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Correlation of Parental and Child Dental Plaque Levels: A Clinical Study

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Abstract: Objective: This clinical study aimed to explore the correlation between dental plaque levels in parents and their children. Specifically, the study examined differences in plaque correlation between mother–child and father–child pairs and evaluated the role of parental education in influencing children's oral hygiene practices. Materials and Methods: A total of 196 subjects were recruited, comprising 49 mother–child and 49 father–child pairs, with children aged 6 to 15 years. Dental plaque was assessed using the O'Leary Plaque Control Record, applying a liquid plaque discloser and explorer. The plaque index was calculated as the percentage of dental surfaces with visible plaque relative to the total surfaces examined. Results: The findings revealed a significant positive correlation between the parental plaque index (IP_PARENTS) and the children's plaque index (IP_CHILD) ($p < 0.001$), indicating a strong relationship. While the father's plaque index (ID_PARENTS(FATHER)) showed a marginally positive effect on IP_CHILD ($p = 0.0589$), the interaction between father identification and IP_PARENTS had a significant negative impact ($p = 0.0344$), suggesting that paternal influence on children's plaque levels may vary. The model accounted for 28% of the variability in IP_CHILD (pseudo $R^2 = 0.2758$). Conclusions: The analysis demonstrated a significant association between parental and child plaque levels, with minor differences observed between maternal and paternal influence. No significant effects were found for the age or gender of the children. Overall, increased plaque levels in parents were associated with higher plaque levels in their children, with slight variations depending on the parent's role.

Keywords: oral health education; plaque index; children's dental health

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1. Introduction

Bacterial biofilms are highly organized communities of microorganisms encased in a self-produced extracellular polymeric substance (EPS) matrix. This matrix, primarily composed of polysaccharides, proteins, lipids, and extracellular DNA, shields bacteria from antimicrobial agents and host immune defenses while strengthening the biofilm's structure [1]. Within the biofilm, micro-ecological niches form, supporting nutrient exchange and bacterial communication [2]. Through quorum sensing—a communication mechanism dependent on population density—bacteria within the biofilm coordinate behavior, modulating gene expression to enhance collective functions like virulence and resistance to antimicrobials as the biofilm matures [3]. Biofilms can house diverse bacterial

species with variations in shape, oxygen requirements (aerobic, facultative anaerobic, or obligate anaerobic), and cell wall characteristics (Gram-positive or Gram-negative) [4,5]. Biofilm formation begins when bacteria adhere to an organic film on surfaces: they then recruit additional bacteria, creating microcolonies that expand and secrete an extracellular matrix. As the biofilm grows, it develops into a complex three-dimensional structure with water channels that distribute nutrients and eliminate waste. In response to environmental shifts or nutrient competition, bacteria within the biofilm may disperse to colonize new surfaces [6].

Dental plaque, or bacterial plaque, is a structured biofilm that forms on the surfaces of teeth and is composed of microorganisms, food particles, and molecules from saliva. This biofilm develops gradually and, if not mechanically removed through actions such as tooth brushing or flossing, can lead to various dental health issues, including dental caries, gingivitis, and even periodontitis. The teeth themselves lack the ability to shed bacteria, making consistent and effective oral hygiene practices crucial for maintaining oral health [7]. Plaque is not a simple bacterial layer but rather a complex microbial community, housing a diverse range of bacterial species, many of which remain only partially identified. Environmental factors also promote strong adhesion to the surfaces of the teeth, making the removal of plaque more challenging without dedicated mechanical cleaning [8].

The biofilm's dense structure and protective matrix form a barrier that enhances its resilience against antimicrobial agents and immune responses, significantly contributing to the development and persistence of chronic periodontal diseases [9]. Over time, the bacterial communities within dental plaque interact with each other and with tooth surfaces, establishing a stable micro-ecosystem that plays a crucial role in both dental and periodontal disease progression. In children, tartar commonly accumulates on the lingual surfaces of the lower incisors [10]. This tartar, or dental calculus, forms when plaque is not removed and subsequently mineralizes, preserving a "fossilized" record of bacterial communities, human proteins, viruses, and food particles, which contain DNA valuable for evolutionary biology studies [11]. Tartar can also develop below the gum line, where it often appears darker due to pigments like hemoglobin and becomes harder and more firmly attached. Subgingival tartar is radiopaque, making it detectable through X-rays [12].

As plaque matures, it becomes increasingly capable of generating acidic byproducts from carbohydrate fermentation, which can demineralize tooth enamel, leading to cavities. The bacteria from plaque, especially *Streptococcus mutans*, which is highly associated with dental caries, can colonize a child's mouth and contribute to plaque formation on their teeth, even before all their primary teeth have erupted [13]. The transfer of plaque-forming bacteria becomes significant for a child's oral health because children's enamel is thinner and more susceptible to decay. When cariogenic bacteria are transmitted, they form plaque, which if not properly managed, leads to early childhood caries [14].

The oral microbiota can be transmitted from parents to children, primarily through close contact and shared habits. Since bacteria from a parent's oral microbiome can be introduced to a child's mouth, this transfer often begins early in life through common interactions, such as kissing, sharing utensils, or cleaning a baby's pacifier with the mouth. Effective management of dental plaque through regular, thorough brushing, flossing, and professional dental cleanings is essential to preventing the onset and progression of these common yet preventable oral health conditions [15].

This clinical study sought to investigate the relationship between dental plaque levels observed in parents and those found in their children, focusing specifically on the potential familial patterns that may influence plaque formation and distribution. By examining how plaque levels in parents correlate with those in their offspring, the study aimed to shed light on the hereditary and environmental factors that contribute to oral health outcomes. Understanding these connections could provide valuable insights into

the transmission of oral bacteria and the development of effective preventative strategies for managing dental plaque and associated diseases within families. Through this research, we hope to identify trends that may help inform future oral health education and intervention programs tailored to both parents and children, ultimately promoting better dental hygiene practices across generations.

The specific objectives included:

1. Mother–child vs. father–child correlation: This study sought to identify significant differences in plaque levels between mother–child and father–child pairs, enhancing understanding of the distinct roles each parent may play in their child's oral health.
2. Parental education's impact: The study also aimed to evaluate how parental education on oral hygiene practices influences children's habits and dental health, emphasizing the role of parents' knowledge and involvement.

2. Materials and Methods

This clinical study was conducted at the Borgo Cavalli Clinical Polyclinic in Treviso and involved a total of 196 participants, comprising 49 mother–child pairs and 49 father–child pairs, which resulted in a total of 98 children. The children, aged between 6 and 15 years, included 37 females and 61 males. Children younger than 6 years were excluded from the study due to the insufficient number of permanent teeth required for an accurate assessment of the plaque index. All patients enrolled in the study come from families with an Equivalent Financial Situation Indicator (EFSI) of less than EUR 15,000 per year, classifying them as lower-income families.

Patients and parents and the second investigator (RGP) were unaware about the study's specifics, helping to reduce the risk of bias, such as coming to the Dental Department having brushed better than usual. Informed consent was taken prior to the oral hygiene session, where the first investigator (SDM) applied Mira-2-Ton (Duisburg, Germanny) to the patients' dental surfaces and a second blinded investigator (RGP) assessed the stained surfaces of the teeth.

During the initial visit to the clinic, the plaque index for each child was evaluated using the O'Leary Plaque Control Record (Figure 1), a standardized method designed to quantify the amount of dental plaque present. This assessment began with the application of a liquid plaque disclosing an agent known as "Mira-2-Ton". This agent serves to stain the plaque, making it more visible against the tooth surface. Following this, a dental explorer was employed by the clinician to meticulously examine each tooth and visually identify any areas where plaque was present.

A principal investigator (SDM) administered the Mira-2-Ton solution to the patients' dental surfaces, while a second investigator (RGP), who was unaware of the study's hypothesis, evaluated the stained areas on the teeth. The process of identifying plaque involves carefully running the explorer along the surfaces of the teeth, allowing the dental professional to accurately record the presence of plaque in specific locations. For each child participant, the plaque index was subsequently calculated as a percentage, representing the number of dental surfaces that exhibited visible plaque in relation to the total number of surfaces examined. This method not only provides a clear quantification of plaque accumulation but also helps to highlight areas that may require more attention in the child's oral hygiene routine.

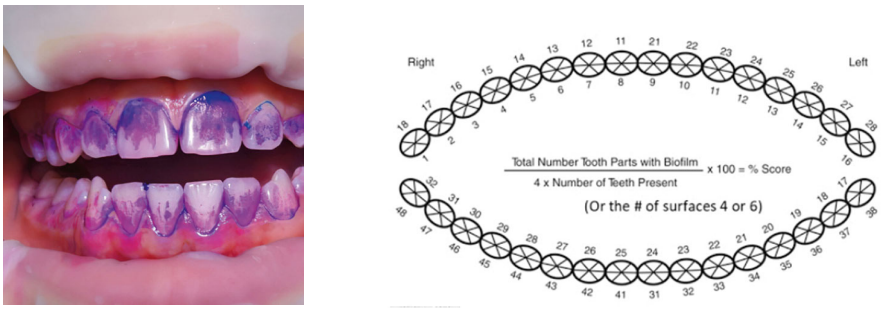

Figure 1. Example of O'Leary Plaque Control Record.

To analyze the collected data, we employed a beta regression model using a software program (SPSS v.18, IBM, Chicago, IL, USA), which is particularly suitable for handling proportional outcomes, such as the plaque index (PI_CHILD) that ranges from 0 to 1. The beta regression model allows us to evaluate not only the mean or expected value of the dependent variable but also its precision, or variability.

The first step in our data analysis involved clearly defining the research problem: determining how various factors influence a child's plaque index (PI_CHILD). We hypothesized that several key predictors might impact this outcome, including the parents' plaque index (PI_PARENTS), the child's age (AGE_CHILD), and which parent accompanied the child to the dentist (ID_PARENTS)—either the mother or the father.

Data preparation consisted of gathering the relevant variables: PI_CHILD, PI_PARENTS, AGE_CHILD, and ID_PARENTS. We then specified the statistical model using the following formula:

$$\text{PI\_CHILD} \sim \text{ID\_PARENTS} + \text{PI\_PARENTS} + \text{ID\_PARENTS} \times \text{PI\_PARENTS}.$$

In this notation, the symbol "~" denotes the relationship between the response variable (PI_CHILD) and the predictor variables.

The model included an interaction term (ID_PARENTS × PI_PARENTS) to evaluate not only the individual effects of the parent's identity (ID_PARENTS) and the parents' plaque index (PI_PARENTS) but also the combined influence of these factors on the child's plaque index. This interaction term is particularly important as it highlights how the effect of a specific parent (ID_PARENTS) on the child's plaque index may vary depending on the plaque levels of the parents themselves (PI_PARENTS). This comprehensive approach allows us to better understand the dynamics of plaque accumulation in children and the potential influence of parental oral hygiene practices.

3. Results

In Table 1, we observe that the sample of 98 observations has the following characteristics: The variable **PI_PARENTS** has a mean of 0.32 with a standard deviation of 0.11, while the variable **PI_CHILD** has a mean of 0.46 with a standard deviation of 0.19. The average age of the children (**AGE_CHILD**) is 10.15 years, with a variation of 2.46 years.

Regarding the gender of the children, there are 37 females (38%) and 61 males (62%). As for the variable **ID_PARENTS**, the sample is evenly divided between mothers and fathers, with 49 observations (50%) from mothers and 49 observations (50%) from fathers. These data provide an overview of the distribution of variables in the sample, highlighting the balanced composition of mothers and fathers, along with a greater proportion of male children.

Table 1. Descriptive Statistics of Parent and Child Variables in the Sample (n = 98).

Characteristic	n = 98
PI_PARENTS	0.32 (0.11)
PI_CHILD	0.46 (0.19)
AGE_CHILD	10.15 (2.46)
SEX_CHILD	
F	37/98 (38%)
M	61/98 (62%)
ID_PARENTS	
MOTHER	49/98 (50%)
FATHER	49/98 (50%)
Mean (SD); n/N (%)	

For the mothers' group, the variable **PI_PARENTS** has a mean of 0.31 with a standard deviation of 0.10. The mean **PI_CHILD** is 0.45 with a standard deviation of 0.19. The average age of the children (**AGE_CHILDREN**) is 9.96 years, with a standard deviation of 2.44 years. Within this group, there are 22 girls (45%) and 27 boys (55%).

For the fathers' group, the variable **PI_PARENTS** has a mean of 0.33 with a standard deviation of 0.12. The mean **PI_CHILD** is 0.46, with a standard deviation of 0.20. The average age of the children is 10.25 years, with a standard deviation of 2.50 years. Within this group, there are 15 girls (31%) and 34 boys (69%) (Table 2).

Table 2. Comparison of Descriptive Statistics Between Mothers' and Fathers' Groups (n = 49 Each).

Characteristic	Mother, N = 49	Father, n = 49
PI_ PARENTS	0.31 (0.10)	0.33 (0.12)
PI_CHILD	0.45 (0.19)	0.46 (0.20)
AGE_CHILD	9.96 (2.44)	10.35 (2.50)
SEX_CHILD		
F	22/49 (45%)	15/49 (31%)
M	27/49 (55%)	34/49 (69%)
Mean (SD); n/N (%)		

In Figure 2, we observe the histogram of the values for **PI CHILD**, showing the distribution of the data. We can see that there is a greater concentration below 0.5. These values are independent of who takes the child to the dentist.

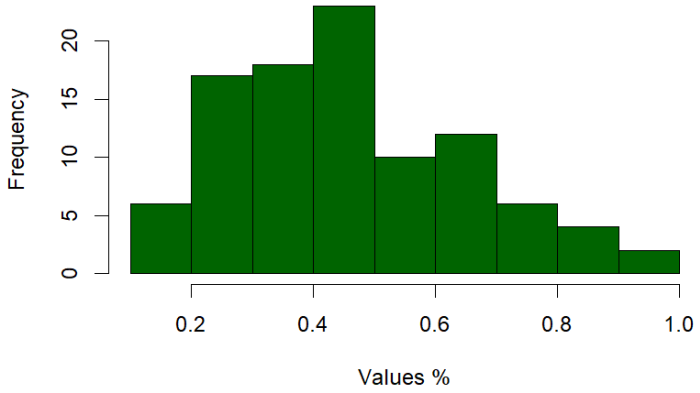

Figure 2. Histogram PI CHILD.

Analyzing the results, we observed that the model fits the data well, with standardized residuals ranging from −1.9110 to 4.0733. This indicates that, although most observations are well explained, there are some extreme cases. The coefficient for **PI_PARENTS** is highly significant and positive ($p < 0.0001$), suggesting that an increase in the parents' plaque index (regardless of who takes the child to the dentist) is strongly associated with an increase in the child's plaque index (**PI_CHILD**).

The child's age (**AGE_CHILD**) and gender (**SEX_CHILD**) did not have a statistically significant effect on **PI_CHILD**. The identification of who takes the child to the dentist (**ID_PARENTS**), while marginally significant ($p = 0.0589$), suggests that when the father accompanies the child to the dentist, this may be associated with an increase in the proportion of **PI_CHILD**.

Furthermore, the interaction between **ID_PARENTS** and **PI_PARENTS** is significant ($p = 0.0344$), indicating that the effect of the parents' plaque index on **PI_CHILD** may vary depending on who takes the child to the dentist. The accuracy of the model, measured by the Phi coefficient, is significantly high, indicating considerable variability in the data. With a pseudo R-squared of 0.2578, the model explains about 28% of the variation in **PI_CHILD**, suggesting moderate explanatory power (Tables 3 and 4).

Table 3. Regression Analysis of Factors Influencing Child's Plaque Index (PI_CHILD).

Variable	Estimate	Std. Error	*p*-Value
(Intercept)	−1.88301	0.45856	<0.001
PI_PARENTS	5.28365	1.03161	<0.001
AGE_CHILD	0.02124	0.02846	0.455
SEX_CHILD	−0.18777	0.14816	0.205
ID_FATHER	0.77352	0.45212	0.087
PI_PARENTS: ID_FATHER	−2.54387	1.37188	0.064

Table 4. Summary of Standardized Residuals Distribution.

Standardized Statistical Residuals	
Measure	***p*-Value**
Lower	−1.9397
1st Quartil	−0.7561
Median	−0.2193
3rd Quartil	0.4918
Higher	3.971

Finally, in the final beta regression model, which considers only the significant variables adjusted with the formula **PI_CHILD~ID_PARENTS + PI_PARENTS + ID_PARENTS * IP_PARENTS**, we observed that the adjustment is quite robust. The standardized residuals range from −1.9110 to 4.0733, indicating that although most observations are well explained, there are some extreme cases. The coefficient for **ID_PARENTS (FATHER)** is positive and marginally significant ($p = 0.0589$), suggesting that identifying the father may have a positive effect on the **PI_CHILD** variable. The coefficient for **PI_PARENTS** is highly significant ($p < 0.001$) and positive, indicating that an increase in the parents' plaque index is strongly associated with an increase in **PI_CHILD** (Table 5).

Table 5. Final Beta Regression Model for Child's Plaque Index (PI_CHILD).

Variable	Estimate	Std. Error	*p*-Value
(Intercept)	−1.8354	0.3307	<0.001
ID_FATHER	0.8496	0.4498	0.0589
PI_PARENTS	5.4872	1.0256	<0.001
ID_FATHER/: IP_PARENTS	−2.8523	1.3484	0.0344

The interaction between **ID_PARENTS (FATHER)** and **PI_PARENTS** has a negative and significant coefficient ($p = 0.0344$), suggesting that the positive effect of **PI_PARENTS** on **PI_CHILD** may be reduced in the presence of a specific paternal identification. This indicates that the influence of the plaque index can vary depending on the identification of the father. The pseudo R-squared is 0.2758, meaning that approximately 28% of the variation in the **PI_CHILD** variable is explained by the model (Table 6).

Table 6. Distribution of Standardized Residuals in the Final Beta Regression Model.

Standardized Statistical Residuals	
Measure	**Value**
Lower	−1.911
1st Quartil	−0.735
Median	−0.235
3rd Quartil	0.4655
Higher	4.0733

4. Discussion

Based on the data analysis and the results obtained, several key conclusions can be drawn regarding the variables and their relationships within the studied sample. The sample comprised 98 observations, evenly split between mothers and fathers, with 49 observations for each group. The average plaque index of parents (PI_PARENTS) was slightly higher for fathers (0.33) compared to mothers (0.31). In terms of the children's plaque index (PI_CHILD), the averages were nearly equivalent, with mothers at 0.45 and fathers at 0.46. Additionally, the average age of children was slightly lower for mothers (9.96 years) than for fathers (10.35 years). The gender distribution indicated a higher percentage of boys in both groups, with 55% in the mothers' group and 69% in the fathers' group.

The beta regression analysis revealed a significant positive effect of PI_PARENTS on PI_CHILD, indicating that an increase in the parents' plaque index is associated with an increase in the children's plaque index. However, the interaction between PI_PARENTS and ID_PARENTS demonstrated a marginally significant negative effect, suggesting that the relationship between PI_PARENTS and the PI_CHILD may vary depending on whether the respondent is the mother or the father. The variables AGE_CHILD and children's gender (SEX_CHILD) did not show significant effects on the PI_CHILD.

The visualization of the data through a histogram of the PI_CHILD by ID_PARENTS illustrated the distribution of children's plaque scores for mothers and fathers, highlighting variability within each group. These findings indicate that, although there are some differences in data characteristics between mothers and fathers, the overall impact of PI_PARENTS on the PI_CHILD remains positive and significant, with nuanced differences depending on the parental group.

This study contributes to the growing body of evidence on the intergenerational transmission of oral health behaviors, emphasizing the distinct role of fathers. Unlike prior studies that focused primarily on maternal influence, our findings add to the literature by suggesting that a paternal plaque index can have a meaningful impact on children's oral health outcomes. This highlights a unique dimension in parent–child oral

health dynamics, where fathers may require specific focus in oral health interventions aimed at reducing plaque transmission and improving family-wide dental health.

The present study aimed to assess the correlation between plaque presence in parents and their children, as well as any significant differences based on who accompanied the child on their first dental visit. Research has consistently shown that parents, particularly fathers, significantly influence their children's oral health. For instance, a study titled "Are parents' education levels associated with either their oral health knowledge or their children's oral health behaviors? A survey of 8446 families in Wuhan" found a strong link between parents' health literacy and their children's oral health. Children with parents who possess better knowledge of oral hygiene practices tend to exhibit improved oral health and lower plaque indices, particularly in families where parents, especially fathers, have higher education levels and a greater awareness of hygiene practices [16].

In our study, the average plaque index for fathers (0.33) was slightly higher than that for mothers (0.31). Additionally, other research has demonstrated that parents' oral health behaviors, such as regular tooth brushing and routine dental visits, directly influence their children's oral hygiene habits. This body of work has highlighted that most indicators related to children's oral health behaviors and parents' knowledge about oral health were significantly associated with the mother's education level, with a slightly lesser but still notable impact from the father's education level.

According to findings by Habbu et al. 2015, despite a generally good level of awareness, significant gaps in specific knowledge and oral hygiene practices persist among parents, potentially contributing to plaque presence in both parents and children. Ineffective oral hygiene behaviors, such as improper toothbrush use or irregular dental visits, underscore the need for targeted educational interventions to improve daily practices and reduce the transmission of inadequate habits to children [17].

Research by Guerra et al. 2017 indicated that many interviewed parents received oral hygiene education from their dentist or hygienist, reflecting a good level of general awareness [18]. However, this awareness does not always translate into effective and consistent practices. Many parents continue to report difficulties in maintaining proper oral hygiene. It was found that only a portion of parents correctly utilized tools such as plaque disclosing agents or practiced thorough tooth cleaning—factors that could contribute to the perpetuation of suboptimal habits in their children [19,20].

Our results indicate a statistically significant association between the plaque index of parents and that of their children, emphasizing the impact of parental oral hygiene on children's oral health outcomes. This finding aligns with previous research demonstrating that parents, especially fathers, play a crucial role in shaping children's hygiene practices and health outcomes. For instance, Chen et al. (2020) [16] found that children's plaque indices were significantly correlated with paternal oral hygiene habits, suggesting a gender-specific influence that complements our observation of slightly higher plaque levels in children associated with fathers. Furthermore, fathers' oral health behaviors were particularly influential, often serving as a model for children's daily routines. This corresponds with our finding that the positive effect of the parental plaque index on the children's plaque index was marginally stronger for fathers than for mothers.

Moreover, other studies (e.g., Habbu et al. 2015 [17]; Guerra et al. 2017 [18]) have highlighted how educational levels and awareness among parents contribute to improved oral health in children. Our study supports these insights by demonstrating that parents' plaque index significantly influences children's plaque levels, indicating that educational interventions aimed at parents, particularly fathers, may be effective in reducing plaque accumulation in children. Finally, our findings add to the literature by providing quantitative data supporting the influence of paternal oral hygiene behaviors on children's plaque scores, suggesting that paternal health practices merit further focus in future family-based oral health interventions.

In a separate study conducted in the refugee camps of Erbil [19], most parents displayed basic knowledge of oral hygiene but exhibited notable gaps, including limited

understanding of the significance of fluoride use and lack of awareness regarding when to initiate oral care for children. Such knowledge deficits may explain the similarities in plaque levels between children and their parents, as effective oral hygiene practices are neither adopted nor properly communicated. Furthermore, the parents interviewed tended to hold a generally negative attitude toward preventing early caries. These limitations in knowledge and unfavorable attitudes may perpetuate non-ideal practices, such as inadequate or delayed oral care and the absence of early dental visits. This study emphasizes the need for targeted educational programs to enhance parents' awareness of oral hygiene and caries prevention, ultimately improving home hygiene practices and decreasing the transmission of poor habits [21].

The limitations of our study depend on the sample size of 98 pairs which, though sufficient for initial findings, limits the generalizability of the results. Future studies with larger and more diverse samples are needed to validate our conclusions. Additionally, unmeasured confounding variables, such as socioeconomic status, dietary habits, and access to dental care, may be taken into consideration in further research.

Future research should use longitudinal designs to track oral health behaviors in families, adding variables like socioeconomic status and dietary habits to better understand influences on children's oral health. Studies on parental education, especially for fathers, could reveal how improved oral hygiene knowledge impacts children's plaque levels and overall dental health.

5. Conclusions

This study shows a strong link between plaque presence in parents and their children, highlighting the impact of parental habits on children's oral health. While parents generally value oral hygiene, fathers show a slightly higher plaque index, suggesting differences in practices or involvement. Supporting studies confirm that increased parental awareness improves children's oral health, though specific gaps remain in the knowledge of preventive care, such as fluoride use and early dental visits. These findings stress the importance of educational programs to improve parental understanding and habits, which could significantly lower the risk of dental plaque and caries in families.

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Informed Consent Statement: Written informed consent for publication was obtained from participating patients.

Data Availability Statement: The original contributions presented in the study are included in the article, further in-quiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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