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# Factors associated with active white enamel lesions

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**Summary.** *Objective*. The aim of this study was to assess the factors associated with the presence of active white enamel lesions among public school students in the city of Natal, Brazil.
*Methods*. A convenience sample of 300 boys and girls aged between 7 and 12 years was selected among the pupils attending public schools in the city of Natal. Only those children presenting with opaque and rough-surface white lesions in a region of biofilm accumulation on the vestibular surface of permanent upper incisors were included. The investigation took the form of a cross-sectional study. A chart containing individual data was used, and a clinical examination was performed to determine the oral health status of the children, including caries (DMF-s[1], DMF-s[2], DMFdmf, dmf and total number of teeth with caries) and oral hygiene status (Gingival Bleeding Index and Visible Plaque Index). Data underwent descriptive analysis and analysis of variance, and chi-square tests were used for the comparison of continuous and dichotomous variables between groups with one, two, or three or more white lesions.
*Results*. On average, each child presented with 2·3 teeth affected by white lesions, relatively high indices of dental caries and poor oral hygiene, with an 85% rate of localized plaque on the surfaces of teeth with lesions. The presence of visible plaque was statistically significant between the three groups, based on the number of lesions ($P = 0{\cdot}006$), indicating a positive association between the number of lesions and the presence of biofilm.
*Conclusion*. There is a strong association between the presence of dental biofilm, high indices of caries and active white enamel lesions. Full professional effort is needed in order to motivate children to carry out oral hygiene sufficient for the adequate control of dental biofilm.

## Introduction

White enamel lesions are the first clinical expression of demineralization occurring on the surface of enamel, resulting from successive pH alterations in the tooth–biofilm interface provoked by bacterial metabolism. The lesion is clinically characterized by a whitish colour and by a rough and opaque appearance, and is characteristically located in regions of biofilm accumulation [1]. This opacity is perceived through the optical phenomenon occurring when the tooth is dried, with increased porosity of enamel resulting from mineral loss from the sub-surface layer generating light dispersion and loss of the normal translucence of the enamel [2].

For many years, these lesions have been treated with invasive interventions because of the belief that the carious process, once started, would necessarily end in cavity formation in the tooth. However, advances in the studies in the area of cariology have revealed that these lesions are reversible as long as the environmental conditions are modified. Many researchers believe that reversal occurs because of the remineralization of the demineralized enamel

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surface, especially when fluoride ion is present in sufficient concentration on the oral environment [3,4]. Others [5–8] have supported the idea of inactivating the lesion, believing that toothbrush abrasion and the removal of the biofilm will result in a clinical impression of increased hardness of the enamel, and a reduction in the whiteness and brightness of the inactivated lesions.

The prevalence of white lesions in the population is little known since most epidemiological studies use indices (DMF) which do not quantify these lesions. On the other hand, epidemiological surveys carried out over the past few years have demonstrated a decline in the world-wide prevalence of caries. Despite the reduction in the severity of this disease, the incidence of caries is high in more underprivileged populations, in contrast to the increased number of people free of these lesions who are in the upper strata of society [9–11].

The polarization of caries seen in some population groups emphasizes the need to predict the factors associated with the incidence of this disease in order to control its severity in affected individuals. Oral hygiene indices are currently used in some epidemiological surveys to check the risk of development of carious lesions [12–14]. The presence of biofilm on the tooth surface may be used to evaluate activity of these lesions [15,16]. Gingival bleeding indicates the presence of long-standing biofilm, and is also considered by some authors to be an important predictor of the progress of carious lesions [17–19].

Caries indices are also considered as a variable which may act as a predictor of caries increment, since those individuals with a higher number of decayed, missing and filled surfaces (DMF) have a greater probability of developing new lesions [20–22]. On this basis, the objective of the present investigation was to determine the factors associated with the presence of active white enamel lesions, since these represent a first sign by which to identify individuals who may be considered to have priority in oral health promotion programmes.

## Subjects and methods

### *Participants*

The subjects were children of both sexes who were aged from 7 to 12 years and enrolled in 25 public elementary schools in the city of Natal, north-west Brazil. The socioeconomic status of the families in these schools was relatively homogeneous (average family income, approximately US$115 per month). The parents received a letter explaining the purpose of the study, along with an informed consent form to be signed and returned. The Ethics Committee in Clinical Research of the Federal University of Rio Grande do Norte approved this study.

### *Sampling*

A convenience sample of 300 children was selected on the basis of a previous clinical trial. The sample included 156 boys and 102 girls [23]. The authors selected children who presented classic carious white lesions (opaque white lesions in a region of biofilm accumulation) on the vestibular surface of permanent upper incisors. White lesions with cavitations or close to extensive carious lesions on other tooth surfaces were excluded. After examination of more than 5000 children, lesions were selected on the basis of the consensus of three dentists who had been trained in the diagnosis of initial caries.

### *Data collection*

A clinical chart was made for each child, including individual data and data concerning oral health, such as the prevalence of caries and oral hygiene. The subjects were examined in the schools under natural day light in an open area with the aid of a mouth mirror, and a dental and periodontal explorer. The presence of caries was recorded using the criteria described by the World Health Organization [24] for the classification of tooth-surface caries status. Caries experience included decay, missing-due-to-decay (or extraction advised), or filled permanent and primary tooth surfaces (DMF-s and dmf-s). The DS index was computed using two diagnostic thresholds: D1 for 'caries of enamel and dentin' (DMF-$s^1$); and D2 including 'white spot' lesions (DMF-$s^2$) [25]. Severity analysis of caries for subjects with mixed dentitions included the results of the DMF-$s^2$ plus the dmf-s (DMFdmf). The overall number of carious teeth (N. CARIES) was recorded using the component decay of DMF-$s^2$ and dmf indices. Oral hygiene was assessed using the Gingival Bleeding Index (GBI) [26] and the Visible Plaque Index (VPI) [26]. The percentage of plaque and bleeding sites after probing was calculated for each child. The examination was performed with the aid of a periodontal probe and was carried out on the surfaces of all teeth.

**Table 1.** Age, sites with visible plaque present, number of bleeding sites, and DMF and dmf values (means ± SD) for 258 schoolchildren with active white lesions in Natal, Brazil, in 2003.

| Variable | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| Age (years) | 9·6 | 1·5 | 6 | 13 |
| Number of active white lesions | 2·3 | 0·99 | 1 | 4 |
| Visible plaque | 40·8 | 20·4 | 1 | 91 |
| Bleeding | 14·3 | 12·1 | 0 | 70 |
| DMFdmf | 15·3 | 9·99 | 1 | 60 |
| DMF-s[1] | 6·5 | 6·4 | 0 | 37 |
| DMF-s[2] | 9·3 | 6·8 | 1 | 39 |
| dmf-s | 6·7 | 8·5 | 0 | 52 |
| Number of caries lesions | 12·6 | 10·2 | 0 | 60 |

*Data analysis*

The data were submitted to descriptive analysis, and comparisons were then made between children with one, two, or three or more white lesions. In the comparative evaluation, analysis of variance (ANOVA) or the Kruskal–Wallis test was used for the quantitative variables, and the chi-square test with Yates correction was used for the dichotomous variables.

## Results

A total of 258 children were included in the study, with 156 boys and 102 girls being selected on the basis of white lesions. As shown in Table 1, which presents the mean values and standard deviations for each of the continuous variables, high values were obtained for VPI (40·8) and the number of white lesions (2·3). Caries severity presented the following results: DMFdmf (3·15), N. CARIES (6·12), DMF-s[1] (5·6) and DMF-s[2] (3·9). These were higher than the average (DMF-t) in Natal in 2002, which was 2·78 [27].

**Table 2.** Number and percentage of sites showing localized bleeding and plaque for 300 schoolchildren with active white lesions in Natal, Brazil, in 2003.

| Variable | Number | Percentage |
|---|---|---|
| Localized bleeding: | | |
| yes | 208 | 34·2 |
| no | 400 | 65·8 |
| Localized plaque: | | |
| yes | 526 | 86·6 |
| no | 82 | 13·4 |

The values for the dichotomous variables, i.e. localized bleeding and localized plaque, are shown in Table 2. With regard to the presence or absence of localized bleeding on the teeth with active white lesions, 34·2% of these surfaces were found to present some bleeding. Localized plaque was present on 525 dental surfaces with active white lesions, with a rate of 86·6%.

In Table 3, the groups are divided according to the number of lesions present, with group 1 consisting of children presenting only one lesion, group 2 children with two lesions, and group 3 children with three or more lesions.

The plaque index was found to be directly associated with the number of white lesions ($P = 0{\cdot}006$), i.e. the higher the plaque index, the higher the number of lesions. No statistically significant differences between the groups were seen among the remaining variables.

With respect to the presence of plaque and of gingival bleeding at the site of the lesion (Table 4),

**Table 3.** Age, sites with visible plaque present, bleeding sites, and DMF and dmf values (mean ± SD) for schoolchildren with one (Group 1), two (Group 2), or three or more (Group 3) active white lesions in Natal, Brazil, in 2003.

| | Group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | |
| Variable | Mean (SD) | Range | Mean (SD) | Range | Mean (SD) | Range | *P*-value |
| Age (years) | 9·5 (1·6) | 7–12 | 9·7 (1·5) | 7–13 | 9·4 (1·5) | 6–12 | 0·405** |
| Visible plaque | 39·7 (22·4) | 1–80 | 37 (17·60) | 2–76 | 45·9 (20·6) | 3–91 | 0·006* |
| Bleeding | 13·0 (11·7) | 0–41 | 13·7 (11·4) | 0–46 | 15·7 (13·0) | 0–70 | 0·341* |
| DMFdmf | 16·6 (12·2) | 1–60 | 14·6 (10) | 2–41 | 15·4 (8·7) | 3–56 | 0·365* |
| DMF-s[1] | 6·9 (6·4) | 0–23 | 6·5 (7·2) | 0–37 | 6·4 (5·4) | 0–21 | 0·894* |
| DMF-s[2] | 8·3 (6·9) | 1–29 | 8·8 (7·3) | 2–39 | 10·4 (5·9) | 3–21 | 0·121* |
| dmf-s | 9·0 (11·1) | 0–52 | 5·9 (7·8) | 0–34 | 5·6 (7·6) | 0–39 | 0·057** |
| Number of caries lesions | 13·5 (12·8) | 1–60 | 11·2 (9·8) | 1–40 | 11·6 (9·0) | 0–56 | 0·175* |

*Analysis of variance.
**Kruskal–Wallis test.

**Table 4.** Number and percentage of sites showing plaque and localized bleeding in teeth with active white lesions.

| | Group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | |
| Variable | Yes | No | Yes | No | Yes | No | *P*-value* |
| Localized plaque | 45 (81·81%) | 10 (18·19) | 188 (83·55) | 37 (16·45) | 292 (89·57) | 34 (10·43) | 0·068 |
| Localized bleeding | 13 (23·63%) | 42 (76·37%) | 81 (35·7%) | 146 (64·3%) | 114 (35%) | 212 (65%) | 0·22 |

*Chi-square test.

about 85% of the teeth with active white lesions were found to present plaque at the site. No significant difference was observed between the three groups, although a trend was seen with increasing number of lesions. This observation was confirmed by the value of the statistical test ($P = 0{\cdot}068$) which was close to the pre-established limit ($P = 0{\cdot}05$). However, a difference was detected when group 1 was compared to group 3 ($P < 0{\cdot}001$), demonstrating that the higher the number of lesions, the greater the quantity of localized plaque. No difference in GBI was detected between the three groups.

## Discussion

The relationship between bacterial plaque and dental caries as the primary factor for the development of carious lesions was first detected by Miller in a classic study conducted at the end of the nineteenth century. However, it has not always been easy to identify the relation between dental caries and oral hygiene indices in epidemiological studies since that time. This may be partly because the DMF-t or DMF-s indices are used, which correspond to the past and present caries experience, with an index that represents the current status with regard to oral hygiene.

In this study, the carious lesion was active so that the relationship between plaque and these lesions, especially those located on the demineralized surfaces, could be detected more easily. A high VPI was detected, as well as a statistically significant difference between the three groups ($P = 0{\cdot}006$). These results agree with those reported by Ravald and Birkhed [12], who reported a highly significant correlation ($P < 0{\cdot}001$) between plaque index and lesion activity in adult patients with periodontal disease.

Among cross-sectional studies carried out on subjects with permanent dentitions, the study of Mascarenhas [13] is particularly important. Her objective was to assess the indicators of risk for enamel and dentin caries among 1189 Indian children. The author detected a positive and highly significant correlation between a high plaque index and enamel caries (OR = 2·04, CI = 1·86, 3·47) and dentin caries (OR = 3·18, CI = 2·26, 4·47). Similarly, Kleemola-Kujala and Räsänen [14] detected a highly significant correlation between dental caries and amount of plaque in 543 children aged from 5 to 13 years, even when differences in sugar consumption were taken into account.

In contrast, Etty *et al.* [28], in a study of the cariogenic challenge on the enamel surface and in occlusal fissures in 548 children aged from 4 to 6 years, and its relation to the index of oral hygiene, failed to detect an association between the amount of biofilm present and the changes (i.e. initiation, progression, stabilization and regression) detected on the dental surface. The above authors concluded that the low level and lack of progression of lesions was not related to adequate oral hygiene practices, but was a result of intensive fluoride treatment. Klock [22] reached a similar conclusion when assessing different factors predictive of dental caries and their relationship to the incidence of caries in 100 adolescents with low caries experience.

Such differing results seem to be at least partly associated with the type of index used in the different studies. Some research assessed oral hygiene on the basis of frequency of brushing or plaque indices demonstrated with the use of a dye. Differences can also be seen in the study design and in the prevalence of caries in the sample under study. In this study, the authors used the VPI, which reflects more clearly the type of cleaning performed by an individual, in a sample consisting of children with low levels of hygiene and high caries indices.

In considering the controversy, it is important to remember that classical and well-designed studies such as those carried out by Axelsson, Lindhe [29–31] and Von Der Fehr [32,33] would appear to have

demonstrated the importance of the control of dental biofilm for the reduction of dental caries. However, the results obtained could equally be attributable to fluoride since treatment for the control of dental biofilm was always associated with fluoride-containing substances such as toothpastes and other methods of topical fluoride application.

The association between localized biofilm and active carious lesions found in this research has also been reported by Backer-Dirks [15], who detected the presence of white lesions in the cervical regions of the molars, especially when the tooth was still in the process of eruption. According to the above author, this finding was a result of the fact that this region is difficult to brush and not subject to clearing through the mechanical forces inherent in mastication. A very similar result was reported by Carvalho [16], who considered the influence of stage of eruption on the formation of occlusal biofilm and on the development of caries in children.

In this study, gingival bleeding was recorded on 208 of 608 dental surfaces (34·2%). Although no differences were seen between groups, this result can be considered to be quite high for the groups as a whole, all of whom had at least one white lesion. It confirms current opinion that bleeding is a result of gingival inflammation as a consequence of the presence of matured plaque, i.e. biofilm present for a long period of time, a factor that may be even more strongly associated with white lesion activity.

Stecksén-Blicks and Gustafsson [17], Al-Banyan [18], and Campos [19] assessed gingival status as a measure of oral hygiene and its relationship with dental caries in adolescents, and detected a strong relationship between a high caries index and gingival bleeding. Thus, the permanence of biofilm in contact with the dental surface for a long period of time and the presence of an environment favourable to the local microbiota may cause a high GBI to be an important risk factor for the progression of carious lesions. However, in this study, the authors frequently detected the presence of a thick biofilm on vestibular surfaces without concurrent gingival bleeding in the adjacent site.

The values of the indices related to the severity of caries, such as the DMFdmf, DMF-s[1], DMF-s[2], dmf-s and N. CARIES, were high in all groups, demonstrating that, among children with white enamel lesions, there is a higher probability of detecting a greater number of carious lesions as a whole. However, no statistically significant relationship was observed between the three groups in terms of differences in extent.

The presence of caries at all has been pointed out by Russel [20] and Klock [22] to be a predictive variable for further caries, with individuals with a larger number of carious, and lost and obturated surfaces (DMF-s) having a greater probability of developing new lesions.

The authors did not assess the activity of cavitated lesions at the time of the examination, and therefore, the analysis of the N. CARIES variable, which is extracted from the DMF-s and dmf-s indices, was impaired. The objective was to identify the possible consequences of the sites of biofilm accumulation at sites of active lesions for the oral environment (e.g. frequent falls in pH). Thus, the authors speculate that, if they had assessed the activity of these cavitated lesions, they might have detected an association.

This hypothesis could be true if we consider that, when the number of active white lesions was added to the exam (DMF-s[2]), a better relationship was observed between the three groups ($P = 0{\cdot}12$) than when the DMF-s[1] alone was used ($P = 0{\cdot}894$), although the difference was not statistically significant.

No significant relationship was observed between the three groups ($P = 0{\cdot}365$) with regard to the sex and age variables. However, boys presented 60·5% of the total number of white lesions in the sample. Since inclusion criteria demanded both lesions and biofilm, this result seems to show that girls devote more care to their oral hygiene, as demonstrated by Lo, Schwarz and Wong [34] who, after establishing a preventive programme, observed that girls presented significantly better results than boys with regard to caries regression.

This discussion about the relationship between biofilm and caries has been limited to the biological causality of the disease, and may be an oversimplification. It is clear that disease is related to the health/disease process of the population and is greatly affected by social factors. The prevalence and severity of oral disease are unequal, with poorer strata of society being particularly affected [9–11,35,36].

The cross-sectional design study used in this and other studies presents a picture of oral hygiene status and the presence of caries at the moment of the investigation. The findings suggest many important hypotheses about the association between variables. However, 'case control' and prospective cohort study designs would be of particular value in defining risk factors for the initial carious lesions.

The clinical diagnosis of the activity of white lesions is an important limitation, and therefore, studies on complementary methods for the detection of these lesions are merited.

**What this paper adds**
- This paper demonstrates the relationship between plaque and active enamel caries.
- In adolescents with active white enamel lesions the number of lesions may be associated with amount of biofilm, and severity of caries.

**Why this paper is important for paediatric dentists**
- For paediatric dentists, this paper confirms the importance of plaque in caries activity in a group with active disease.

## Conclusions

Dental biofilm, gingival bleeding and dental caries severity may be associated with the presence of active white enamel lesions. The presence and number of active white enamel lesions are positively related to an increase in the dental plaque index. The sex and age of the children were not considered to be risk factors for the presence of active white lesions, although a larger number of lesions was detected among boys.

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**Résumé.** *Objectif.* Evaluer les facteurs associés à la présence de lésions actives de l'émail dans les écoles de la ville de Natal/Brésil.
*Methodologie. Participants*: Un échantillon adéquat de 300 garçons et filles de 7 à 12 ans a été sélectionné parmi les écoliers fréquentant les écoles publiques de la ville de Natal. Les enfants inclus dans l'étude ont été seulement ceux présentant des lésions opaque et rugueuses de surface dans une zone d'accumulation de biofilm sur la face vestibulaire des incisives permanentes supérieures.
*Type d'étude.* transversale
*Recueil des données.* Une fiche contenant les données individuelles a été utilisée et l'examen clinique a été effectué pour déterminer l'état de santé buccale des enfants, incluant les caries (CAO-f[1], CAO-f[2], CAOcao, cao et N. CARIES) et le niveau d'hygiène buccale (Indice de saignement gingival – GBI et l'indice de plaque visible – VPI).
*Analyse des données.* les données ont été soumises à une analyse descriptive, l'analyse de variance (ANOVA) et le test du Khi2 ont été utilisés pour la comparaison des variables continues et dichotomiques entre les groupes avec une (groupe 1), deux (groupe 2) et 3 ou plus lésions (groupe 3).
*Resultats.* Chaque enfant a présenté en moyenne 2,3 dents affectées par des lésions blanches, des indices carieux relativement élevés et une hygiène buccale faible avec un taux de 85% de plaque localisée à la surface des dents avec lésions. La présence de plaque visible était significativement significative entre les trois groupes définis par le nombre de lésions ($p$ = 0,006) indiquant une association positive entre le nombre de lésions et la présence de biofilm.
*Conclusion.* Il existe une association forte entre la présence de biofilm dentaire, des indices carieux élevés et des lésions blanches actives de l'émail. Des efforts professionnels complets sont nécessaires afin de motiver les enfants à avoit une hygiène buccale suffisante pour contrôler efficacement le biofilm dentaire.

**Zusammenfassung.** *Ziele.* Bestimmung von Faktoren, welche mit dem Vorkommen von aktiven kariösen Initialläsionen bei Schulkindern öffentlicher Schulen der Stadt Natal/Brasilien assoziiert sind.
*Methoden. Teilnehmer*: Es wurde eine Stichprobe von 300 Jungen und Mädchen der Atersgruppe von 7 bis 12 Jahren ausgewählt aus den Schulkindern öffentlicher Schulen der Stadt Natel. Es wurden ausschließlich Kinder mit opaken und rauhen weißlichen Schmelzläsionen im Bereich von Biofilmakkumulation an den Vestibularflächen von bleibenden Oberkiefer-Schneidezähnen einbezogen.
*Studienanlage.* Querschnittstudie. *Datenerhebung*: Es wurde ein Befund mit personenbezogenen Daten dokumentiert, folgende klinische Daten zur Mundgesundheit wurden erhoben: DMF-s[1], DMF-s[2], DMF dmf, dmf und N. Außerdem wurde die Mundhygiene bewertet (Gingival Bleeding Index – GBI sowie Visible Plaque Index – VPI). *Datenanalyse*: Die Daten wurden mittels deskriptiver Statistik, Varianzanalyse (ANOVA) sowie Chi-Quadrat-Test analysiert um were used for the comparison of stetige and dichotome Variablen zwischen folgenden

Gruppen zu trennen: Gruppe 1 (eine aktive Läsion) Gruppe 2 (zwei Läsionen) Gruppe 3 (drei oder mehr Läsionen).
*Ergebnisse*. Im Mittel waren 2.3 Zähne von Initialläsionen betroffen, die Kariesindizes waren relativ hoch, mit einer Rate von rund 85% war Plaque an Zähnen mit Läsionen lokalisiert, was für eine positive Assoziation zwischen der Zahl der Läsionen und der Anwesenheit von Biofilm spricht. Es besteht ein starker zusammenhang zwischen der Anwesenheit von dentalem Biofilm, hoher Kariesindexwerte und dem Auftreten von aktiven Initialläsionen. Es bedarf intensiver professioneller Anstrengung, um die Kinder zur Ausübung einer effektiven Mundhygiene im Sinne der Entfernung des Biofilms zu motivieren.

**Resumen.** *Objetivo*. Valorar los factores asociados con la presencia de lesiones de esmalte blancas activas entre estudiantes de escuela pública en la ciudad de Natal/Brasil.
*Metodología*. Participantes: Entre los alumnos que asisten a escuelas públicas en la ciudad de Natal, se seleccionó una muestra de conveniencia de 300 niños y niñas entre 7 y 12 años. Los niños incluidos en el estudio fueron sólo aquellos que presentaban lesiones blancas de superficie opaca y rugosa en una región de acúmulo de biofilm en la superficie vestibular de los incisivos superiores permanentes. Tipo de estudio: transversal. Recogida de datos: Para determinar la salud bucal de los niños se usó una ficha que contenía datos individuales y se realizó un examen clínico, que incluía Caries (CAO s[1], CAO-s[2], CAOcao, cao y N. CARIES) y el estado de la Higiene Bucal (Índice de Sangrado Gingival – ISG e Índice Visible de Placa IVP). Análisis de los Datos: Los datos se sometieron a un análisis descriptivo, para comparar variables dicotómicas y continuas entre grupos con una (grupo 1), dos (grupo 2) y tres o más lesiones blancas (grupo 3) se utilizaron el Análisis de la Varianza (ANOVA) y el test de la Chi-cuadrado.
*Resultados*. Cada niño presentó un promedio de 2,3 dientes afectados por lesiones blancas, índices de caries dental relativamente altos e higiene bucal pobre con un porcentaje del 85% de placa localizada en la superficie de dientes con lesiones. La presencia de placa visible fue estadísticamente significativa entre los 3 grupos basándose en el número de lesiones ($p$ = 0,006), indicando una asociación positiva entre el número de lesiones y la presencia de biofilm.
*Conclusión*. Hay una asociación fuerte entre la presencia de biofilm dental, índices de caries altos y lesiones de esmalte blancas activas. Se necesita un esfuerzo profesional pleno para motivar a los niños a llevar una higiene bucal suficiente para conseguir un control adecuado del biofilm dental.

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