pattern in relation to the stage of eruption and its association with the initiation, progression and arrestment of carious lesions has also been demonstrated for the occlusal surface of FPM in clinical studies<sup>7,8,10</sup>. In the case of the present study, the absence of effective masticatory contact combined with cariogenic biofilm stagnation and poor hygiene may have favored the appearance of initial lesions in the FPM. When the tooth reached sufficient height for occlusal contact, masticatory contacts might have prevented biofilm stagnation, favoring caries arrestment regardless of the application of pit and fissure sealant. This assumption somehow contradicts the literature that supports the use of seal-

ants as an effective strategy for preventing and controlling occlusal caries in permanent teeth<sup>28</sup>. It is important to consider, however, that the criteria for the indication of sealants in the routine of the school program was based on the existence of risk factors, with the high caries experience in the deciduous dentition and the presence of enamel hypomineralization in FPM being the main ones. This may explain why the preventive effect of the sealant was not observed, since its application was combined with the two factors significantly associated with a greater chance of progression of the lesions to cavitated caries in the dentin.

Regarding the upper and lower FPM, despite not showing statistical difference, it was observed that the cavitated caries lesion reached the lower FPM more, in line with other studies found in the literature<sup>22-25,30</sup>. This fact may be associated with the difference in the anatomical structures of the upper and lower FPM<sup>30</sup>, which have a greater number of pits, fissures and grooves, and may be more susceptible to the accumulation of biofilm<sup>25</sup>.

The children who composed the study sample come from a single neighborhood and attend the same public school, thus presenting a similar socioeconomic profile. However, the non-inclusion of socioeconomic factors among the analyzed variables, such as maternal education, family income, number of people residing in the family home and basic sanitation conditions, as well as dietary habits, is an important limitation of the study. After all, the literature shows that both the social character and the unequivocal influence of a diet rich in sucrose have an impact on the development of dental caries<sup>20,22,31</sup>. Concerning sources of fluoride, it is worth mentioning that all children live in a fluoridated area and are provided with toothpaste by the oral health program regularly.

Furthermore, the study had an observational design and was carried out with a convenience sample that is assisted by a school oral health program. Therefore, the evaluations are based on the effects of the routine assistance practice of this program. Nonetheless, despite the low incidence of cavitated dentin caries in FPM, it was possible to identify two risk factors significantly associated with the main outcome. However, limitations regarding the origin and size of the sample restrict the external validity of the data. Considering the population evaluated in the present study, the results emphasize the importance of the oral health program directing special attention to children with a high caries experience in the primary dentition and who have MIH.

In conclusion, the incidence of cavitated dentin caries on the occlusal surface of FPM was relatively low, significantly influenced by caries experience in the primary dentition and the presence of MIH.

## Conflict of Interest

The authors declare no conflict of interest

## Data availability

Datasets related to this article cannot be shared because they are part of ongoing research.



## Author Contribution

V.M.S. conceived the idea. B.M.S.G., P.P.G.R., and R.C.J. collected the data. V.M.S. and B.M.S.G. performed the analyzes of the data. All authors discussed the findings. V.M.S. and B.M.S.G. wrote the manuscript with input from all authors. All author revised and approved the final version of the manuscript.

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