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ORIGINAL RESEARCH

Oral Health Status in Children from the Community of Madrid, Spain: A Population-Based Cross-Sectional Investigation

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Purpose: To evaluate the oral health status of children aged 3–14 years in the Community of Madrid, Spain, between 2017 and 2020, and to identify associated protective and risk factors.

Methods: A cross-sectional, descriptive, and analytical study was conducted in 39 schools. Clinical examinations followed WHO guidelines and included caries detection (ICDAS codes 4–6), enamel developmental defects (DDE), tooth wear, malocclusion, and oral hygiene indicators. Sociodemographic data and oral hygiene habits were collected via parental questionnaires. Schools were stratified by socioeconomic status (SES). Statistical analyses were performed using SPSS v29 with a 95% confidence level ($p < 0.05$).

Results: Data from 11,646 children (mean age: 8.46 ± 1.99 years) revealed that 40.65% had caries in at least one tooth, and 9.42% had five or more affected teeth. Caries prevalence was higher among preschoolers (48.7%) than school-aged children (40.3%). Dental restorations were present in 10.5%, while only 11.7% had at least one sealant and 4.8% had all first permanent molars sealed. DDE affected 11% of children (mild: 8.1%, moderate: 2.5%, severe: 0.4%), tooth wear 4%, dental trauma 2%, and malocclusion 41.4%. Visible plaque was observed in 62.6% of participants, despite 50.5% reporting twice-daily brushing and 29.6% brushing three or more times per day. SES strongly influenced caries prevalence: 69.4% of children from low SES backgrounds had decayed teeth compared to 23.1% and 7.5% in medium and high SES groups, respectively. Logistic regression identified low SES (odds ratio (OR)=1.53, 95% CI: 1.03–2.28) as a risk factor for caries development, while absence of malocclusion (OR=0.54, 95% CI:0.32–0.93) and absence of visible plaque (OR=0.32, 95% CI: 0.20–0.51) as protective factors in preschool children. In school-aged children, low SES (OR = 3.66; 95% CI:3.21–4.18) increased the odds of caries; while toothbrushing ≥2 times/day showed a protective effect (OR range = 0.19–0.23) and absence of visible plaque (OR = 0.59; 95% CI:0.55–0.65 for absence vs presence).

Conclusion: Caries remains highly prevalent among children in Madrid, particularly in socioeconomically disadvantaged groups, highlighting the urgent need for targeted preventive strategies.

Keywords: dental caries, pediatric dentistry, dental status, oral health

Introduction

The World Health Organization (WHO) defines oral health (OH) as an integral state that enables the performance of essential functions such as eating, breathing, and speaking, while also significantly impacting psychosocial aspects such as self-esteem, well-being, and social interaction. This dimension of health evolves throughout the course of life, forming an inseparable part of overall health and determining individuals' ability to fully participate in society and achieve their full potential.[1] Besides, FDI (World Dental Federation) updated its OH definition as a multifaceted condition, which

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includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex.[2]

Dental caries is a chronic, multifactorial, dynamic, and non-communicable disease, mediated by biofilm and primarily influenced by diet. It is characterized by the progressive demineralization of hard dental tissues. Its onset is influenced by biological, behavioral, psychosocial, and environmental factors, leading to characteristic dental lesions.[3] Although caries is a preventable condition, recent global data indicate that children's OH has not shown substantial improvement in recent decades. It is estimated that approximately 573 million children had untreated caries in primary teeth as of 2015. Caries in permanent teeth is the most prevalent condition worldwide, with approximately 2.03 billion cases reported in 2019.[4,5] Moreover, OH-related quality of life (OHRQoL) is significantly lower in children affected by caries, particularly in disadvantaged socioeconomic status (SES). This underscores the importance of assessing this indicator to develop effective and targeted interventions.[6] The highest prevalence of caries has been identified in the Western Pacific Region (46%), while the lowest prevalence is observed in the African Region (39%). Similarly, the greatest absolute number of cases is concentrated in the South-East Asia Region, with approximately 135 million cases, whereas Europe reports the lowest number, at around 41 million.[1] Between 1990 and 2019, although a 3% reduction in the global average prevalence of caries in deciduous teeth was observed, the absolute number of cases increased by 6%. This increase has been particularly pronounced in low-income and lower-middle-income countries.[1] Good brushing habits, higher maternal education, help with tooth brushing, among others, have been described as protectors against caries.[7]

According to European data, in a recent systematic review with meta-analysis,[8] a significant association was found between Gross National Income (GNI) and caries, the lower income category, the higher caries experience. Also, the countries of West Europe presented the lowest experience of caries, followed by North European countries, and finally, the East and South European countries. However, unemployment rate or Human Development Index were not strongly related. Besides, per capita expenditure on dental health care was related to caries index, showing that all countries with per capita expenditure on dental health above 100USD (included Spain) had lower mean caries index than the overall pooled mean caries index. In Spain[9] the prevalence of caries among children aged 5 to 6 years has remained relatively stable in recent years (35.5% in 2020 compared to 38% in 1993). However, a slight increase has been recorded in the decayed, missing, and filled teeth index, rising from 0.97 to 1.28. Early childhood caries (ECC) is defined as the presence of one or more decayed, missing or filled tooth in any primary in a child under 71 months (6 years) of age. ECC differs from caries in adults mainly due to its rapid progression. Besides, it is considered an indicator of social inequality, as it disproportionately affects children from disadvantaged SES backgrounds, ethnic minorities, and single-parent families.[10,11] Numerous studies have highlighted the urgent need for targeted interventions and inclusive public health policies.[5]

Among oral diseases in children, tooth wear (TW), dental trauma, and developmental defects of enamel (DDE) are highlighted. Dental trauma overall prevalence in Spain is estimated in 9.94%, with higher prevalence in males than females, and in children compared to teenagers.[12] TW was positive associated with education, family income, and private school among teenagers.[13] DDE in primary or permanent dentition prevalence in Spanish children aged 2–15 is 27.15%.[14]

As part of its plan to eliminate caries in children, the WHO recommends the early detection of carious lesions, the integration of OH assessments into primary care, and the inclusion of community-based health interventions.[11] Although Spain presents notable regional variations in socioeconomic composition and health indicators, the Community of Madrid constitutes one of the most densely populated and socioeconomically diverse regions in the country. Madrid combines urban, suburban, and semiurban districts with wide SES gradients, and hosts a large proportion of Spain's school-aged population. For these reasons, epidemiological data from Madrid are considered informative for understanding national pediatric OH patterns, although they cannot fully replace nationally representative studies. The main hypothesis was "Children from lower SES strata will exhibit higher odds and greater severity of cavitated caries and OH than peers from medium/high SES, in both preschool and school-aged groups". The aim was to conduct an epidemiological study to evaluate the OH status of children in the Community of Madrid between 2017 and 2020.

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Materials and Methods

Study Design

A cross-sectional, descriptive, and analytical study with prospective data was conducted. This manuscript complied with the STROBE guidelines for reporting cross-sectional research[15] and was prepared according to the Reporting Standards for research in Paediatric Dentistry (RAPID).[16]

Ethics Statement

This research was conducted with the acceptance of the Institutional Bioethical Committee (code 2024_4/267, acceptance date 9th May 2024) and complies with the requirements of the Declaration of Helsinki for biomedical research. Parents or legal guardians were properly informed with a written informational document, and Informed Consent was obtained prior to this study. Besides, the children's assent was also required to participate in this study. Due to national and European data protection regulations, all participants were encoded and blinded both in the data sheets and database. The principal investigator administered the data during this study and eliminated personal data after this research was finished.

Participants and Sample Size

Several schools located in the Community of Madrid were invited between 2017 and 2020 to participate in an educational dental project with the University (BLINDED). Finally, 39 schools accepted, so the study population was children from the participating schools (Supplementary File T1). Prior to dental visit, all Schools were informed about the data collection and the educational and research purpose of the dental project. Parents or legal guardians were informed with an Informed Consent, and only children whose parents agreed to participate, and signed Informed Consent were explored by the pediatric dentists. Inclusion criteria for the study were (1) children under 14 years old, (2) who studied at the 39 visited Schools, (3) whose parents or legal guardians accepted to participate in the program. Children whose parents or legal guardians did not sign the Informed Consent at the exploration date, with systemic disease, special needs or craniofacial syndromes were excluded from the study. During the preliminary visit to the schools, the available resources were assessed, revealing that none of them had oral hygiene facilities. Therefore, no distinction was made between public and semi-private/private schools. A non-probabilistic sampling of consecutive cases was conducted, including data of explored children.

Outcomes

The participating institutions (Supplementary Table T1) included public, semiprivate, and private schools from the Community of Madrid. However, no distinction was made between school types, as none of the evaluated schools included oral hygiene education, nor did they have facilities or resources for students' oral hygiene. Therefore, it was considered that access to oral hygiene did not differ based on the type of school. Instead, schools were classified according to their SES based on district, neighborhood, and census tract income indicators. Schools were classified as having a high, medium, or low SES based on average income indicators by district, neighborhood, and census tract, using data from 2017 to 2020 provided by the Madrid City Council, which draws from National Statistics Institute and EPdata sources (Urban Audit - Ayuntamiento de Madrid, accessed on February 2024).

Demographic data such as age, gender, school, exploration date, and scholar course were recorded. We collected the educational stage, categorizing into four groups. We distinguished between pre-scholar and scholar stage. Schoolar stage was categorized according to Royal Decree 157/2022, of March 1, which establishes the structure and minimum educational requirements for Primary Education, organizes this stage into three cycles, each comprising two academic years. Accordingly, a distinction is made between the first cycle (1st and 2nd grade), the second cycle (3rd and 4th grade), and the third cycle (5th and 6th grade).

We collected caries index and dental status according to the WHO manual which provides guidelines for assessing the current OH status of a population.[17] Because the primary objective of the study was to estimate the overall prevalence of cavitated caries at the population level, we did not differentiate between primary and permanent teeth, consistent with

WHO Basic Methods for epidemiological surveys. This approach provides a unified estimate of disease burden across the full pediatric age range and facilitates comparisons with national and international surveillance studies that also use cavitated-lesion thresholds. According to WHO manual, we collected decayed (D+d), missed (M+m) and filled (F+f) tooth. It was recorded as absent, present in one, two, three, four, or five or more teeth. The presence of pit and fissure sealants was recorded in one, two, three, or all four first permanent molars. Bacterial dental plaque was recorded through direct visual examination dichotomy as present (soft debris or extrinsic stains in buccal or lingual surfaces) or absence. According to the International Caries Detection and Assessment System (ICDAS), caries presence was diagnosed as ICDAS codes 4 to 6, while "caries-free" status was considered ICDAS codes 0 to 3.[18] ICDAS scores 0–3 were grouped as "caries-free", while ICDAS 4–6 were considered "caries present". Following the WHO Basic Methods,[17] which define epidemiological caries as clinically cavitated lesions detected visually without drying. ICDAS 1–3 represent early-stage, non-cavitated enamel changes but not classified as cavitated disease in WHO surveillance. Grouping ICDAS 0–3 allows comparability with WHO-based national surveys and with previous Spanish and international epidemiological reports, where cavitated lesions are the diagnostic threshold for caries prevalence assessments.

Along with the signed Informed Consent, parents were surveyed regarding whether their children had experienced any dental trauma and the number of times their children brushed their teeth per day. To cross-check the information, children were also asked how many times per day they brushed their teeth. This variable was categorized as a qualitative categorical variable. According to FDI, malocclusion is defined as the irregularity of the teeth, or a mal relationship of the dental arches beyond the range is accepted as normal.[19] Dental malocclusion was recorded as dichotomous variable. Pathological or erosive TW was recorded as absent (no erosive TW), initial loss or enamel surface, distinct defect, or hard tissue loss less than 50%, or hard tissue loss more than 50% of the surface according to Bartlett et al[20] DDE were documented according to the DDE index modified for epidemiological research, approved by the FDI,[21] according to the extension as normal, less than one-third (mild), from one- to two.-thirds (moderate), or more than two-thirds (severe).

Study Procedure

The selection of participating schools was conducted through direct telephone contact with the administration of each institution, during which the objectives and procedures of the study were explained in detail. Schools that expressed interest and requested further information were subsequently provided with a comprehensive document via Email outlining the methodology for the students' intraoral examinations. In the schools that agreed to participate, a preliminary visit was conducted jointly with the dental professional team to familiarize themselves with the school setting, organize the clinical assessments, and strengthen coordination with school staff. Together with each institution, a detailed information sheet for families was prepared, accompanied by an Informed Consent form and a brief questionnaire soliciting relevant data. Dates for the dental examinations were then scheduled accordingly.

Examinations were consistently conducted at the beginning of the school day to ensure that students had not consumed food beforehand, thereby minimizing potential interference with the clinical evaluation. Dental explorations were conducted according to the WHO manual[17] which provides guidelines for assessing the current OH status of a population. Prior to each examination, informed consent signed by the families was verified. A research data sheet was completed, and a short report on the OH status of each child was generated and subsequently shared with their family.

Although several schools were visited in more than one year, each child was examined only once, corresponding to the academic year in which the school agreed to participate. No participant was reexamined in subsequent years, and no repeated observations from the same subject were included in the dataset. Therefore, all data points represent independent cross-sectional observations, and no longitudinal structure or within subject clustering was present, ensuring that the statistical analyses used were appropriate.

Blinding

The data were collected by university professors who were experimented pediatric dentists, previously calibrated and trained in the study procedure. The calibration procedure was carried out with the International Caries Classification and

Management System (ICCMSTM) guide for practitioners and educators[18] until the consistency level was higher than 90%. During dental explorations, while the main operator was blinded to the reported data by the family while dental exploration, the second operator extracted data from the questionnaire and wrote down data from the dental exploration, to maintain blinding. Also, the data analysis was conducted by a blinded statistical expert.

Statistical Analysis

Data were analysed using descriptive methods, both for quantitative (mean and standard deviation) and qualitative (frequency and percentage) variables. Due to differences in age group distribution, inferential analysis was conducted separately for the preschool and school-aged populations. Normality of distribution was assessed using the Kolmogorov–Smirnov (KS) test, and homogeneity of variable distribution was evaluated using the Chi square (χ^2) test. χ^2 and Fisher's exact tests were used for cross-analysis of qualitative variables. A binary logistic regression model was applied for caries (no/yes). An ordinal regression analysis was performed to assess the effect of independent variables on the caries index. Due to the cross-sectional design of the study, all regression coefficients must be interpreted as associations, not causal effects. In the preschool subgroup, some variables showed near-complete separation due to very low prevalence. These predictors (eg, rare categories of DDE, tooth wear, or restored/missing teeth) were initially retained because they represent clinically relevant risk factors and were part of our prespecified conceptual model, a practice recommended in explanatory epidemiological modelling to avoid residual confounding even when estimation may be unstable Nonetheless, given the sparse-cell structure, the final preschool model was simplified to retain only predictors with adequate frequency and clinical importance to ensure numerical stability.

Statistical analyses were conducted with SPSS software for Windows (version 29.0, IBM SPSS Statistics, Chicago, IL, USA), with 95% confidence interval (p value <0.05) and asymptotic significance.

Results

Overall Results

Data from 11,646 children (age range: 3–14 years) were obtained (children distribution by school and educational level is available in Supplementary Table T1). The mean age of the overall sample was 8.46±1.987 years; 8.48±1.974 years for boys and 8.45±2.001 years for girls. Age distribution did not meet the criteria for normality (Kolmogorov–Smirnov test, p<0.001), nor was it homogeneous across age groups (X^2-test, p<0.001). However, age groups were homogeneously distributed by gender (X^2-test, p=0.270), and no statistically significant differences were found between boys and girls in terms of mean age (*T*-test, p=0.410). Children came from various SES backgrounds (X^2-test, p<0.001), with the majority belonging to a low SES (57.6%), and fewer from middle (28.1%) or high (14.3%) SES. Regarding gender, 53.6% identified as boys and 46.4% as girls, with a heterogeneous distribution in the overall sample (X^2-test, p<0.001). In terms of educational level, 4% were enrolled in preschool, while the remaining students were distributed across the first (35.2%), second (31.3%), or third (29.4%) cycles of primary education.

The values of the caries indices are illustrated in Figure 1. As observed, most children were free of decayed, filled, or missed teeth; however, it is notable that 40.65% of the examined children had caries in at least one tooth, and 9.42% had caries in five or more teeth. Additionally, 10.51% of children already filled teeth, and nearly 1% had lost at least one tooth. Regarding dental sealants, only 11.7% had at least one sealant, and only 4.8% had all first permanent molars sealed. Concerning other variables analyzed, 11% of the children exhibited enamel developmental defects, categorized as mild (8.1%), moderate (2.5%), or severe (0.4%). TW was present in 4% of the children, mainly affecting the enamel (3.1%), less frequently the dentin (0.8%), and pulpal exposure was rare (0.1%). A history of dental trauma was reported in 2% of the children, and 41.4% exhibited some degree of dental malocclusion. Regarding tooth brushing habits, most of the examined children (62.6%) had visible dental plaque, with half of them (50.5%) reporting brushing their teeth twice daily. However, 29.6% reported brushing three or more times per day.

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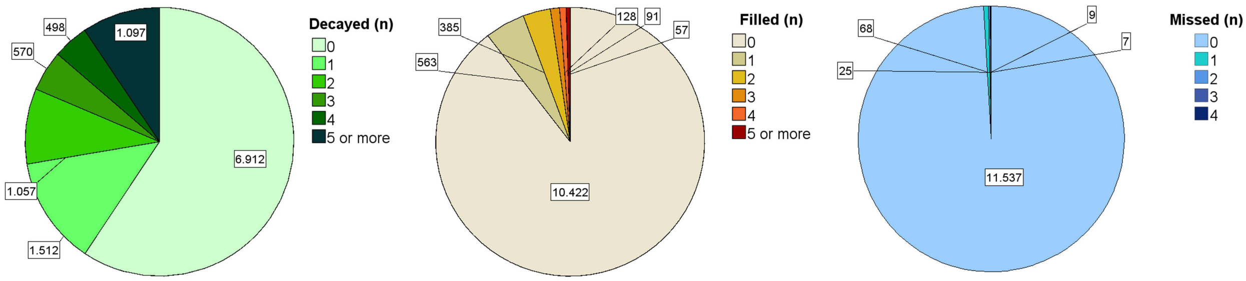

Figure 1 Distribution of different categories of affected teeth (n) among the three components (decayed, filled and missed teeth) of the caries indices.

Pre-School Sample

The sample of children enrolled in preschool courses consisted of 468 children, evenly distributed by gender (50.6% boys and 49.4% girls) (X^2-test, p=0.781). The age range was between 2 and 6 years, with a mean age of 4.37±0.906 years (4.38±0.929 for boys and 4.37±0.884 for girls) and no differences by gender (U Mann–Whitney, p=0.948). Age distribution did not meet the criteria for normality (Kolmogorov–Smirnov test, p<0.001) nor categorical homogeneity (X^2-test, p<0.001). However, the distribution of age categories by sex was homogeneous (X^2-test, p=0.653). Regarding SES, the evaluated children belonged to either low (62.2%) or middle (37.8%) SES, showing an asymmetric distribution (X^2-test, p<0.001).

Regarding caries indices (Table 1), 51.3% of the children were caries-free. However, there was a notable prevalence of children with five or more decayed teeth, followed by one and two decayed teeth. Only two children had missed tooth, with one child with two missed teeth and another with four missed teeth. Concerning filled teeth, only 4.3% of children had dental restorations, with the most common finding one filled tooth (2.6%).

Regarding DDE, their prevalence was very low, with mild changes observed at 3.6% and moderate alterations in 0.6%. Pathological dental wear was identified in 2.6% of the sample, with excessive enamel wear in 2.1% of children, and dentin exposure in 0.4% of the study sample. Dental trauma had been experienced by 2.4% of the children. Malocclusion was found in 15.8% of the cases. With respect to oral hygiene, visible dental plaque was present in 56.6% of the children. Most children (48.3%) reported brushing their teeth twice a day regularly, while brushing only once a day was also common (34.6%). Notably, 16.7% stated that they brushed their teeth three or more times daily, while 0.4% reported not brushing their teeth regularly.

Dental caries was analyzed as a dichotomous variable, revealing significant differences in its prevalence related to dental malocclusion (χ^2 p=0.006), SES (χ^2 p=0.007), daily toothbrushing (Fisher p<0.001), and the presence of dental plaque (χ^2 p<0.001). No statistically significant associations were found with DDE, dental wear, missed or filled teeth, or gender (χ^2 and

Table 1 Descriptive Statistics (Frequency and Percentage) of Affected Tooth of the Three Components of Caries Indices in Preschool Participants

Tooth Affected (n)	Decayed		Missed		Filled	
	N	%	N	%	N	%
0	240	51.3	466	99.6	448	95.7
1	57	12.2	–	–	12	2.6
2	53	11.3	1	0.2	4	0.9
3	25	5.3	–	–	2	0.4
4	22	4.7	1	0.2	2	0.4
≥5	71	15.2	–	–	–	–

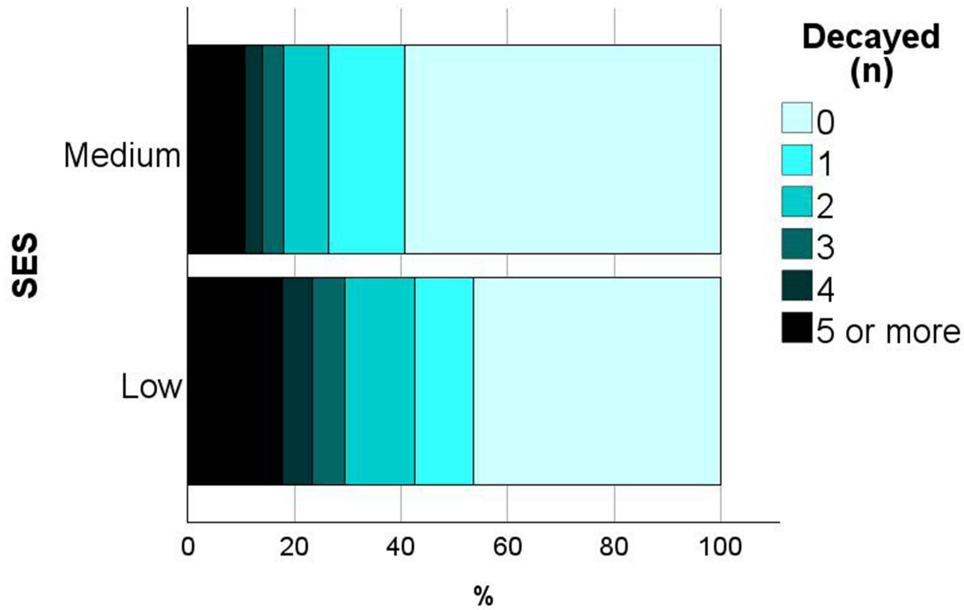

Figure 2 Percentage of decayed teeth according to SES in pre-school participants.

Fisher p>0.05 for all comparisons). Caries prevalence was notably higher in children with malocclusion (63.5%), those with visible dental plaque (61.5%), those who brushed only once per day (62.3%), and those from lower SES backgrounds (53.6%).

Pairwise comparisons revealed statistically significant differences in caries behavior across SES strata (Figure 2). Children from low SES backgrounds exhibited a caries prevalence of 53.6%, significantly higher than the 40.7% observed in children from medium SES (χ^2 p=0.007). The number of carious lesions was also significantly associated with SES (χ^2 p=0.031), with children from lower SES backgrounds more frequently presenting with five or more caries (17.9%) compared to their medium-level counterparts (10.7%). Conversely, caries-free status was more prevalent among children from medium SES backgrounds (59.3%) than those from lower levels (46.4%). On contrary, no significant differences were found in the prevalence of missing or restored teeth according to SES (χ^2 and Fisher p>0.05).

Regarding the relationship between gender and evaluated outcomes, no significant differences were found in relation to caries number or presence, filled or missed tooth, sealed molars, DDE, TW, dental trauma, bacterial plaque or malocclusion (p>0.05 for all comparisons).

The findings indicate that SES does not significantly influence the prevalence of DDE (Fisher p=0.375), dental trauma (χ^2 p=0.174), malocclusion (χ^2 p=0.604), or daily toothbrushing frequency (Fisher p=0.249). However, significant differences were observed in dental wear (Fisher p=0.002), with 63.4% of children without dental wear belonging to the low SES group, while 80% of children with pathological enamel wear and 100% with dentin exposure were from the medium SES group, suggesting a higher prevalence of pathological TW among children with better SES. Moreover, visible bacterial plaque differed significantly by SES (χ^2 p=0.019), being less common among children from higher SES backgrounds, than children belonging to low or medium SES group (60.8% vs. 49.7%).

A multivariable logistic regression model was performed to evaluate the association between SES, malocclusion, bacterial plaque, and daily toothbrushing with the presence of dental caries (binary outcome) (Table 2). The overall model was statistically significant ($\chi^2(4)=50.42$, Nagelkerke R^2 of 0.136, $p<0.001$). After adjustment for all covariates, children from lower SES demonstrated significantly higher odds of presenting caries (odds ratio (OR)=1.53, 95% CI: 1.03–2.278; $p=0.035$). The absence of malocclusion was associated with a reduced likelihood of caries (OR=0.54, 95% CI:0.317–0.929 $p=0.026$). Bacterial plaque presence remained the strongest outcome related to caries in the model, decreasing the odds of being caries-free by approximately 68% (OR=0.32, 95% CI: 0.202–0.511; $p<0.001$). In contrast, daily toothbrushing did not show a significant association with caries experience ($p=0.849$). The predictive accuracy of the model improved from 51.3% in the null model to 64.3% after including the predictors.

Table 2 Binary Logistic Regression Model in Pre-School Sample

	B	SE	Wald	Sig.	Exp (B)	95% C.I.	
						Lower	Upper
SES (low)	0.426	0.202	4.434	0.035*	1.532	1.030	2.278
Malocclusion (none)	−0.611	0.0274	4.963	0.026*	0.543	0.317	0.929
Dental plaque (no)	−1.135	0.236	23.076	<0.001*	0.321	0.202	0.511
Daily toothbrush	−0.031	0.161	0.036	0.849	0.970	0.707	1.330
Constant	0.737	0.375	3.872	0.049	2.090		

Note: * Sig., statistically significant p<0.05.
Abbreviations: SE, standard error; SES, socioeconomic status.

An ordinal logistic regression was conducted to explore the association between malocclusion, visible plaque, SES, and daily toothbrushing with increasing levels of caries severity. The final model demonstrated a significant improvement in fit compared with the intercept-only model ($\chi^2(4)=52.82$, Nagelkerke $R^2=0.113$, $p<0.001$), and the assumption of proportional odds was satisfied ($\chi^2(16)=21.76$, $p=0.151$). Children without visible bacterial plaque had substantially lower odds of being in higher caries categories ($\beta=-1.12$, $p<0.001$), while those from lower SES exhibited increased odds of more severe caries ($\beta=0.47$, $p=0.013$). Malocclusion showed a trend toward significance ($p=0.057$), and daily toothbrushing frequency was not significantly related to caries severity ($p=0.880$).

In preschool children, estimates indicating apparent protective effects should be interpreted as non-causal statistical associations, likely influenced by low cell counts and sparse data structure, rather than true protective mechanisms.

School Sample

A total of 11,178 primary school children were analyzed (53.7% boys and 46.3% girls). The mean age was 8.63±1.83 years (8.64±1.824 in boys and 8.63±1.837 in girls), with no significant gender differences (U Mann–Whitney p=0.768). Age and gender categories did not meet homogeneity assumptions (χ^2 p<0.001), and age did not conform to a normal distribution (Kolmogorov–Smirnov test p<0.001). The children were evenly distributed across the three primary education cycles: first cycle (36.7%), second cycle (32.7%), and third cycle (30.7%). Regarding SES, most children belonged to the low SES group (57.4%), followed by medium (27.7%) and high (14.9%) levels (χ^2 p<0.001).

Regarding caries indices (Table 3), a caries prevalence of 40.3% was observed among the examined children, with the most common finding being one decayed tooth (13%). A notable proportion presented five or more decayed teeth (9.2%).

Table 3 Descriptive Statistics (Frequency and Percentage) of Affected Tooth of the Three Components of Caries Indices in School Participants

Tooth Affected (n)	Decayed		Missed		Filled	
	N	%	N	%	N	%
0	6672	59.7	11,071	99.0	9974	89.2
1	1455	13.0	68	0.6	551	4.9
2	1004	9.0	24	0.2	381	3.4
3	545	4.9	9	0.1	126	1.1
4	476	4.3	6	0.1	89	0.8
≥5	1026	9.2	–	–	57	0.5

Among school-aged children, the prevalence of dental restorations was 10.8%, most frequently involving one (4.9%) or two (3.4%) teeth. The prevalence of missing teeth was very low (1%). Regarding the presence of pit and fissure sealants, the prevalence was 12.2%; however, only 5% of children had sealants placed on all four first permanent molars.

A total of 11.3% of the examined children presented DDE, predominantly mild (8.3%), though moderate (2.6%) and severe (0.5%) alterations were also reported. Pathological TW was observed in 4.1% of the sample, mainly restricted to enamel (3.2%). Dental trauma history was identified in 2% of the children, while malocclusion was present in 42.5% of the evaluated cohort. With respect to oral hygiene, visible bacterial plaque was found in the majority of children (62.8%). Most children reported brushing their teeth two (50.6%) or three times daily (28%), although toothbrushing once a day was also common (19.1%).

The presence of decayed teeth was significantly associated with previously restored teeth (X^2 $p<0.001$), with 14.15% of children exhibiting filled teeth, and 1.55% having missed teeth. Notably, 75% of children with all four molars sealed were caries-free, while 40% of children without sealants presented dental caries (X^2 $p<0.001$). Paired analysis revealed statistically significant differences in relation to the prevalence of DDE, TW, dental trauma, malocclusion, and visible plaque accumulation (X^2 $p<0.001$ across all comparisons). Regarding DDE, 39.59% of children with enamel defects were free of dental caries, compared to 60.40% who exhibited decayed teeth. Children with caries showed significantly higher levels of enamel wear (4.06%), dentin exposure (1.24%), and pulp involvement (0.15%) compared to their caries-free counterparts (2.56%, 0.49%, and 0.04%, respectively). Dental trauma was also more prevalent among children with caries (2.77%) than those without (1.53%). Malocclusion alterations were observed in 45.36% of children with caries compared to 40.51% without caries. Additionally, the presence of visible dental plaque was higher in children with carious lesions (71.32%) than in caries-free children (57.06%).

A paired analysis was conducted to examine the effect of SES, revealing that both the prevalence of dental caries and the number of affected teeth were significantly associated with SES (X^2 $p<0.001$) (Figure 3). Specifically, 69.4% of children from low SES backgrounds presented decayed teeth, compared to 23.1% and 7.5% among those from higher SES. No statistically significant differences were found regarding the presence of dental fillings (X^2 $p=0.26$) or the number of restored teeth (X^2 $p=0.751$), nor in the presence (X^2 $p=0.476$) or number of teeth lost due to caries (X^2 $p=0.551$).

In addition, 7.83% of children from high SES backgrounds had sealants on all four permanent molars, compared to only 3.77% among those from lower SES (X^2 $p<0.001$). TW also demonstrated significant differences (X^2 $p=0.02$), with

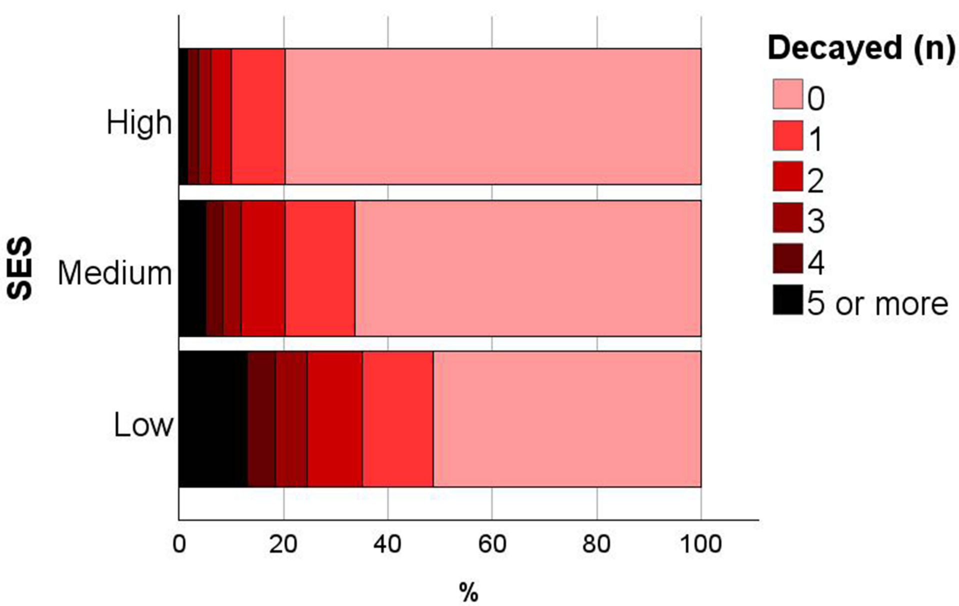

Figure 3 Percentage of decayed teeth according to SES in school participants.

a higher prevalence observed in children from lower SES backgrounds (4.46%) compared to those from higher levels (2.99%), along with increased severity of wear. The prevalence of dental trauma was significantly greater in children from low SES backgrounds (2.59%) than in children from middle (1.32%) or high (1.19%) SES (X^2 p<0.001). Similarly, the prevalence of malocclusion was higher among children from low SES backgrounds (43.95%) compared to those from middle or high levels (41.03% vs. 39.44%) (X^2 p=0.001). Visible plaque accumulation was also more frequent among children from middle and low SES backgrounds compared to those from high SES (63.97% vs. 52.72%) (X^2 p<0.001).

In relation to gender, no significant differences were found regarding decayed, filled, sealed or missed tooth or presence (p>0.05 for all comparisons). Neither analyzing DDE (X^2 p=0.215). However, significant differences were found related to TW (X^2 p=0.026), malocclusion (X^2 p<0.001), bacterial plaque presence (X^2 p<0.001) and dental trauma (X^2 p=0.021). The obtained results indicate that males present higher prevalence of TW (4.52% vs 3.51%) and dental traumatism (2.32% vs 1.69%) than females. Besides, the absence of visual bacterial plaque was more prevalent in females (38.96% vs 35.66%). On the other hand, females showed a higher malocclusion (44.39% vs 40.81%) prevalence than males.

The multivariate logistic regression (Table 4) model evaluating predictors of dental caries was statistically significant overall ($\chi^2 = 941.63$, df = 19, $p < 0.001$), confirming that the included variables collectively contributed to caries risk. The model explained 8.1–10.9% of the variance (Cox & Snell $R^2 = 0.081$; Nagelkerke $R^2 = 0.109$) and achieved a global classification accuracy of 63.9%, with higher sensitivity for caries absence (79.0%) than presence (41.5%). Several predictors demonstrated strong and clinically relevant associations. SES emerged as the most influential factor, children from low SES households had 61.9 percentual points of caries compared to those from high SES families (OR = 3.659; 95% CI: 3.206–4.176; $p < 0.001$), while middle SES status also increased risk 46.3 percentual points (OR = 1.916; 95%

Table 4 Binary Logistic Regression Model in School Sample

	B	SE	Wald	p value	Exp (B)	95% C.I.	
						Lower	Upper
Age	−0.009	0.011	0.637	0.425	0.991	0.969	1.013
Gender (male)	−0.120	0.041	8.728	0.003*	0.887	0.819	0.960
SES			471.577	0.000*			
SES (low)	1.297	0.067	370.245	0.000*	3.659	3.206	4.176
SES (medium)	0.650	0.073	78.635	0.000*	1.916	1.660	2.212
Filled (no)	−0.570	0.064	79.562	0.000*	0.566	0.499	0.641
Missed (no)	−1.013	0.215	22.245	0.000*	0.363	0.238	0.553
Daily toothbrush			24.300	0.000*			
Daily toothbrush (no)	−0.183	1.022	0.032	0.858	0.832	0.112	6.168
Daily toothbrush (1)	−1.476	0.816	3.270	0.071	0.229	0.046	1.132
Daily toothbrush (2)	−1.650	0.815	4.094	0.043*	0.192	0.039	0.950
Daily toothbrush (3)	−1.712	0.816	4.405	0.036*	0.180	0.036	0.893
Daily toothbrush (4)	−1.616	0.827	3.821	0.051	0.199	0.039	1.004
TW			19.288	0.000*			
TW (no)	−0.680	0.704	0.932	0.334	0.507	0.128	2.014
TW (enamel)	−0.354	0.712	0.246	0.620	0.702	0.174	2.837

(*Continued*)

Table 4 (Continued).

	B	SE	Wald	p value	Exp (B)	95% C.I.	
						Lower	Upper
TW (dentin)	0.071	0.740	0.009	0.924	1.073	0.252	4.574
Malocclusion (no)	−0.096	0.042	5.373	0.020*	0.908	0.837	0.985
Dental plaque	−0.514	0.046	126.982	0.000*	0.598	0.547	0.654
DDE			13.312	0.004*			
DDE (mild)	−0.839	0.304	7.620	0.006*	0.432	0.238	0.784
DDE (moderate)	−0.703	0.311	5.110	0.024*	0.495	0.269	0.911
DDE (severe)	−0.623	0.328	3.623	0.057	0.536	0.282	1.019
Constant	3.653	1.135	10.360	0.001*	38.600		

Note: * Sig., statistically significant p<0.05.
Abbreviations: SE, standard error; SES, socioeconomic.

CI: 1.660–2.212; $p < 0.001$). Presence of bacterial plaque significantly elevated caries risk (OR = 0.598; 95% CI: 0.547–0.654; $p < 0.001$) in 14.26 percentual points compared to children with plaque absence. Conversely, previous restorative or surgical treatment (filled and missed tooth) were associated with reduced caries presence in 14 and 22.4 percentual points, respectively (OR = 0.566 and OR = 0.363, respectively; both $p < 0.001$). Daily brushing frequency showed a dose-response effect, brushing ≥2 times/day markedly reduced caries risk compared to no brushing (OR range: 0.192–0.229; $p < 0.05$). DDE (mild to moderate) were also significant (OR range: 0.432–0.495; $p < 0.05$), suggesting that developmental defects may predispose to caries despite preventive measures. Malocclusion and gender exhibited modest but significant effects (OR = 0.908 for malocclusion; OR = 0.887 for female gender; both $p < 0.05$). However, age and TW were not significant predictors.

The ordinal regression model was statistically significant overall (Δ−2LL = 1134.20; df = 19; $p < 0.001$), indicating that the included variables collectively explained variation in caries severity. The model showed modest explanatory power (Nagelkerke $R^2 = 0.104$; McFadden $R^2 = 0.039$) and acceptable fit based on deviance (p = 1.000), although Pearson χ^2 suggested potential lack of fit ($p < 0.001$), likely due to sparse cells (68.4% zero-frequency combinations). The test of parallel lines was significant ($p < 0.001$), suggesting violation of the proportional-odds assumption; therefore, interpretation should be cautious. SES was the strongest determinant, low SES increased odds of higher caries severity by approximately 3.95 times (β = 1.374; $p < 0.001$), and medium SES by 1.92 times (β = 0.652; $p < 0.001$), compared to high SES. Presence of bacterial plaque was highly associated with greater severity (β = −0.570; $p < 0.001$; OR ≈ 0.57 for absence vs presence), confirming plaque as a critical risk factor. TW (absence vs enamel/dentin involvement) showed strong protective effects (β range: −1.832 to −1.551; $p \leq 0.010$), suggesting that advanced wear correlates with higher caries burden. Daily brushing frequency demonstrated a dose-response effect: brushing ≥2 times/day significantly reduced odds of higher severity (β ≈ −1.25 to −1.31; $p \approx 0.03$–0.04), reinforcing preventive benefits. Children with missed or filled teeth showed lower OR values compared with the reference category (β = −0.922 and −0.385; both $p < 0.001$), reflecting increased follow-up care. Age and gender were significant but with small effects: older age slightly reduced severity (β = −0.035; $p = 0.001$), and females had lower odds than males (β = −0.130; $p = 0.001$). DDE was not significant in this model.

In school-aged children, regression coefficients similarly reflect associative, not causal, relationships; counterintuitive patterns (eg, mild or moderate DDE showing lower odds of caries) most likely arise from confounding or differential diagnostic patterns, not biological protection.

Discussion

A cross-sectional, retrospective, descriptive, and analytical study was conducted. While similar cross-sectional studies have been reported in the literature,[22–33] additional epidemiological[34,35] and longitudinal.[36,37] Research designs have also been identified, offering broader insights into OH trends over time and population-level determinants. These diverse methodological approaches contribute complementary perspectives that enrich the understanding of pediatric OH dynamics. Regarding the study population, previous research in Spain have been conducted,[29,30,32,33,35] although other populations have been also studied, finding previous researches in India,[24,31] Australia,[38] Brazil,[22,27] Egypt,[23] Slovakia,[39] Africa,[25,28,34] Servia,[26] western Asia,[40] Korea,[37] China[36] can be found.

The interpretation of our findings must also consider the representativeness of Madrid within the Spanish context. The Community of Madrid, despite being highly diverse in terms of SES distribution, migration patterns, and school typology, does not fully capture the heterogeneity of other Spanish regions, some of which differ markedly in rurality, fluoridation practices, and access to preventive programs. Therefore, while the large sample size and socioeconomic variability of Madrid offer valuable insights into national pediatric OH trends, the results should be extrapolated to the broader Spanish population with caution.

Sample sizes among existing cross-sectional studies on pediatric OH are highly variable, with no consistency in the population sizes examined. Some investigations have included fewer than 410 participants,[22,23,25,26,37] while others have analyzed samples ranging from 650 to 900 children[31,39] or between 1000 and 2200 participants.[24,27,28,34] In Spain, five relevant studies were identified: some with fewer than 400 participants,[29,30] others with sample sizes between 650 and 900,[32,35] and the largest Spanish study with 1397 children.[33] By contrast, our study included a total of 11,646 children, making it the largest pediatric sample reported in scientific literature to date.

Although previous studies have applied classifications based on population rurality or school type (public or private), in our case, the sample was stratified according to population income. This decision was because, within the region studied (Community of Madrid), there are no differences in access to OH services depending on geographical location or school type. Regarding age, no consistent criteria were found across studies for sample selection. In our research, children were classified as preschoolers (under 6 years old) and school-aged (6 years and older), in addition to categorization by academic cycle. Studies have been conducted exclusively in preschool children,[25,27] in school-aged children and adolescents,[22,26,28,31,34,37] and in populations spanning a broad age range without differentiation between preschoolers and school-aged children.[23,24,36,39] Spanish studies also exhibit heterogeneity in the age ranges of participants, including cohort studies of children aged 5–10 years[29] or 6–14 years;[33] comparative studies between two age groups[30] aged 6–12 and 13–18 years; studies comparing age groups of 6, 12, and 15 years;[32] and studies including children aged 6, 9, and 12 years.[35]

Regarding evaluation methodology, our study was conducted by two calibrated examiners, consistent with the studies by Ferizi et al[26] and Cortés Martinicorena et al[33] Other studies reported data collection by one calibrated examiner,[22,24,25,28,30,31,34,39] four calibrated examiners,[36] or six calibrated examiners.[23,32] The study by Borges et al[27] involved five examiners who were not calibrated. Undergraduate students conducted additional research.[29,35]

Most studies followed a similar examination methodology to ours, conducted in school classrooms with children seated in chairs, using a plane mirror under natural light, without drying the teeth prior to inspection.[25–28,30,34,36] However, Álvarez-Arenal et al[35] conducted their study using dental equipment, including a dental chair, mirror, and a portable air compressor to dry the teeth. In contrast, Dalla Nora et al[22] performed clinical examinations in schools with children in a supine position using portable equipment (artificial light, air compressor, and suction system).

In several studies, sociodemographic and covariate data were collected through parental questionnaires,[22,25–27,33] as was done in our study. OH, status data collection followed WHO methodology based on the caries index. Like García-Barata et al,[30] we employed the latest version Other authors followed earlier versions.[22–28,31,32,35–37,39] Most authors conducted clinical examinations including all erupted permanent teeth[22,26,31,37] or all erupted primary teeth.[25] Some studies examined both dentitions.[23,29,30,32,33,36,39–41] In our study, the presence of caries was assessed using ICDAS criteria without differentiating between primary and permanent dentition. Other authors[22,27,32,33] also considered criteria for non-cavitated lesions and dental caries experience. Additionally, our study evaluated other parameters as covariates,

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like other studies, including malocclusion, history of dental trauma, pathological or erosive TW, and visible bacterial plaque.[29–31,33,37]

Caries prevalence varies depending on the populations studied. In our sample, the overall prevalence of caries in at least one tooth was 40.65%, with 9.42% of children presenting caries in five or more teeth. When stratified by study groups, 51.3% of preschool children were caries-free. However, a notable proportion had caries in five or more teeth (15.2%), followed by caries in one tooth (12.2%) and two teeth (11.3%). Among school-aged children, caries prevalence was 40.3%, with the most frequent finding being caries in a single tooth (13%). A high prevalence of caries in five or more teeth was also observed (9.2%). By contrast, Longas-Bravo et al[42] documented a lower (30.7%) prevalence in children aged 6–14 years, with a cod of 0.98 at age 6 and a CAOD of 1.16 at age 12, indicating milder disease patterns than those observed in our population. These regional contrasts are further illustrated by Adanero et al[29] who examined children aged 6–12 years attending Madrid schools and reported caries prevalence values generally lower than those seen in our cohort, while also identifying marked socioeconomic disparities in oral-health outcomes within the region. Moreover, extreme intra-regional variability is evident in vulnerable subpopulations: Beltri Orta et al[43] found 97.05% caries prevalence among children aged 3–15 years attending a non-profit dental foundation in Madrid, with the highest burden concentrated in the 3–6-year group. In contrast, the study by Almerich-Silla et al[32] reported increasing caries prevalence with age in both primary and permanent dentition, although only school-aged children were evaluated. According to their data, the prevalence of cavitated caries was 30%, 37.7%, and 43.6% at ages 6, 12, and 15 years, respectively, while the prevalence of both cavitated and non-cavitated caries (including incipient lesions) was 56%, 76.8%, and 84.8% in the same age groups.

In international studies, caries prevalence (cavitated and non-cavitated) in primary dentition ranges from 10.5%[25] to 43.9%[27] with higher prevalence among younger children (ages 5–8 years), compared to older children.[24] Previous studies report higher rates of permanent dentition caries than ours, with a prevalence of 76–88%,[22] similar to findings by Abbass et al[23] and Sivakumar et al[31] By contrast, other authors report lower caries prevalence, ranging between 3% and 35%.[24,34,37,40]

In Spanish studies, the prevalence of caries in primary dentition ranges from 45.21%[29] to 70.37%,[30] both slightly higher than the prevalence observed in our study. Regarding preschool-aged children, according to data from the last National Survey in 2020,[44] caries prevalence in primary teeth was 28.3% and 1% in permanent teeth, showing a significantly lower prevalence than reported in 1993 (35.1% and 2.9% in primary and permanent teeth, respectively). The effect of age on caries prevalence has also been analyzed in previous studies,[33,35] showing an upward trend in primary dentition caries with increasing age. Similarly,[33,35] caries prevalence in permanente dentition increases with age.[33,35]

Regarding dental fillings,[44] only 4.3% of preschool children in our study presented dental restorations, with the most frequent finding being restoration of a single tooth (2.6%). In Spain, according to 2020 data,[44] the restoration index for primary teeth was 27.1%, with an average of 0.35 restored teeth per child. This prevalence was significantly higher among children from high SES backgrounds (48.2%) and those born in Spain (31.8%).

School-aged children in our study presented dental restorations with a prevalence of 10.8%, most commonly involving one (4.9%) or two teeth (3.4%). Sivakumar et al[31] analyzed a population aged 11–13 years, reporting a prevalence of preventive resin restorations of 7.6%, and overall restoration rates ranging from 12.6% to 22.8%. In contrast, Park et al[37] reported significantly higher prevalence, with 74% of permanent teeth restored in pediatric populations. In Spain, the study by Cortés Martinicorena et al[33] also reported elevated restoration indices: 26.1% of primary teeth restored at age 6, and 68.9% and 74.1% of permanent teeth restored at ages 12 and 14, respectively. According to 2020 national data,[44] the restoration index in Spanish children was 29.4% at 6 years old and 72.4% at 15 years old, with an average number of restored teeth of 0.01, and 0.68 in those age groups. In our study, the overall prevalence of pit and fissure sealants was 12.2%, although, only 5% of children had sealants placed on all four first permanent molars. These data reflect a higher prevalence of sealants than reported in previous research (8.4%).[31] Besides, [3136]sealant prevalence trends to be lower among migrant children compared to native children at younger ages, although this trend reversed at age 15.[36] In Spain, sealant prevalence was notably higher. Cortés Martinicorena et al[33] reported that 40% of children had at least one sealed tooth, with a mean of 1.26 and 1.21 sealed teeth at ages 12 and 14, respectively. According to national data from the 2020 Survey,[44] sealant prevalence was 4.2% at age 6, increasing to 34.8% and 32.2% at ages 12 and 15, respectively.

Visible bacterial plaque was found in 56.6% of preschool children. Regarding self-reported oral hygiene habits, 48.3% reported brushing their teeth twice daily, while brushing once per day was also common (34.6%). In the school-aged group, visible plaque was observed in 62.8% of children. The majority reported brushing two (50.6%) or three times (28%) per day. The absence or infrequent practice of toothbrushing, has been associated with increased prevalence of dental caries in children,[22,23] consistent with our data. Regarding brushing habits, variable outcomes have been reported, with 46% of children brushing without toothpaste, and only 46.8–70.98% brushing once daily or less, while 2.2–42.6% brushing two or three times per day.[25–27,37,39,41] In Spanish populations, according to 2023 data,[30] 40.7% of children never brushed their teeth, and 48.1% brushed less than once per week. Data from the 2020 Survey[44] reported that the majority (68.2–76%) of adolescents brushed their teeth more than once daily. The best oral hygiene levels at age 12 and 15 were observed in children from high or moderate SES backgrounds, respectively. A trend in Spain toward increased daily brushing frequency from 2015 to 2020[45] can be found, both in two or more times (from 70% to 72%) and three times (from 24% to 35%) a day. In our population, the prevalence of DDE among preschool children was low, with mild alterations observed in 3.6% and moderate defects in 0.6%. However, among school-aged children, the prevalence was higher: 11.3% of examined children presented some degree of DDE, predominantly mild defects (8.3%), followed by moderate (2.6%) and severe alterations (0.5%). Recent studies in Spain have reported heterogeneous data regarding DDE prevalence. According to 2020[44] findings, 20.7% of 12-year-old children presented dental hypomineralization, with 14.3% classified as mild and 6.4% as moderate to severe, predominantly affecting children from middle and high SES backgrounds. More recent data indicate an increase in DDE prevalence, with rates of mild MIH at 22.2%, moderate at 14.8%, and severe at 3.7% among children in Sevilla in 2023.[30] Additionally, a multicentric study by Ortega-Luengo et al[46] reported an overall DDE prevalence of 28.63%. Regarding the severity of affected teeth, 83.17% exhibited mild defects (limited to color changes), while 16.82% presented severe involvement. TW was identified in 2.6% of the preschool sample and 4.1% of school-aged children, predominantly limited to enamel, and more frequently observed in preschool children from high SES backgrounds. Although data in general population states a highly variable prevalence of TW (from 1.4% to 100%),[13] previous research regarding pediatric population report a lower prevalence in permanent (from 5.9% to 61%) and primary dentition (from 10.7% to 17.7%).[37,47–50] An increase in erosive dental defects has been associated with age, lower maternal education level, and poor oral hygiene[48] although other authors have found no association between parental education level or oral hygiene and erosive TW.[47] No differences in dental erosion were observed in relation to the presence of caries in children, consistent with our findings. While Duangthip et al[48] reported greater prevalence of TW in children with lower maternal education, Yip et al[47] did not identify differences based on SES. According to our data, 2.4% of preschool children and 2% of school-aged children had a history of dental trauma. In studies conducted among preschool populations, the prevalence of dental trauma reached 11.2%,[40] like findings in Spanish children, where a prevalence of 12.2% was reported.[51] Recent meta-analyses conducted in Spain[12,51] estimated an overall prevalence of 9.94%, with higher rates observed in boys (10.5%) compared to girls (5.7%), and in children (11.1%) compared to adolescents (6.1%). Dental occlusion alterations were identified in 15.8% of preschool children and 42.5% of the school-aged sample. Similar findings have been reported in previous literature, with overall malocclusion prevalence ranging from 15% to 32.9%.[31,37] Spanish studies report higher prevalence rates of malocclusion, ranging from 43.89% to 77.8%,[29,30,33,44,52] with mild malocclusion occurring in 14.8% to 31.6% of cases and moderate to severe malocclusion affecting 13.8% to 63%. Studies evaluating orthodontic treatment needs found similar trends, with 21.8% to 63% of children requiring treatment at age 12, and 17.1% to 79.8% requiring treatment at age 15.[53,54]

In bivariate analysis, dental caries in preschool children were significantly associated with malocclusion, low SES, daily brushing, and visible bacterial plaque, but not with other studied variables. According to the 2020 National Survey,[44] the number of teeth filled or missed did not vary by SES. Multivariable analysis revealed that only the absence of malocclusion and absence of visible plaque were associated to lower caries risk among preschoolers, although low SES, male gender, and lack of toothbrushing showed a trend toward increased caries risk. Among school-aged children, a lower caries risk was associated to male gender, the presence of DDE, absence of malocclusion, brushing three or more times daily, absence of visible plaque, and no prior caries experience. In contrast, low SES increased both the likelihood of caries and the number of affected teeth. Most authors report strong associations between dental caries and factors such as low parental educational level, reduced household income,[23,27,32,33,55–57] lack of preventive dental visits, poor oral hygiene and dietary habits,[39,58] prior caries experience, cariogenic microorganisms, and exposure to prenatal or passive smoking,[58] as well as elevated cortisol levels.[55,59] Maternal education level has been identified as a strong predictor of early childhood caries (ECC).[60, 61] Conversely, some studies found higher caries prevalence among children from high SES backgrounds compared to middle and low groups,[24,34] mainly due to an improved oral hygiene outcomes in higher SES groups.[28,38] Regarding sample origin, children from rural areas or with immigrant status were at greater risk for caries in primary teeth, but not in permanent teeth,[22,36,58, 61] with no gender influence observed. Notably, Sowole et al[25] concluded that SES, brushing frequency, and type of toothbrush were not associated with caries in primary teeth, whereas other studies[23,26,58,60] highlighted brushing frequency and dental visits as protective factors. Nutritional habits also showed strong correlations, with ECC significantly associated with sugar intake,[23,41,58,60] and a protective role reported for consumption of eggs, fruits/vegetables, and dairy products.[23] Additional factors such as birth order, number of siblings, oral hygiene status, and presence of DDE were also found to be predictive of dental caries.[34, 62] In a large-scale epidemiological study conducted in Spain in 2020,[44] high SES was associated with significantly lower caries prevalence in primary teeth among preschoolers and in permanent teeth among 15-year-olds, but not in other evaluated age groups. Additionally, native-born 12-year-old Spanish children had significantly fewer carious permanent teeth compared to their immigrant counterparts.

Non-treated caries is an indicator of OH status improvement.[1] Despite the rigorous methodology, the research presents certain limitations that may affect the generalizability of the data. Firstly, the origin of the children was not assessed, and no differentiation was made between immigrants and children born in Spain, nor by racial background. This variable was not considered, as children born in Spain to immigrant families are enrolled in the national health and education system and therefore receive the same oral hygiene and dietary guidelines and have equivalent access to healthcare services as children born in Spain. Moreover, the aim of the study was to assess OH status in children residing in the Madrid region, regardless of origin or nationality, in order to determine the current prevalence of pediatric caries and community needs. Parent reported variables (such as toothbrushing frequency or previous dental trauma) may be affected by social desirability and recall bias, potentially leading to under or overreporting and attenuating true associations with caries outcomes. Additionally, the voluntary participation of schools and examiners may introduce selection bias, as those who choose to participate might differ systematically from those who do not. Another limitation was the lack of differentiation between primary and permanent teeth in caries index calculations. This decision was made because, as previously mentioned, the objective was to assess the general presence of caries in children of different ages (3–6 and 6–14 years) rather than distinguishing by dentition type, with the aim of estimating current caries risk in the pediatric population of the Madrid region. Additionally, the use of a non-probabilistic sampling method may reduce the external validity of the findings. The selected schools and participating children may not fully represent the entire pediatric population of the Community of Madrid, and results should therefore be generalized with caution.

The present study offers multiple strengths that allow for a realistic assessment of OH status in children from the Madrid region. Firstly, the multicentric design involving 39 schools and a total of 11,646 children enabled the inclusion of populations from various areas of the region, with diverse SES backgrounds and age groups (3–14 years), spanning the years 2017 to 2020. Clinical examinations were conducted by experienced pediatric dentists who had undergone inter-examiner calibration, ensuring an elevated level of observational accuracy.

As future lines of research, it would be scientifically relevant to include additional variables in the parental questionnaire, such as parenting style, birth rank, and number of children. It is also recommended to calculate indices not assessed in the present study, such as treatment need, which provide valuable information regarding the severity of dental caries. In alignment with the strategic objectives established by the WHO for 2030,[1] it is essential to examine the relationship between children's OH and the consumption of processed foods and sugar-rich products. This analysis supports the broader global health agenda, which emphasizes the reduction of noncommunicable diseases and the promotion of health across all stages of life, particularly during early childhood.

Conclusion

This large-scale epidemiological study provides a comprehensive overview of pediatric OH in the Community of Madrid. The findings reveal a substantial burden of dental caries, affecting over 40% of children, with nearly 10% presenting severe involvement (≥5 teeth). Additionally, the prevalence of DDE was 11%, dental wear 4%, dental trauma 2%, and malocclusion 41.4%. More than half of the examined children presented with visible bacterial plaque, despite the majority reporting brushing their teeth two or more times daily.

SES emerged as the most influential determinant of caries prevalence and severity, with children from low SES backgrounds exhibiting markedly higher risk. Protective factors varied by age group: in preschoolers, absence of malocclusion and plaque were key, whereas in school-aged children, frequent toothbrushing, prior dental treatment, and even mild DDE were associated with reduced caries risk. These findings highlight the need for policymakers to strengthen school-based preventive programs, particularly in low-SES districts, by implementing systematic tooth-brushing initiatives, regular dental screenings, and targeted OH education.

Abbreviations

Caries Classification and Management System (ICCMSTM); Chi-square (χ^2); Developmental defect of enamel (DDE); Early childhood caries (ECC); FDI (World Dental Federation); Gross National Income (GNI); International Caries Detection and Assessment System (ICDAS); Kolmogorov–Smirnov (KS); Oral health (OH); Oral health-related quality of life (OHRQoL); Reporting Standards for research in Pediatric Dentistry (RAPID); Socioeconomic status (SES); Strengthening the reporting of observational studies in epidemiology (STROBE); Tooth wear (TW); World Health Organization (WHO).

Data Sharing Statement

All relevant data are in the manuscript. However, the minimal data underlying all the findings in the manuscript are available from the corresponding author on reasonable request.

Ethics Approval and Informed Consent

The study protocol was approved by the Bioethical Committee of the BLINDED (code 2024_4/267, acceptance date 9th May, 2024), and the study was conducted according with the Declaration of Helsinki on human studies. All participants' parents or legal guardians signed an Informed Consent before enrolment.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

References

1. World Health Organization. *Global Strategy and Action Plan on Oral Health 2023–2030*. Geneva: World Health Organization; 2024.
2. Glick M, Williams DM, Kleinman DV, Vujicic M, watt RG, Weyant RJ. A new definition for oral health developed by the FDI World Dental Federation opens the door to a universal definition of oral health. *Int Dent J*. 2016;66(6):322–324. doi:10.1111/idj.12294

3. Machiulskiene V, Campus G, Carvalho JC, et al. Terminology of dental caries and dental caries management: consensus report of a workshop organized by ORCA and cariology research group of IADR. *Caries Res*. 2020;54(1):7–14. doi:10.1159/000503309
4. Uribe SES, Innes N, Maldupa I. The global prevalence of early childhood caries: a systematic review with meta-analysis using the WHO diagnostic criteria. *Int J Paediatr Dent*. 2021;31(6):817–830. doi:10.1111/ipd.12783
5. Cots E, Casas M, Gregoriano M, et al. Ethnic disparities in the prevalence of Molar-Incisor-Hypomineralisation (MIH) and caries among 6-12-year-old children in Catalonia, Spain. *Eur J Paediatr Dent*. 2024;25(3):188–199. doi:10.23804/ejpd.2024.2029
6. Chaffee BW, Rodrigues PH, Kramer PF, Vítolo MR, Feldens CA. Oral health-related quality-of-life scores differ by socioeconomic status and caries experience. *Community Dent Oral Epidemio*l. 2017;45(3):216–224. doi:10.1111/cdoe.12279
7. Yousaf M, Aslam T, Saeed S, Sarfraz A, Sarfraz Z, Cherrez-Ojeda I. Individual, family, and socioeconomic contributors to dental caries in children from low- and middle-income countries. *Int J Environ Res Public Health*. 2022;19(12):7114. doi:10.3390/ijerph19127114
8. Vukovic A, Schmutz KA, Borg-Bartolo R, et al. Caries status in 12-year-old children, geographical location and socioeconomic conditions across European countries: a systematic review and meta-analysis. *Int J Paediatr Dent*. 2025;35(1):201–215. doi:10.1111/ipd.13224
9. Prieto-Regueiro B, Gómez-Santos G, Reichard-Monefeldt G, Diéguez-Pérez M. Caries indicators in relation to healthcare access and hygienic-dietary habits in Spanish preschoolers. *Int J Dent Hyg*. 2024;22(3):736–748. doi:10.1111/idh.12786
10. Drury TF, Horowitz AM, Ismail AI, Maertens MP, Rozier RG, Selwitz RH. Diagnosing and reporting early childhood caries for research purposes. A report of a workshop sponsored by the national institute of dental and craniofacial research, the health resources and services administration, and the health care financing administration. *J Public Health Dent*. 1999;59(3):192–197. doi:10.1111/j.1752-7325.1999.tb03268.x
11. World Health Organization. *Ending Childhood Dental Caries: WHO Implementation Manual*. Genva: World Health Organization; 2020.
12. Méndez EEG, Ribas-Pérez D, Menacho DR, Navarro IB, Gallardo ER, Séiquer AC. Prevalence of dental trauma in Spain: systematic review and meta-analysis. *Clin Exp Dent Res*. 2025;11(1):e70128. doi:10.1002/cre2.70128
13. Entezami S, Peres KG, Li H, Albarki Z, Hijazi M, Ahmed KE. Tooth wear and socioeconomic status in childhood and adulthood: findings from a systematic review and meta-analysis of observational studies. *J Dent*. 2021;115:103827. doi:10.1016/j.jdent.2021.103827
14. Alvarado-Gaytán J, Saavedra-Marbán G, Velayos-Galán L, Gallardo-López NE, de Nova-García MJ, Caleya AM. Dental developmental defects: a pilot study to examine the prevalence and etiology in a population of children between 2 and 15 years of age. *Dent J*. 2024;12(4):84. doi:10.3390/dj12040084
15. Ghaferi AA, Schwartz TA, Pawlik TM. STROBE reporting guidelines for observational studies. *JAMA Surg*. 2021;156(6):577–578. doi:10.1001/jamasurg.2021.0528
16. Jayaraman J, Dhar V, Donly KJ, et al. Reporting stAndards for research in PedIatric Dentistry (RAPID): a development protocol. *Int J Paediatr Dent*. 2020;30(1):96–103. doi:10.1111/ipd.12569
17. World Health Organization. *Oral Health Surveys: Basic Methods*. Geneva: World Health Organization; 2013.
18. Pitts NB, Ismail AI, Martignon S, et al. *ICCMS™ Guide for Practitioners and Educators* (London: King's College London). 2014.
19. Jacobson A. *The Dental Aesthetic Index (DAI)*. *AJODO*. 1987;92(6):521–522.
20. Bartlett D, Ganss C, Lussi A. Basic Erosive Wear Examination (BEWE): a new scoring system for scientific and clinical needs. *Clin Oral Investig*. 2008;12 Suppl 1(Suppl 1):65. doi:10.1007/s00784-007-0181-5
21. FDI. A review of the developmental defects of enamel index (DDE Index). Commission on Oral Health, Research & Epidemiology. Report of an FDI Working Group. *Int Dent J*. 1992;42(6):411–426.
22. A, Dalmolin A, Gindri LD, Moreira CHC, Alves LS, JEdA Z. Oral health status of schoolchildren living in rural and urban areas in southern Brazil. *Braz Oral Res*. 2020;34:e060.
23. Abbass MMS, Mahmoud SA, El Moshy S, et al. The prevalence of dental caries among Egyptian children and adolescences and its association with age, socioeconomic status, dietary habits and other risk factors. A cross-sectional study. *F1000Res*. 2019;8:8. doi:10.12688/f1000research.17047.1
24. Amudha S, Moses J, Vijayakumar M, Shankar P. Prevalence of dental caries among different socioeconomic status and their treatment needs among 5-15-year-old school-going children in Maduravoyal Area, Chennai. *Int J Clin Pediatr Dent*. 2021;14(3):403–411. doi:10.5005/jp-journals-10005-1963
25. Sowole A, Sote E, Folayan M. Dental caries pattern and predisposing oral hygiene related factors in Nigerian preschool children. *Eur Arch Paediatr Dent*. 2007;8(4):206–210. doi:10.1007/BF03262598
26. Ferizi L, Bimbashi V, Kelmendi J. Dental caries prevalence and oral health status among 15-year- old adolescents in Kosovo. *Acta Stomatol Croat*. 2022;56(1):42–49. doi:10.15644/asc56/1/5
27. Borges HC, Garbín CAS, Saliba O, Saliba NA, Moimaz SAS. Socio-behavioral factors influence prevalence and severity of dental caries in children with primary dentition. *Braz Oral Res*. 2012;26(6):564–570. doi:10.1590/S1806-83242012000600013
28. Oyedele TA, Folayan MO, Chukwumah NM, Onyejaka NK. Social predictors of oral hygiene status in school children from suburban Nigeria. *Braz Oral Res*. 2019;33:e022–2019. doi:10.1590/1807-3107bor-2019.vol33.0022
29. Adanero A, Baquero L, Berasategui M, et al. Oral health status of 6- to 12-year-old children in Madrid, Spain: a cross-sectional study. *Heliyon*. 2022;8(6):e09557. doi:10.1016/j.heliyon.2022.e09557
30. García-Barata AR, Ventura I, Ribas-Pérez D, Flores-Fraile J, Castaño-Séiquer A. Oral health status in a group of Roma children in Seville, Spain. *Healthcare*. 2023;11(7):1016. doi:10.3390/healthcare11071016
31. Sivakumar V, Jain J, Haridas R, Paliayal S, Rodrigues S, Jose M. Oral health status of tibetan and local school children: a comparative study. *J Clin Diagn Res*. 2016;10(11):ZC29–ZC33. doi:10.7860/JCDR/2016/22853.8887
32. Almerich-Silla J, Boronat-Ferrer T, Montiel-Company J, Iranzo-Cortés J. Caries prevalence in children from Valencia (Spain) using ICDAS II criteria, 2010. *Med Oral Patol Oral Cir Bucal*. 2014;19(6):e574–e579. doi:10.4317/medoral.19890
33. Cortés Martinicorena, F, Artázcoz, J, Rosel, E, González, P, Asenjo, MA, Sainz de Murieta, I, Bravo, M Dental health of children and adolescents of Navarra,2007(4th edition) An Sist Sanit Navar : 2009 32 2 199–215.
34. Oyedele TA, Fadeju AD, Adeyemo YI, Nzomiwu CL, Ladeji AM. Impact of oral hygiene and socio-demographic factors on dental caries in a suburban population in Nigeria. *Eur Arch Paediatr Dent*. 2018;19(3):155–161. doi:10.1007/s40368-018-0342-z
35. Alvarez-Arenal A, Alvarez-Riesgo JA, A-Lopez JMP, Fernandez-Vazquez JP. DMFT, dmft and treatment requirements of schoolchildren in Asturias, Spain. Community Dent Oral Epidemiol. 1998;26(3):166–169. doi:10.1111/j.1600-0528.1998.tb01945.x
36. Zhang H, Zeng X, Jiang Y, et al. The disparity in caries and sealants between migrant and native children in Shanghai: a cross-sectional study. *Int J Dent Hyg*. 2020;18(1):84–91. doi:10.1111/idh.12411

37. Park S, Lim J, Lee J. Evaluation of the effectiveness of children's dental care programs: a retrospective study. *Healthcare*. 2024;12(7):721. doi:10.3390/healthcare12070721
38. Andrew L, Wallace R, Wickens N, Patel J. Early childhood caries, primary caregiver oral health knowledge and behaviours and associated sociological factors in Australia: a systematic scoping review. *BMC Oral Health*. 2021;21(1):521. doi:10.1186/s12903-021-01887-4
39. Pilát Z, Gaľová J, Petrejčíková E, Mathia M, Boroňová I, Bernasovská J. Oral health status of 6- and 12-year-old children of Roma origin from Eastern Slovakia: a pilot study. *Cent Eur J Public Health*. 2020;28(4):292–296. doi:10.21101/cejph.a6225
40. Nazar H, Al-Mutawa S, Asad AAR, Ariga J, AlSahli A, Baskaradoss JK. Oral health in the State of Kuwait: an appraisal. *Int Dent J*. 2024;74 (6):1343–1349. doi:10.1016/j.identj.2024.04.010
41. Husain FA, Alanzi AN. Caries experience and oral health-related factors of Kuwaiti preschool children and their mothers: a pilot study. *Int J Clin Pediatr Dent*. 2019;12(4):283–287. doi:10.5005/jp-journals-10005-1652
42. Bravo Pérez M, Almerich Silla JM, Canorea Díaz E, et al. Encuesta nacional de salud oral en España 2020. *Rev Española Odontol*. 2020;47:123–135.
43. Consejo General de Dentistas de España. *Libro Blanco: Encuesta poblacional de la salud buco dental en España*. 2020.
44. Ortega-Luengo S, Feijóo-Garcia G, Miegimolle-Herrero M, Gallardo-López NE, Caleya-Zambrano AM. Prevalence and clinical presentation of molar incisor hypomineralisation among a population of children in the community of Madrid. *BMC Oral Health*. 2024;24(1):229. doi:10.1186/s12903-024-04003-4
45. Yip K, Lam PPY, Yiu CKY. Prevalence and associated factors of erosive tooth wear among preschool children-a systematic review and meta-analysis. *Healthcare*. 2022;10(3):491. doi:10.3390/healthcare10030491
46. Duangthip D, Chen KJ, Gao SS, Lussi A, Lo EC, Chu CH. Erosive tooth wear among preschool children in Hong Kong. *Int J Paediatr Dent*. 2018; 29(2): 185–193. doi:10.1111/ipd.12457
47. Salas MMS, Nascimento GG, Huysmans MC, Demarco FF. Estimated prevalence of erosive tooth wear in permanent teeth of children and adolescents: an epidemiological systematic review and meta-regression analysis. *J Dent*. 2015;43(1):42–50. doi:10.1016/j.jdent.2014.10.012
48. Maharani DA, Zhang S, Gao SS, Chu C, Rahardjo A. Dental caries and the erosive tooth wear status of 12-year-old children in Jakarta, Indonesia. *Int J Environ Res Public Health*. 2019;16(16):2994. doi:10.3390/ijerph16162994
49. Prieto-Regueiro B, Gómez-Santos G, Diéguez-Pérez M. Prevalence of traumatic injuries in deciduous dentition and associated risk factors in a Spanish children population. *J Clin Exp Dent*. 2021;13(7):e678–e684. doi:10.4317/jced.58051
50. Cid CM, Barbería E, Sanz A, García R. Prevalencia de maloclusiones en niños de la Comunidad Autónoma de Madrid según el índice estético dental. *Rev Esp Ortod*. 2009;39:1–12.
51. Iranzo-Cortés JE, Montiel-Company JM, Bellot-Arcís C, Almerich-Torres T, Almerich-Silla JM. Need for orthodontic treatment in pupils aged between 12 and 15 in the Valencian Region (Spain). *Int J Environ Res Public Health*. 2021;18(19):10162. doi:10.3390/ijerph181910162
52. Manzanera D, Montiel-Company JM, Almerich-Silla JM, Gandía JL. Orthodontic treatment need in Spanish schoolchildren: an epidemiological study using the Index of Orthodontic Treatment Need. *Eur J Orthod*. 2009;31(2):180–183. doi:10.1093/ejo/cjn089
53. Kopycka-Kedzierawski DT, Scott-Anne K, Ragusa PG, et al. Social, psychological, and behavioral predictors of salivary bacteria, yeast in caries-free children. *JDR Clin Trans Res*. 2022;7(2):163–173. doi:10.1177/2380084421999365
54. Lally C, Maliq NN, Schreiber M, Wilson A, Tiwari T. Association of parental social support and dental caries in hispanic children. *Front Oral Health*. 2023;4:1261111. doi:10.3389/froh.2023.1261111
55. Stormon N, Ford PJ, Lalloo R. Community-level predictors of Australian children's dental caries and injury. *Aust Dent J*. 2019;64(3):263–272. doi:10.1111/adj.12706
56. Lam PPY, Chua H, Ekambaram M, Lo EC, Yiu CKY. Risk predictors of early childhood caries increment-a systematic review and meta-analysis. *J Evid Based Dent Pract*. 2022;22(3):101732. doi:10.1016/j.jebdp.2022.101732
57. Aboubakr RM, Alkhadragy DM, Okda MMES, Rady HWM, Elnagar RM. Predictors of caries risk among egyptian children attending pediatric dental clinics at a university hospital. *Saudi J Med Med Sci*. 2023;11(3):219–228. doi:10.4103/sjmms.sjmms_128_23
58. Hernandez M, Chau K, Charissou A, et al. Early predictors of childhood caries among 4-year-old children: a population-based study in north-eastern France. *Eur Arch Paediatr Dent*. 2021;22(5):833–842. doi:10.1007/s40368-021-00627-0
59. Shen A, Bernabé E, Sabbah W. The socioeconomic inequality in increment of caries and growth among Chinese children. *Int J Environ Res Public Health*. 2020;17(12):4234. doi:10.3390/ijerph17124234
60. Onyejaka NK, Olatosi OO, Ndukwe NA, Amobi EO, Okoye LO, Nwamba NP. Prevalence and associated factors of dental caries among primary school children in South-East Nigeria. *Niger J Clin Pract*. 2021;24(9):1300–1306. doi:10.4103/njcp.njcp_633_20