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ORIGINAL RESEARCH

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Socio-behavioral and clinical determinants of high caries experience among 12-year-old Thai schoolchildren: a cross-sectional study

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Abstract

Background: High caries experience among schoolchildren represents a substantial disease burden. Understanding the associated factors is essential for developing targeted prevention strategies. This study aimed to identify socio-behavioral and clinical factors associated with high caries experience among 12-year-old Thai schoolchildren. **Methods**: A cross-sectional study was conducted among 12-year-old schoolchildren in Pathum Thani Province, Thailand. Data were collected through clinical oral examinations and structured questionnaires completed by children and their primary caregivers to assess sociodemographic characteristics, oral health behaviors, and oral clinical conditions. Chi-square tests and multivariable logistic regression were used for analysis. **Results**: A total of 400 children were included in the analysis. The mean Decayed, Missing, and Filled Permanent Teeth (DMFT) score was 2.60 (Standard Deviation (SD) = 2.41). Overall, 49.8% had high caries experience (DMFT $\geq$3). Multivariable analysis showed that low caregiver education level (middle school or lower) (adjusted odds ratio (AOR) = 1.67; 95% confidence interval (CI): 1.03–2.72) and low family income ($\leq$10,000 Thai Baht (THB)) (AOR = 1.93; 95% CI: 1.02–3.65) were significantly associated with high caries experience. Enamel defects in permanent molars (*e.g.*, hypoplasia and hypomineralization) (AOR = 7.87; 95% CI: 2.95–20.95), fair oral hygiene (AOR = 2.62; 95% CI: 1.60–4.28), poor oral hygiene (AOR = 4.23; 95% CI: 2.43–7.38), infrequent toothbrushing (AOR = 3.55; 95% CI: 1.34–9.44), frequent consumption of cariogenic snacks ($\geq$3 times/day) (AOR = 2.07; 95% CI: 1.21–3.55), and daily consumption of sugar-sweetened beverages (AOR = 5.19; 95% CI: 2.94–9.15) were also independently associated with high caries experience. **Conclusions**: High caries experience among 12-year-old Thai schoolchildren was associated with socioeconomic disadvantage, enamel defects in permanent molars, fair-to-poor oral hygiene, infrequent toothbrushing, and cariogenic dietary behaviors. These findings may help guide oral health promotion policies and targeted preventive strategies in this population.

Keywords

Dental caries; Caries experience; Schoolchildren; Enamel defects; Oral hygiene; Plaque index; Toothbrushing; Oral health promotion

1. Introduction

Dental caries remains one of the most prevalent chronic diseases affecting children and adolescents worldwide, imposing a substantial burden on health, quality of life, and healthcare systems [1–3]. As a multifactorial disease influenced by biological, behavioral, and socio-environmental factors, effective prevention requires comprehensive and holistic approaches [4, 5]. In Thailand, dental caries remains a major public health concern among school-aged children, as evidenced by both national oral health surveys and recent regional studies [6, 7]. The 2023 national oral health survey reported a prevalence of 49.7% among 12-year-old children [7]. Despite ongoing preventive programs [8], a substantial proportion of children continue to experience dental caries [9], while untreated decay and caries-related risk behaviors persist [7]. The burden falls disproportionately on children from socioeconomically disadvantaged backgrounds. Key determinants include socioeconomic status, oral health behaviors, dietary practices, access to dental care, and clinical factors such as enamel defects [10–15].

School-aged children are in a transitional phase toward adolescence, during which they begin to develop greater autonomy in health-related behaviors, including oral hygiene practices and dietary behaviors [16, 17]. The age of 12 years has been identified by the World Health Organization (WHO) as a key

index age for monitoring oral health, as most permanent teeth have erupted and behaviors become more established, allowing cumulative caries experience to be more reliably assessed [18]. This represents a critical window for understanding the influence of behavioral and environmental determinants on dental caries [19, 20].

Caries experience in this age group, commonly assessed using the Decayed, Missing, and Filled Permanent Teeth (DMFT) index, a WHO-recommended epidemiological tool [18], reflects the cumulative history of dental caries in an individual or population. Beyond reflecting current tooth decay alone, the DMFT index captures evidence of both past and present disease through decayed, missing, and filled teeth, thereby providing a more comprehensive assessment of lifetime caries burden and offering broader insight into an individual's oral health status, including patterns of dental service utilization and access to dental care [21].

Children with high caries experience may represent a particularly high-risk group that warrants further investigation. A better understanding of the factors associated with high caries experience is essential for identifying high-risk groups and developing targeted prevention strategies. Therefore, this study aimed to identify the socio-behavioral and oral health-related clinical factors associated with high caries experience among 12-year-old schoolchildren, with the goal of elucidating the underlying determinants of these impacts and informing interventions to improve the oral health of Thai schoolchildren. We hypothesized that unfavorable socio-behavioral factors and poor oral health conditions would be significantly associated with high caries experience in this population.

2. Materials and methods

2.1 Study design, population and sampling

This study was conducted in 2024 among 12-year-old schoolchildren enrolled in public primary schools in Pathum Thani Province, Thailand. Schools were selected based on feasibility and administrative approval. Within each selected school, two sixth-grade classrooms were randomly selected using a simple lottery method to reduce selection bias at the classroom level. All eligible students in the selected classrooms were considered for inclusion.

This study did not employ cluster sampling. The number of participants from each school was not predetermined, but rather depended on the number of eligible children who were present on the day of data collection and whose parents or legal guardians had provided informed consent.

2.2 Participant recruitment and eligibility criteria

All eligible students in the selected classrooms who were present on the day of data collection were invited to participate. Written informed consent was obtained from parents or legal guardians, and assent was obtained from the children prior to participation.

Inclusion criteria were sixth-grade primary school students aged 12 years who were enrolled in the selected public schools and present on the day of data collection. Participants were required to be generally healthy, with no history of serious systemic illness, chronic medical conditions, or developmental disorders that could interfere with study participation or oral examination. Children with either permanent dentition or mixed dentition were included. For children with mixed dentition, only permanent teeth were included in the caries assessment and analysis.

Exclusion criteria included students currently undergoing orthodontic treatment and those with incomplete caregiver questionnaires.

2.3 Sample size calculation

The required sample size was determined based on two complementary approaches. First, since no published prevalence data on high caries experience specifically among 12-year-old Thai children were available, the dental caries prevalence of 49.7% from the 9th Thailand National Oral Health Survey [7] was applied as a proxy estimate in the single population proportion formula ($n = Z^2P(1-P)/d^2$), using a 95% confidence level ($Z = 1.96$) and a precision level of 5%, yielding a minimum sample size of 384 children. After adding a 10% non-response rate, the final required sample size was 423.

Second, since the primary objective involved multivariable logistic regression, sample size adequacy was further confirmed using the events-per-variable (EPV) criterion. Each model included one primary independent variable adjusted for four covariates (residence, gender, family income, and caregiver education), yielding a maximum of five parameters per model. The expected number of outcome events was approximately 210 (423×0.497), resulting in an EPV of 42, which exceeded the recommended minimum EPV of 10.

2.4 Data collection

Data were collected through caregiver-completed questionnaires, clinical oral examinations, and face-to-face interviews assessing children's oral health behaviors. Before data collection, the caregiver questionnaire was developed and tested for content validity using the Index of Item-Objective Congruence (IOC) by pediatric dentistry specialists, with revisions made until all items achieved an IOC score >0.7. The reliability of the caregiver questionnaire was assessed in a pilot test with 20 caregivers, demonstrating good internal consistency (Cronbach's alpha = 0.81). For clinical examinations, intra-examiner reliability was assessed prior to data collection by re-examining 20 children, yielding a kappa coefficient of 0.90.

Sociodemographic information, use of fluoridated toothpaste, and children's dental service utilization were obtained from a structured questionnaire completed by the child's primary caregiver, who was defined as an individual residing in the same household, including parents, grandparents, or legal guardians responsible for the children's daily care.

Clinical oral examinations were conducted among children at the schools using a portable field examination setup equipped with a dental chair and artificial light source. Examinations were performed by a single examiner using a dental mouth mirror and a WHO periodontal probe, with findings recorded according to the WHO community oral health survey form [18]. Oral hygiene status was assessed

using the Simplified Oral Hygiene Index [22]. Children's oral health behaviors, including tooth-cleaning and dietary behaviors, were assessed through face-to-face interviews using a structured questionnaire adapted from the Thai National Oral Health Survey [7].

2.5 Measures and variables

2.5.1 Outcome measure

The primary outcome was high caries experience, assessed using DMFT index. High caries experience was defined as a DMFT score of ≥3, corresponding to the 75th percentile [23] of the study population. Children were categorized into high caries experience (DMFT ≥3) and non-high caries experience (DMFT = 0–2).

2.5.2 Independent variables

Independent variables were organized into two domains: caregiver- and family-related factors, and child-related factors.

Caregiver- and family-related factors comprised six variables. Area of residence was categorized as urban or suburban. Relationship to the child was classified as father, mother, or grandparent/relative. Caregiver age was grouped into three categories: ≤35 years, 36–45 years, and ≥46 years. Caregiver education level was classified as middle school or lower, high school, or college or higher. Monthly family income was categorized as low (≤10,000 Thai Baht (THB)), middle (10,001–30,000 THB), or high (>30,000 THB). The caregiver's primary source of oral health consultation was classified as healthcare professionals, non-healthcare persons (family members or friends), or internet sources.

Child-related factors comprised three domains: general child characteristics, oral health status, and oral health behaviors. General child characteristics included gender, birth order, and body mass index (BMI). Gender was recorded as male or female. Birth order was classified as first-born, second-born, or third-born or later. BMI was calculated from measured weight and height and classified according to the WHO Growth Reference standards for age and sex, as normal weight or overweight/obese [24].

Oral health status included enamel defects and oral hygiene status. The presence of enamel defects was assessed using the Modified Developmental Defects of Enamel (DDE) Index [25] in permanent molars. Enamel defects were defined as qualitative or quantitative enamel anomalies, including enamel hypoplasia and molar–incisor hypomineralization, identified through direct visual clinical examination based on demarcated opacities, diffuse opacities, or enamel loss. Enamel defect status was recorded as absent or present. Oral hygiene status was assessed using the Simplified Oral Hygiene Index [22], which evaluates debris and calculus on six index teeth (16, 11, 26, 36, 31, and 46) and classifies oral hygiene status as good, fair, or poor according to standard criteria.

Oral health behaviors encompassed nine variables. Daily toothbrushing frequency was categorized as none, once per day, ≥2 times per day, or don't know. Toothbrushing duration was categorized as <2 minutes or ≥2 minutes. Use of fluoridated toothpaste was recorded as yes or no. Use of dental floss was classified as none, irregular, or routine. Frequency of cariogenic snack consumption between meals was categorized as ≤1 time/day, 2 times/day, or ≥3 times/day. Sugar-sweetened beverage consumption was categorized as ≤1 time/week, 2–6 times/week, or ≥1 time/day. Primary source of oral health consultation was classified as caregivers, teachers, or internet sources. Dental check-up within the past six months was recorded as yes or no. Type of dental care setting was classified as public dental services or private dental clinics.

2.6 Data analysis

Data analysis was performed using SPSS version 27 for Windows (IBM Corp., Armonk, NY, USA). A p-value < 0.05 was considered statistically significant. Descriptive statistics were used to summarize the characteristics of the study population. All variables were categorical and presented as frequencies and percentages. Associations between independent variables (caregiver- and family-related factors and child-related factors) and caries experience (categorized as high *vs.* non-high) were assessed using the chi-square test.

Multivariable logistic regression analysis was performed to identify factors associated with high caries experience. Variables that were statistically significant in the chi-square analysis ($p < 0.05$) were entered into the multivariable model. Prior to model fitting, the assumptions of logistic regression were assessed. The outcome variable was binary (high *vs.* non-high caries experience), observations were independent, and no evidence of multicollinearity among independent variables was identified based on examination of correlation matrices. The model was adjusted for area of residence, sex, caregiver education level, and monthly family income as potential confounders. Adjusted odds ratios (AOR) and 95% confidence intervals (CI) were reported.

3. Results

A total of 423 children were initially assessed for eligibility. After excluding 2 children with ongoing orthodontic treatment, and 21 children with incomplete questionnaires (caregiver questionnaires or child interviews), 400 children were included in the final analysis. The overall non-response rate was 5.0%.

3.1 Sociodemographic characteristics

Most children resided in urban areas (68.5%). The distribution of gender was approximately equal between males and females. The majority had a normal BMI (92.8%). More than half had mothers as their primary caregivers (58.3%), and were from middle-income families (54.8%). Caregiver education levels were relatively evenly distributed, with 39.8% having middle school education or lower and 37.0% having a college education or higher. The characteristics of the participants are presented in Tables 1 and 2.

TABLE 1. Caregiver and family factors associated with high caries experience among 12-year-old schoolchildren (N = 400).

Variable	n (%)	Caries experience		*p*-value[1]
		High DMFT (≥3)	Non-high DMFT (0–2)	
Area of residence				
Urban	274 (68.5)	128 (46.7)	146 (53.3)	0.073
Suburban	126 (31.5)	71 (56.3)	55 (43.7)	
Primary caregiver				
Father	98 (24.5)	49 (50.0)	49 (50.0)	
Mother	233 (58.3)	117 (50.2)	116 (49.8)	0.940
Grandparent/relative	69 (17.3)	33 (47.8)	36 (52.2)	
Age of caregiver				
≤35 yr	125 (31.3)	66 (52.8)	59 (47.2)	
36–45 yr	171 (42.8)	81 (47.4)	90 (52.6)	0.652
≥46 yr	104 (26.0)	52 (50.0)	52 (50.0)	
Education level (of caregiver)				
Middle school or lower	159 (39.8)	93 (58.5)	66 (41.5)	
High school	93 (23.3)	43 (46.2)	50 (53.8)	0.015
College or higher	148 (37.0)	63 (42.6)	85 (57.4)	
Monthly family income				
Low (≤10,000 THB)	99 (24.8)	62 (62.6)	37 (37.4)	
Middle (10,001–30,000 THB)	219 (54.8)	104 (47.5)	115 (52.5)	0.007
High (>30,000 THB)	82 (20.5)	33 (40.2)	49 (59.8)	
Primary source of oral health consultation				
Consult healthcare professional	198 (49.5)	96 (48.5)	102 (51.5)	
Ask non-healthcare persons (family/friends)	21 (5.3)	8 (38.1)	13 (61.9)	0.405
Search the internet	181 (45.3)	95 (52.5)	86 (47.5)	

[1] *Chi-square test.*
DMFT: Decayed, Missing, and Filled Permanent Teeth; THB: Thai Baht (1 USD ≈ 33 Baht).
Statistically significant at $p < 0.05$.

TABLE 2. Child-related factors associated with high caries experience among 12-year-old schoolchildren (N = 400).

Variable	N (%)	Caries experience n (%)		*p*-value[1]
		High DMFT (≥3)	Non-high DMFT (0–2)	
Gender				
Male	193 (48.3)	89 (46.1)	104 (53.9)	0.160
Female	207 (51.8)	110 (53.1)	97 (46.9)	
Birth order				
First-born	145 (36.3)	66 (45.5)	79 (54.5)	
Second-born	186 (46.5)	92 (49.5)	94 (50.5)	0.163
Third-born or later	69 (17.3)	41 (59.4)	28 (40.6)	
BMI				
Normal	371 (92.8)	188 (50.7)	183 (49.3)	0.186
Overweight/obese	29 (7.3)	11 (37.9)	18 (62.1)	

TABLE 2. Continued.

Variable	N (%)	Caries experience n (%)		*p*-value[1]
		High DMFT (≥3)	Non-high DMFT (0–2)	
Enamel defects in permanent molars				
None	362 (90.5)	166 (45.9)	196 (54.1)	<0.001
Present	38 (9.5)	33 (86.8)	5 (13.2)	
Oral hygiene				
Good	155 (38.8)	48 (31.0)	107 (69.0)	
Fair	143 (35.8)	81 (56.6)	62 (43.4)	<0.001
Poor	102 (25.5)	70 (68.6)	32 (31.4)	
Daily toothbrushing				
None	24 (6.0)	18 (75.0)	6 (25.0)	
Once/day	76 (19.0)	32 (42.1)	44 (57.9)	0.019
≥2 times/day	300 (75.0)	149 (49.7)	151 (50.3)	
Toothbrushing duration				
<2 min	112 (28.0)	45 (40.2)	67 (59.8)	
≥2 min	147 (36.8)	71 (48.3)	76 (51.7)	0.088
Don’t know	141 (35.3)			
Use of fluoride toothpaste				
No	62 (15.5)	32 (51.6)	30 (48.4)	0.750
Yes	338 (84.5)	167 (49.4)	171 (50.6)	
Use of dental floss				
No	210 (52.5)	102 (48.6)	108 (51.4)	
Irregular	104 (26.0)	58 (55.8)	46 (44.2)	0.421
Routine	86 (21.5)	41 (47.7)	45 (52.3)	
Daily cariogenic snack consumption between meals				
≤1	178 (44.5)	78 (43.8)	100 (56.2)	
2	128 (32.0)	61 (47.7)	67 (52.3)	0.006
≥3	94 (23.5)	60 (63.8)	34 (36.2)	
Sugar-sweetened beverage consumption				
≤1 time/week	133 (33.3)	36 (27.1)	97 (72.9)	
2–6 times/week	153 (38.3)	90 (58.8)	63 (41.2)	<0.001
≥1 time/day	114 (28.5)	73 (64.0)	41 (36.0)	
Primary source of oral health consultation				
Caregivers	63 (15.8)	37 (58.7)	26 (41.3)	
Teacher	160 (40.0)	79 (49.4)	81 (50.6)	0.331
Search the internet	177 (44.3)	85 (48.0)	92 (52.0)	
Dental check-up within the past 6 months				
No	132 (33.0)	69 (52.3)	63 (47.7)	0.479
Yes	268 (67.0)	130 (48.5)	138 (51.5)	
Type of dental care				
Public dental services	154 (38.5)	84 (54.5)	70 (45.5)	0.174
Private dental clinics	246 (61.5)	117 (47.6)	129 (52.4)	

[1]*Chi-square test.*

DMFT: Decayed, Missing, and Filled Permanent Teeth; BMI: Body Mass Index.

Statistically significant at $p < 0.05$.

3.2 Caries experience

The mean DMFT score was 2.60 (SD = 2.41), with a median of 2 (Interquartile Range (IQR): 0–3). The decayed teeth (DT) accounted for the largest proportion of the DMFT index, with a mean DT score of 2.30 (SD = 2.41), whereas the mean missing teeth (MT) and filled teeth (FT) scores were 0.04 (SD = 0.24) and 0.27 (SD = 0.80), respectively. Overall, 71.7% had caries experience (DMFT >0), and 49.8% of the total sample were classified as having high caries experience (DMFT ≥3). The Significant Caries Index (SiC), representing the mean DMFT score among the one-third of participants with the highest caries levels, was 5.24 (SD = 2.03).

3.3 Caregiver- and family-related factors

Caregiver and family factors associated with high caries experience are presented in Table 1. Caregiver education level and monthly family income were significantly associated with high caries experience ($p = 0.015$ and $p = 0.007$, respectively). Children whose caregivers had a middle school education or lower showed a higher prevalence of high caries experience (58.5%) compared with those whose caregivers had a college education or higher (42.6%). Similarly, children from low-income families showed a higher prevalence of high caries experience (62.6%) compared with those from high-income families (40.2%). In contrast, no significant associations were observed between high caries experience and area of residence ($p = 0.073$), primary caregiver ($p = 0.940$), caregiver age ($p = 0.652$), or caregiver's primary source of oral health consultation ($p = 0.405$).

3.4 Child oral health status and behavioral factors

Table 2 presents child oral health status and behavioral factors associated with high caries experience. Among oral health status factors, the presence of enamel defects in permanent molars was significantly associated with high caries experience, with 86.8% of children with enamel defects having high caries experience compared with 45.9% of those without enamel defects ($p < 0.001$). Poor oral hygiene was also significantly associated with high caries experience, with the prevalence increasing from 31.0% among children with good oral hygiene to 68.6% among those with poor oral hygiene ($p < 0.001$).

Regarding oral health behaviors, daily toothbrushing frequency was significantly associated with high caries experience ($p = 0.019$). Children who did not brush their teeth daily had the highest prevalence of high caries experience (75.0%). Frequent consumption of cariogenic snacks between meals and frequent sugar-sweetened beverage consumption were also significantly associated with high caries experience ($p = 0.006$ and $p < 0.001$, respectively), with the prevalence of high caries experience increasing as the frequency of consumption increased. However, other variables, including gender ($p = 0.160$), birth order ($p = 0.163$), BMI ($p = 0.186$), toothbrushing duration ($p = 0.088$), fluoride toothpaste use ($p = 0.750$), dental floss use ($p = 0.421$), primary source of oral health consultation ($p = 0.331$), dental check-up in the past six months ($p = 0.479$), and type of dental care ($p = 0.174$), were not significantly associated with high caries experience.

3.5 Multivariable analysis of factors associated with high caries experience

Univariable and multivariable logistic regression analyses are presented in Table 3. Children whose caregivers had a middle school education or lower and those from low-income families were more likely to have high caries experience (AOR = 1.67; 95% CI: 1.03–2.72; $p = 0.039$ and AOR = 1.93; 95% CI: 1.02–3.65; $p = 0.042$, respectively). Enamel defects in permanent molars were strongly associated with higher odds of high caries experience (AOR = 7.87; 95% CI: 2.95–20.95; $p < 0.001$). Poor oral hygiene (AOR = 4.23; 95% CI: 2.43–7.38; $p < 0.001$) and fair oral hygiene (AOR = 2.62; 95% CI: 1.60–4.28; $p < 0.001$) were also independently associated with increased odds of high caries experience.

Regarding behavioral factors, children who did not brush their teeth daily (AOR = 3.55; 95% CI: 1.34–9.44; $p = 0.011$), those who frequently consumed cariogenic snacks (≥3 times/day) (AOR = 2.07; 95% CI: 1.21–3.55; $p = 0.008$), and those who consumed sugar-sweetened beverages at least once daily (AOR = 5.19; 95% CI: 2.94–9.15; $p < 0.001$) had higher odds of high caries experience.

4. Discussion

This study identified several socio-behavioral and clinical-related factors associated with high caries experience among Thai 12-year-old schoolchildren. A substantial burden of dental caries was observed in this population, with more than two-thirds of children experiencing caries and nearly half classified as having high caries experience. The mean DMFT score in this study (2.60) was considerably higher than that reported in the Thai National Oral Health Survey [7] (DMFT = 1.2), as well as those reported in other countries [12, 26–29]. This discrepancy may reflect differences in study settings, population characteristics, and potential clustering of high-risk individuals in the selected schools. Notably, our study found that MT and FT were low, indicating that the DMFT score was predominantly driven by DT. This pattern may reflect poor oral health status and suggest a substantial unmet need for dental treatment [21], despite the study being conducted in a non-rural setting. Furthermore, the high SiC index observed in this study suggested that dental caries is disproportionately concentrated among a subgroup of children with the highest disease burden. This finding indicates a clear polarization of dental caries and highlights substantial inequalities in oral health within the study population [20, 30, 31].

Socioeconomic status, particularly low caregiver education level and low family income, remained significantly associated with high caries experience, with children from disadvantaged families being more likely to experience higher levels of caries [26, 32–37]. This may partly reflect the continued influence of family and caregiver-related factors during the transition to adolescence, when children still largely depend on their families and caregivers. Consistent with this, poor caregiver oral health has been associated with increased caries prevalence among children and adolescents [38]. Family income

TABLE 3. Logistic regression analysis of factors associated with high caries experience.

Variables	Crude OR (95% CI)	*p*-value	Adjusted OR[1] (95% CI)	*p*-value
Socio-demographic factors				
Caregiver education level				
Middle school or lower	1.90 (1.21–2.99)	0.005	1.67 (1.03–2.72)	0.039
High school	1.16 (0.69–1.96)	0.577	1.07 (0.62–1.85)	0.812
College or higher	1		1	
Monthly family income				
Low (≤10,000 THB)	2.49 (1.37–4.54)	0.003	1.93 (1.02–3.65)	0.042
Middle (10,001–30,000 THB)	1.34 (0.80–2.25)	0.262	1.11 (0.64–1.93)	0.706
High (>30,000 THB)	1		1	
Clinical factors				
Enamel defects in permanent molars				
None	1		1	
Present	7.79 (2.98–20.41)	<0.001	7.87 (2.95–20.95)	<0.001
Oral hygiene				
Good	1		1	
Fair	2.64 (1.64–4.25)	<0.001	2.62 (1.60–4.28)	<0.001
Poor	4.00 (2.35–6.84)	<0.001	4.23 (2.43–7.38)	<0.001
Behavioral factors				
Daily toothbrushing				
No	3.04 (1.17–7.87)	0.022	3.55 (1.34–9.44)	0.011
Once/day	0.74 (0.44–1.23)	0.240	0.59 (0.34–1.01)	0.055
≥2 times/day	1		1	
Cariogenic snack between meal				
≤1 time/day	1		1	
2 times/day	1.17 (0.74–1.84)	0.506	1.15 (0.72–1.84)	0.567
≥3 times/day	2.26 (1.35–3.78)	0.002	2.07 (1.21–3.55)	0.008
Sugar-sweetened beverage consumption				
≤1 time/week	1		1	
2–6 times/week	3.85 (2.34–6.35)	<0.001	3.80 (2.70–6.37)	<0.001
≥1 time/day	4.80 (2.79–8.24)	<0.001	5.19 (2.94–9.15)	<0.001

[1] *Adjusted for area of residence, gender, caregiver education level, and monthly family income.*
OR: Odds Ratio; CI: Confidence interval; THB: Thai Baht (1 USD ≈ 33 Baht).
Statistically significant at $p < 0.05$.

reflects access to essential resources, such as dental care services, fluoride products, and healthy dietary options, all of which are critical for maintaining oral health [39]. In addition, caregiver education may be associated with oral health knowledge [40] and the capacity to promote appropriate oral health behaviors in children. These indicators remain strong determinants of oral health inequalities and are commonly used as proxies for assessing caries risk [10, 37]. However, no significant associations were found between high caries experience and caregiver-related or child-related characteristics, including caregiver age, sex, birth order, and BMI. The lack of association with BMI is consistent with a previous study [41]. Although other studies reported an association between BMI and dental caries [42], the relationship remains inconclusive, possibly reflecting the multifactorial nature of dental caries [43, 44], which is shaped by complex behavioral, dietary, and socioeconomic factors not fully captured by BMI alone [45].

It was noted that enamel defects were strongly associated with high caries experience. This finding is expected, as enamel defects are well-established risk factors for dental caries and are commonly included in caries risk assessment models [10]. Teeth with enamel defects are inherently more

susceptible to caries due to their compromised structure, which increases vulnerability to demineralization and disease progression [14]. Consequently, enamel defects were associated with higher DMFT scores, consistent with findings from previous studies [46, 47]. These findings highlight the importance of early identification and management of enamel defects in children. Children with enamel defects should receive more intensive preventive care, including active dental monitoring and preventive strategies such as the application of remineralizing agents (*e.g.*, fluoride varnish and casein phosphopeptide–amorphous calcium phosphate (CPP-ACP)), dental sealants, and intensive oral hygiene instruction [48–50]. In addition, our study found an association between oral hygiene status and caries experience. Dental biofilm (plaque) is widely used as an indicator in oral health surveys [7, 18] and caries risk assessment tools [10, 51]. Previous studies have also reported that dental biofilm is associated with increased caries prevalence [12, 28]. This finding supports the well-established role of dental biofilm as a primary etiological factor in dental caries, as inadequate dental biofilm control promotes the proliferation of cariogenic bacteria and sustained acid production, leading to demineralization of the tooth structure [52].

Unhealthy dietary and cariogenic consumption behaviors were observed among children with high caries experience, consistent with previous studies [15, 19, 44]. Frequent consumption of cariogenic foods and beverages was common in this age group, with many children reporting daily intake despite existing policies promoting healthy snack consumption [8]. This may reflect the current social and environmental context, where easy access to convenience stores and the continued availability of cariogenic foods contribute to frequent sugar exposure. These findings suggest the need for strengthened environmental and policy-level interventions, particularly within schools, to limit access to cariogenic foods and support healthier dietary choices. Public health policies, such as the WHO recommendation on sugar-sweetened beverage taxation and sugar reduction strategies [53], may help reduce sugar consumption and support caries prevention.

Frequency of toothbrushing may play an important role in caries experience [12, 15, 19]. Children who did not brush their teeth daily had higher odds of high caries experience. Interestingly, a non-significant reverse pattern was observed, with children who brushed once daily appearing to have lower odds of high caries experience compared with those who brushed at least twice daily. This finding should be interpreted with caution, possibly due to reverse causation. Notably, more than half of the children were unaware of their toothbrushing duration, which may reflect a gap in oral health knowledge. However, no significant associations were observed between toothbrushing duration, dental floss use, and high caries experience. Toothbrushing duration alone may not adequately reflect effective plaque control, which also depends on brushing technique, frequency, and supervision [54]. Overall, toothbrushing at least twice daily for at least 2 minutes remains a standard recommendation [55, 56]. In addition, the low prevalence of regular dental floss use may have limited the ability to detect a significant association, despite previous studies reporting an association between floss use and lower caries prevalence [13].

Fluoride toothpaste use was highly prevalent in this population (84.5%). However, no significant association was observed between fluoride toothpaste use and high caries experience, possibly due to the limited variability in its use between groups. In Thailand, most commercially available toothpastes contain fluoride, and their use is widely promoted through national oral health policies [8]. Similarly, no association was observed between dental check-ups and high caries experience, despite 67.0% of participants reporting having had a dental check-up within the past 6 months. Nevertheless, more than two-thirds of the children still experienced dental caries. This may reflect limitations of self-reported data, including recall bias and potential misinterpretation, as well as the influence of routine school-based dental examinations, which may not represent active care-seeking behavior or timely treatment.

It was noted that the internet played an important role as a source of oral health information among children in this age group, with 44.3% of children reporting the internet as their primary source of oral health information, followed by teachers. These findings suggest that digital media and school-based education may play an important role in promoting oral health knowledge and positive oral health behaviors among schoolchildren [57–59].

The findings of this study have important public health implications. A substantial proportion of children experienced dental caries, while the proportion of filled teeth remained relatively low, suggesting a considerable unmet need for dental treatment in this population. Targeted preventive strategies should focus not only on children with unhealthy oral health behaviors, but also on children from socioeconomically disadvantaged families and those with enamel defects. School-based oral health promotion programs and digital media-based oral health interventions may help reduce the burden of dental caries. In addition, strategies to promote healthier dietary habits and encourage routine oral health visits should be considered.

This study has several limitations. First, the cross-sectional design precludes causal inference. Second, the use of self-reported data from structured questionnaires may be susceptible to recall and reporting bias. Third, the study was conducted in public schools in Pathum Thani Province, which may limit the generalizability of the findings to rural populations or private school settings. Fourth, although a single examiner was used throughout the study to minimize inter-examiner variability, the use of only one examiner may raise concerns regarding objectivity. Additionally, the binary classification of caries experience (high *vs.* non-high) did not distinguish children with no caries experience (DMFT = 0) as a separate category, which may have limited the identification of factors associated with being free of caries experience. Future studies involving more diverse populations and settings are recommended to improve generalizability. Longitudinal studies are also needed to further investigate causal relationships, evaluate targeted interventions, and explore additional behavioral, environmental, and psychosocial determinants of dental caries.

5. Conclusions

High caries experience among 12-year-old Thai schoolchildren was associated with socioeconomic, behavioral, and oral health-related clinical factors, including low caregiver education (middle school or lower), low family income ($\leq$10,000 THB), enamel defects in permanent molars, fair-to-poor oral hygiene, infrequent toothbrushing, and frequent cariogenic food and beverage consumption. These findings provide insights for developing oral health promotion policies and preventive strategies in this population.

ABBREVIATIONS

WHO, World Health Organization; DMFT, Decayed, Missing, and Filled Permanent Teeth; DT, Decayed Teeth; MT, Missing Teeth; FT, Filled Teeth; SiC, Significant Caries Index; THB, Thai Baht; AOR, Adjusted Odds Ratio; CI, Confidence Interval; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; EPV, Events-per-variable; IOC, Item-Objective Congruence; BMI, Body Mass Index; DDE, Developmental Defects of Enamel; CPP-ACP, casein phosphopeptide–amorphous calcium phosphate; SD, Standard Deviation; IQR, Interquartile Range.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

KK—designed the study, collected and analyzed the data, and drafted the manuscript. NP—analyzed the data and revised the manuscript. Both authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Human Research Ethics Committee, Faculty of Science, Thammasat University, Thailand (HREC-TU COA No. 027/2567). Written informed consent was obtained from legal guardians or primary caregivers, and written assent was obtained from participating children prior to data collection. Participants received information regarding the study objectives, procedures, potential risks and benefits, and their right to withdraw at any time without consequences. All procedures were conducted in accordance with the Declaration of Helsinki.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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