Impact Of Dietary Habits And Snacking Frequency On Caries Experience Among Adolescents

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Abstract

Background: Dental caries remains the most prevalent chronic oral disease among adolescents globally. While the relationship between sugar consumption and caries is well-established, the specific contributions of contemporary dietary patterns, snacking frequency, and food choices to caries experience in modern adolescent populations require further investigation given the rapidly evolving food environment. Objective: This cross-sectional study aimed to evaluate the association between dietary habits, snacking frequency, and types of snack foods consumed with caries experience among adolescents, and to identify independent dietary predictors of elevated caries levels. Methods: A total of 480 adolescents aged 12–17 years were recruited from six secondary schools. Dietary assessment was performed using a validated food frequency questionnaire and a three-day dietary diary. Clinical examination for caries was conducted using the DMFT/DMFS indices according to WHO criteria by calibrated examiners. Snacking frequency was categorized as low (≤1/day), moderate (2–3/day), or high (≥4/day). Data were analyzed using chi-square tests, one-way ANOVA, Spearman correlations, and multiple linear regression analysis. Results: The mean DMFT score for the entire sample was 3.84 ± 2.67. Adolescents with high snacking frequency demonstrated significantly greater mean DMFT scores (5.47 ± 2.89) compared with moderate (3.62 ± 2.41) and low (2.18 ± 1.78) snacking frequency groups ($p < 0.001$). Frequent consumption of sugar-sweetened beverages ($\beta = 0.284$, $p < 0.001$), confectionery ($\beta = 0.216$, $p < 0.001$), and sticky carbohydrate snacks ($\beta = 0.194$, $p = 0.002$) were significant independent predictors of DMFT scores. Conversely, regular consumption of dairy products ($\beta = -0.147$, $p = 0.008$) and fresh fruits ($\beta = -0.118$, $p = 0.024$) demonstrated protective associations. Snacking frequency alone explained 18.4% of variance in DMFT scores, while the comprehensive dietary model explained 34.7%. Conclusion: Snacking frequency and the type of foods consumed between meals are significantly associated with caries experience in adolescents. Interventions targeting snacking behaviors and promoting healthier food choices represent important strategies for caries prevention in this population.

Keywords: dental caries, dietary habits, snacking frequency, adolescents, sugar consumption, DMFT, caries prevention, nutrition.

1. Introduction

Dental caries constitutes the most prevalent chronic disease affecting the global population, with untreated carious lesions in permanent teeth impacting an estimated 2.3 billion individuals worldwide**[1]**. Among adolescents specifically, dental caries represents a significant public health burden, with prevalence rates ranging from 40% to over 80% across different geographic and socioeconomic contexts**[2]**. The consequences of caries extend beyond oral health, encompassing pain, infection, compromised nutritional status, impaired academic performance, diminished self-esteem, and substantial economic costs associated with treatment[3].

The etiological framework for dental caries recognizes the disease as a multifactorial process resulting from complex interactions among susceptible host factors, cariogenic microorganisms, and fermentable carbohydrate substrates operating over time[4]. Among these determinants, dietary factors occupy a central position, as the frequency and pattern of fermentable carbohydrate consumption directly modulate the metabolic activity of biofilm organisms, the magnitude and duration of acid challenges to dental hard tissues, and the balance between demineralization and remineralization cycles[5]. The landmarkVipeholmstudy, conducted between 1945 and 1953, provided foundational evidence that the frequency of sugar intake, particularly between meals, exerted a stronger influence on caries development than the total quantity consumed[6].

Contemporary dietary landscapes have undergone profound transformations that carry significant implications for oral health. The increasing availability and aggressive marketing of ultra-processed foods, sugar-sweetened beverages, energy drinks, and calorie-dense snack products have substantially altered the dietary patterns of adolescents in both developed and developing nations[7]. The frequency of between-meal snacking among adolescents has increased markedly over the past three decades, with studies indicating that modern adolescents consume an average of two to four snacks daily, contributing approximately 25–35% of total daily energy intake[8]. Many of these snacking episodes involve foods with high concentrations of free sugars, refined carbohydrates, and acidic components, creating repeated cariogenic challenges throughout the day that overwhelm the natural protective capacity of saliva [9].

The World Health Organization has recommended limiting free sugar intake to less than 10% of total energy intake, with a conditional recommendation for further reduction below 5% for additional health benefits, including oral health[10].Sheihamand James provided comprehensive evidence that the dose-response relationship between sugar intake and caries follows a logarithmic curve,with significant caries increments observable even at consumption levels well below established thresholds[11]. However, these macrolevel recommendations require translation into specific, actionable dietary guidance that addresses the real-world eatingbehaviorsof contemporary adolescents.

Despite the well-established relationship between dietary sugars and caries, several important gaps remain in the current understanding of how specific dietary patterns influence caries outcomes in modern adolescent populations. First, while the cariogenic potential of sucrose has been extensively studied, the relative contributions of other commonly consumed carbohydrate sources, including glucose-fructose syrups, starch-containing snacks, and acidic beverages, to caries development in adolescents require further characterization[12]. Second, the protective effects of certain dietary components, including dairy products, cheese, fibrous foods, and specific micronutrients, have been suggested by some studies but not consistently confirmed across adolescent populations[13]. Third, the interplay between snacking frequency, snacking timing relative to main meals, and the specific cariogenic properties of snack food types remains incompletely delineated[14]. Fourth, contemporary studies utilizing validated dietary assessment instruments combined with standardized clinical caries evaluation in large adolescent samples are needed to generate evidence relevant to current food environments[15].

Additionally, the growing prevalence of snacking as a dominant dietary pattern among adolescents, influenced by factors including peer pressure, screen time, advertising exposure, and the availability of convenience foods, necessitates targeted investigation of how thesebehavioralpatterns translate into measurable caries outcomes[16]. Understanding the specific dietarybehaviorsmost strongly associated with caries risk in adolescents would inform the development of evidence-based nutritionalcounselingstrategies within dental practice and school-based health promotion programs.

The present study aimed to comprehensively evaluate the association between dietary habits, snacking frequency, and specific food choices with caries experience among adolescents, and to identify independent dietary predictors of elevated caries levels. The findings are intended to inform the development of targeted dietarycounsellinginterventions for caries prevention in adolescent populations.

2.Materials and Methods

2.1 Study Design and Ethical Approval

This cross-sectional analytical study was conducted between October 2023 and May 2024 across six public secondary schools in an urban metropolitan area. All procedures were conducted in compliance with the Declaration of Helsinki. Written informed consent was obtained from parents or legal guardians, and written assent was obtained from each participating adolescent prior toenrolment.

2.2 Sample Size Determination

The sample size was estimated using G*Power software (version 3.1.9.7) for multiple linear regression with 12 predictor variables. Assuming a medium effect size ($f^2 = 0.15$), a significance level of 0.05, and a statistical power of 0.90, the minimum required sample size was 428 participants. To accommodate potential incomplete data and non-response, 510 adolescents were approached, ofwhom 480 provided complete data and were included in the analysis, yielding a response rate of 94.1%.

2.3 Participant Selection

Adolescents aged 12 to 17 years who were enrolled in the selected schools and who provided complete informed consent documentation were eligible for inclusion. Schools were selected through stratified random sampling from a list of all public secondary schools in the metropolitan area, with stratification by geographic zone and socioeconomic classification.

Inclusion criteria comprised age between 12 and 17 years, permanent dentition stage (excluding third molars), residence in the study area for a minimum of two years (to ensure consistent fluoride exposure history), and ability to comprehend and complete the dietary assessment instruments.

Exclusion criteria included the presence of systemic diseases known to affect oral health status (diabetes mellitus, immunodeficiency conditions, eating disorders), chronic medication use known to influence salivary function or oral health, current or recent orthodontic treatment with fixed appliances (within the preceding six months), craniofacial anomalies or developmental dental conditions (amelogenesis imperfecta,dentinogenesisimperfecta), history of extensive dental rehabilitation involving full-coverage crowns on multiple teeth, and refusal to participate or inability to provide reliable dietary history.

2.4 Data Collection Instruments

2.4.1 Sociodemographic and Oral Health Behaviour Questionnaire

A structured questionnaire was administered to collect information regarding age, sex, parental education level, household income category, oral hygiene practices (brushing frequency, brushing technique, fluoride toothpaste use, dental floss use, mouthwash use), dental visit patterns, and exposure to community water fluoridation.

2.4.2 Dietary Assessment

Dietary habits were assessed using two complementary instruments:

(a) Food Frequency Questionnaire (FFQ):A semi-quantitative, 78-item FFQ was adapted from validated instruments previously employed in adolescent nutritional epidemiology. The FFQ assessed the habitual consumption frequency of food items organized into 12 categories: fresh fruits, vegetables, dairy products (milk, cheese, yogurt), whole grains, refined grain products, confectionery and candies, cookies and pastries, sugar-sweetened beverages (soft drinks, fruit-flavoureddrinks, sweetened tea/coffee), energy and sports drinks, sticky carbohydrate snacks (caramel, toffee, dried fruit, granola bars),savorysnacks (chips, crackers, pretzels), and sugar-free chewing gum. Response options for each item ranged from "never or less than once per month" to "three or more times per day" on a nine-point frequency scale. The FFQ was pilot-tested on 40 non-study adolescents, demonstrating acceptable test-retest reliability (intraclass correlation coefficient = 0.83) and content validity as assessed by a panel of two nutritionists and two dental public health specialists.

(b) Three-Day Dietary Diary: Participants maintained a detailed dietary diary recording all foods and beverages consumed over three consecutive days (two weekdays and one weekend day). Instructions for diary completion were provided verbally and in writing, including guidance on estimating portion sizes using household measures and photographic aids. Diaries were reviewed by trained research assistants upon collection, and any ambiguous entries were clarified with the participant. Total dailysugar intake (grams) and percentage of total energy from free sugars were calculated using nutrient analysis software.

Snacking Frequency Determination: Snacking frequency was operationally defined as the number of discrete eating or drinking occasions (excluding water) occurring between the three main meals (breakfast, lunch, dinner) per day. Based on the dietary diary data, participants were categorized into three snacking frequency groups: low (≤1 snack/day), moderate (2–3 snacks/day), and high (≥4 snacks/day).

2.4.3 Clinical Oral Examination

Dental caries was assessed by two calibrated examiners (inter-examiner kappa = 0.91; intra-examiner kappa = 0.94 and 0.92, respectively) using the DMFT (Decayed, Missing due to caries, Filled Teeth) and DMFS (Decayed, Missing, Filled

Surfaces) indices according to World Health Organization criteria. Examinations were conducted in a designated school health room using portable dental chairs, standardized artificial illumination, disposable mouth mirrors, and WHO CPI probes. Teeth were dried with cotton rolls prior to assessment. Radiographic examination was not employed, consistent with epidemiological survey protocols. Additionally, the presence of visible plaque was assessed using a simplified plaque assessment (presence/absence on six index teeth), and the Significant Caries Index (SiC) was calculated representing the mean DMFT of the one-third of the study population with the highest caries scores.

2.5 Statistical Analysis

Data were entered into Microsoft Excel andanalyzedusing SPSS version 28.0 (IBM Corporation, Armonk, NY, USA) and R software (version 4.3.2). Descriptive statistics were computed as means with standard deviations for continuous variables and frequencies with percentages for categorical variables. Normality was assessed using the Shapiro-Wilk test and visual inspection of histograms. Between-group comparisons were performed using one-way ANOVA with Tukey's post hoc test for continuous variables and chi-square tests for categorical variables. Spearman's rank correlation coefficients were calculated to assess bivariate associations between dietary variables and caries indices. Hierarchical multiple linear regression analysis was conducted with DMFT as the dependent variable, entering variables in three sequential blocks: Block 1 (sociodemographic and oral hygiene variables), Block 2 (snacking frequency), and Block 3 (specific food category consumption frequencies). Model assumptions were verified through assessment of residual normality, multicollinearity (variance inflation factors < 3.0 for all variables), and homoscedasticity. Statistical significance was set at $p < 0.05$ for all analyses.

3.Results

3.1 Sociodemographic and Oral Health Characteristics

The study sample comprised 480 adolescents with a mean age of 14.3 ± 1.6 years; 248 (51.7%) were female and 232 (48.3%) were male. The overall mean DMFT score was 3.84 ± 2.67, and the mean DMFS score was 5.92 ± 4.18. The caries prevalence (DMFT ≥ 1) was 74.6% (n = 358). The Significant Caries Index (SiC) was 7.24 ± 2.13. Regarding oral hygiene practices, 62.7% reported brushing twice or more daily, and 83.5% used fluoride toothpaste. The demographic, oral health, and dietary characteristics by snacking frequency group are presented in Table 1.

Table 1: Sociodemographic, oral health, and dietary characteristics by snacking frequency category (N = 480)

Variable	Low Snacking ≤1/day (n = 128)	Moderate Snacking 2–3/day (n = 214)	High Snacking ≥4/day (n = 138)	p-value
Age (years), mean ± SD	14.4 ± 1.7	14.2 ± 1.5	14.5 ± 1.6	0.348
Female sex, n (%)	68 (53.1)	112 (52.3)	68 (49.3)	0.764
Parental education ≥ college, n (%)	62 (48.4)	94 (43.9)	52 (37.7)	0.187
Brushing ≥ 2×/day, n (%)	92 (71.9)	138 (64.5)	71 (51.4)	0.002*
Fluoride toothpaste use, n (%)	114 (89.1)	182 (85.0)	105 (76.1)	0.012*
Dental floss use, n (%)	28 (21.9)	34 (15.9)	14 (10.1)	0.027*
Regular dental visits (≥1/year), n (%)	54 (42.2)	72 (33.6)	36 (26.1)	0.017*
Visible plaque present, n (%)	52 (40.6)	108 (50.5)	94 (68.1)	< 0.001*

Variable	Low Snacking ≤1/day (n = 128)	Moderate Snacking 2–3/day (n = 214)	High Snacking ≥4/day (n = 138)	p-value
DMFT score, mean ± SD	2.18 ± 1.78	3.62 ± 2.41	5.47 ± 2.89	< 0.001*
DMFS score, mean ± SD	3.14 ± 2.67	5.68 ± 3.84	8.94 ± 4.72	< 0.001*
Caries prevalence (DMFT ≥ 1), n (%)	78 (60.9)	162 (75.7)	118 (85.5)	< 0.001*
Free sugar intake (% of energy), mean ± SD	7.8 ± 3.2	12.4 ± 4.1	18.7 ± 5.6	< 0.001*
Total daily sugar intake (g), mean ± SD	42.3 ± 18.4	68.7 ± 24.6	97.4 ± 32.8	< 0.001*

*Statistically significant at $p < 0.05$

3.2 Dietary Consumption Patterns and Caries Experience

Significant associations were observed between the consumption frequency of specific food categories and DMFT scores. Table 2 presents the mean DMFT scores stratified by consumption frequency of key dietary categories and the corresponding Spearman correlation coefficients.

Table 2: Mean DMFT scores by consumption frequency of key food categories and correlation analysis (N = 480)

Food Category	Consumption Frequency	n (%)	Mean DMFT ± SD	Spearman ρ with DMFT	p-value
Sugar-sweetened beverages				0.487	< 0.001*
Rarely/never	84 (17.5)	2.12 ± 1.64			
1–3 times/week	148 (30.8)	3.24 ± 2.18			
4–6 times/week	134 (27.9)	4.28 ± 2.56			
Daily or more	114 (23.8)	5.67 ± 2.94			
Confectionery/candies				0.423	< 0.001*
Rarely/never	92 (19.2)	2.34 ± 1.72			
1–3 times/week	164 (34.2)	3.42 ± 2.28			
4–6 times/week	128 (26.7)	4.36 ± 2.64			
Daily or more	96 (20.0)	5.48 ± 2.87			
Sticky carbohydrate snacks				0.394	< 0.001*
Rarely/never	112 (23.3)	2.56 ± 1.84			
1–3 times/week	176 (36.7)	3.68 ± 2.34			
4–6 times/week	118 (24.6)	4.54 ± 2.72			
Daily or more	74 (15.4)	5.38 ± 2.96			
Cookies and pastries				0.312	< 0.001*
Rarely/never	96 (20.0)	2.78 ± 1.94			
1–3 times/week	186 (38.8)	3.64 ± 2.38			

Food Category	Consumption Frequency	n (%)	Mean DMFT ± SD	Spearman ρ with DMFT	p-value
≥ 4 times/week	198 (41.3)	4.58 ± 2.78			
Dairy products				−0.284	< 0.001*
Rarely/never	98 (20.4)	4.87 ± 2.84			
1–3 times/week	168 (35.0)	3.94 ± 2.56			
Daily or more	214 (44.6)	3.18 ± 2.34			
Fresh fruits				−0.218	< 0.001*
Rarely/never	86 (17.9)	4.72 ± 2.78			
1–3 times/week	196 (40.8)	3.86 ± 2.54			
Daily or more	198 (41.3)	3.28 ± 2.42			
Sugar-free chewing gum				−0.178	< 0.001*
Never	264 (55.0)	4.24 ± 2.74			
Occasional	142 (29.6)	3.46 ± 2.48			
Regular (≥ daily)	74 (15.4)	2.87 ± 2.12			

*Statistically significant at $p < 0.05$

3.3 Hierarchical Multiple Regression Analysis

Table 3 presents the results of the hierarchical multiple linear regression analysis predicting DMFT scores.

Table 3: Hierarchical multiple linear regression analysis predicting DMFT scores (N = 480)

Block / Variable	Standardized β	t-value	p-value	ΔR²	Cumulative R²
Block 1: Sociodemographic and oral hygiene				0.124	0.124
Age	0.112	2.67	0.008*		
Sex (female)	−0.024	−0.58	0.562		
Parental education	−0.087	−2.04	0.042*		
Brushing frequency (≥ 2/day)	−0.148	−3.42	0.001*		
Fluoride toothpaste use	−0.098	−2.24	0.026*		
Regular dental visits	−0.076	−1.78	0.076		
Visible plaque present	0.168	3.89	< 0.001*		
Block 2: Snacking frequency				0.184	0.308
Snacking frequency (continuous)	0.347	8.42	< 0.001*		
Block 3: Specific food categories				0.039	0.347
Sugar-sweetened beverages	0.284	5.87	< 0.001*		

Block / Variable	Standardized β	t-value	p-value	ΔR²	Cumulative R²
Confectionery/candies	0.216	4.28	< 0.001*		
Sticky carbohydrate snacks	0.194	3.14	0.002*		
Cookies and pastries	0.087	1.68	0.094		
Dairy products	−0.147	−2.68	0.008*		
Fresh fruits	−0.118	−2.26	0.024*		
Sugar-free chewing gum	−0.094	−1.87	0.062		

*Statistically significant at $p < 0.05$Overall model: $F(15, 464) = 16.42$, $p < 0.001$; Adjusted $R^2 = 0.326$VIF range: 1.08–2.47; Durbin-Watson: 1.94

The full model explained 34.7% of the total variance in DMFT scores. Block 1 (sociodemographic and oral hygiene variables) accounted for 12.4% of variance. The addition of snacking frequency in Block 2 contributed a further 18.4%, representing the largest single incremental contribution. Block 3 (specific food categories) added an additional 3.9% after accounting for overall snacking frequency.

Subgroup analysis revealed that among adolescents who exceeded the WHO recommendation of <10% energy from free sugars (n = 284, 59.2%), the mean DMFT was significantly higher (4.72 ± 2.78)compared with those meeting the recommendation (2.64 ± 1.92) ($p < 0.001$). Furthermore, among those consuming <5% energy from free sugars (n = 86, 17.9%), the mean DMFT was lowest (1.94 ± 1.48).

4.Discussion

This study comprehensively evaluated the associations between dietary habits, snacking frequency, and specific food consumption patterns with caries experience among adolescents, revealing strong and clinically significant relationships that underscore the central role of dietary factors in caries epidemiology. The findings demonstrate that snacking frequency represents the single most influential dietary determinant of caries experience, while the type of foods consumed between meals further modulates caries outcomes.

The overall caries prevalence of 74.6% and mean DMFT of 3.84 ± 2.67 observed in this adolescent sample reflect a substantial disease burden consistent with epidemiological data from comparable populations. The Global Burden of Disease Study reported that untreated caries in permanent teeth remains among the most prevalent conditions worldwide, with adolescents experiencing a critical period of caries increment[17]. The significant dose-response relationship between snacking frequency and DMFT scores, with high-frequency snackers demonstrating DMFT values 2.5 times greater than low-frequency snackers, constitutes a central finding that corroborates the foundational evidence from theVipeholmstudy and its subsequent confirmatory investigations[18].

The biological mechanism underlying the snacking frequency–caries relationship is well-established. Each episode of fermentable carbohydrate intake triggers metabolic activation of acidogenic biofilm bacteria, principally*Streptococcus mutans*and*Lactobacillus*species, resulting in organic acid production that depresses plaque pH below the critical threshold of approximately 5.5 for enamel demineralization[19]. The Stephan curve model predicts that plaque pH requires approximately 20–30 minutes to return to resting levels following each acid challenge. When snacking episodes occur at intervals shorter than this recovery period, cumulative demineralization exceeds the remineralization capacity of saliva, leading to net mineral loss and eventual cavitation[20]. The high-frequency snacking group in our study consumed an average of 4 or more snacks daily, suggesting that these individuals may experience near-continuous acid exposure with minimal recovery intervals.

The identification of sugar-sweetened beverages as the strongest dietary predictor of caries experience (β = 0.284) aligns with the substantial body of evidence implicating these products as major contributors to caries risk in adolescent populations. Bernabé and colleagues demonstrated a significant and consistent association between soft drink consumption and caries experience across multiple national surveys[21]. The particularly potent cariogenic effect of sugar-sweetened beverages likely reflects their combination of high free sugar content (typically 25–40 grams per serving), low pH (2.4–3.5 for carbonated varieties), and the prolonged oral exposure associated with sippingbehaviorscommon among adolescents[22]. Skinner and colleagues reported that sugar-sweetened beverages constituted the single largest source of added sugars in the diets of American adolescents, contributing approximately 35–40% of total added sugar intake[23].

The significant association between sticky carbohydrate snack consumption and elevated caries experience observed in this study reinforces the importance of food retentiveness as a determinant ofcariogenicity. Gustafsson and colleagues in the originalVipeholmstudy demonstrated that sticky confections consumed between meals produced the greatest caries increments[24]. Sticky foods such as caramels, toffees, dried fruits, and chewy granola bars exhibit prolonged retention times ontooth surfaces, extending the duration of substrate availability for bacterial acid production beyond that of soluble sugars that are rapidly cleared by saliva[25].

The protective associations observed for dairy product and fresh fruit consumption merit careful interpretation. The inverse relationship between dairy consumption and caries experience is biologically plausible and consistent with previous evidence. Dairy products, particularly cheese and milk, contain caseinphosphopeptidesthat stabilize amorphous calcium phosphate nanoclusters, promoting remineralization of incipient enamel lesions[26]. Furthermore, cheese consumption stimulates salivary flow, increases plaque pH through ammonia production from casein degradation, and provides bioavailable calcium and phosphate ions at the tooth surface[27]. Moynihan and colleagues similarly reported protective associations between dairy consumption and caries in their systematic review of dietary factors[28].

The protective association of fresh fruit consumption, despite the inherent sugar content of fruits, likely reflects several factors. Fresh fruits contain sugars in a cellular matrix that slows their release and oral clearance, limiting the intensity of the acid challenge compared with free sugars in processed foods. Additionally, the highfiberand water content of fresh fruits stimulates salivary flow, which enhances acid neutralization and mineral supersaturation at the tooth surface[29]. This finding is consistent with the WHO distinction between intrinsic sugars naturally present in intact fruits, which are not associated with adverse health effects, and free sugars, which demonstrate clear cariogenic potential[30].

The finding that the comprehensive dietary model explained 34.7% of variance in DMFT scores, with snacking frequency alone contributing 18.4%, provides quantitative context for the relative importance of dietary factors within the multifactorial caries model. While substantial, the unexplained variance reflects the significant contributions of non-dietary determinants including genetic susceptibility, salivary composition and flow rate, oral microbiome ecology, fluoride exposure, and socioeconomic factors.Selwitzand colleagues emphasized that effective caries prevention requires addressing multiple risk factors simultaneously rather than targeting any single determinant in isolation[31].

The significant associations between snacking frequency and poorer oral hygienebehaviors(less frequent brushing, lower fluoride toothpaste use, greater visible plaque accumulation) observed in this study suggest that high-frequency snacking may serve as a marker for a broader pattern of health-compromisingbehaviorsamong adolescents. This clustering of riskbehaviorshas been described in the healthbehaviorliterature and has implications for the design of comprehensive health promotion interventions that address multiplebehavioralrisk factors simultaneously[32].

This study possesses several strengths, including a large sample size, the use of complementary dietary assessment methods (FFQ and dietary diary) providing both habitual and detailed consumption data, calibrated clinical examination, and comprehensive statisticalmodelingwith hierarchical regression enabling assessment of incremental contributions from different variable categories. The multi-school recruitment enhances the representativeness of the sample.

However, several limitations require acknowledgment. The cross-sectional design precludes establishment of causal relationships between dietarybehaviorsand caries development, as DMFT scores reflect cumulative lifetime caries experience rather than contemporaneous dietary effects. Dietary assessment through self-report is susceptible to recall bias, social desirability bias, and underreporting of unhealthy foods, particularly among adolescents. The three-day dietary diary, while providing detailed intake data, may not fully capture habitual dietary patterns that varysubstantially across weeks and seasons[33]. Additionally, the study did not assess salivary parameters (flow rate, buffering capacity, microbial counts) that mediate the relationship between diet and caries. Future prospective longitudinal studies incorporating objective biomarkers of sugar intake and serial caries assessments would strengthen the evidence base.

5.Conclusion

This study demonstrates that dietary habits and snacking frequency are significantly and independently associated with caries experience among adolescents. The frequency of between-meal snacking emerges as the single most influential dietary determinant, with high-frequency snackers exhibiting substantially greater caries burden. Sugar-sweetened beverages, confectionery, and sticky carbohydrate snacks represent the specific food categories most strongly associated with elevated caries levels, while dairy products and fresh fruits demonstrate protective associations. The comprehensive dietary model explained over one-third of the total variance in caries experience, confirming the pivotal role of diet within the multifactorial caries framework.

These findings carry important implications for dental practitioners, public health professionals, and educators engaged in caries prevention among adolescents. Dietarycounselingwithin dental practice should emphasize the reduction of between-meal snacking frequency as a primarybehavioraltarget, with specific focus on substituting sugar-sweetened beverages and sticky confections with less cariogenic alternatives. School-based health promotion programs should integrate oral health messaging with broader nutritional education, and policy-level interventions addressing the availability and marketing of ultra-processed snack foods to adolescents merit consideration. Adherence to the WHO recommendation of limiting free sugar intake to less than 10% of total energy, with aspiration toward the 5% target, should be promoted as a dual-benefit strategy for both oral and general health improvement in adolescent populations.

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