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BEHAVIORAL AND LIFESTYLE DETERMINANTS OF ORAL HEALTH STATUS AMONG UNIVERSITY STUDENTS: A MULTIVARIATE ANALYSIS BASED ON DMFT AND OHI-S INDICES AT QUANG BINH UNIVERSITY, VIETNAM

Nguyen Duc Binh[1], Hoang Thi Nga[2*]

Abstract – *This study aimed to identify behavioral and lifestyle factors associated with dental caries and oral hygiene status among university students. An analytical cross-sectional study was conducted on 707 students at Quang Binh University on 30 March 2026, of whom 683 also completed the behavioral/lifestyle questionnaire and were included in the associated-factors analysis. The DMFT and OHI-S indices were used to assess dental caries and oral hygiene status, and data were analyzed using descriptive statistics, Chi-square tests, multivariate logistic regression, and multivariate linear regression. The results revealed a high prevalence of dental caries among students (78.8%), with a mean DMFT of 3.05 $\pm$ 2.59. The mean OHI-S was 1.64 $\pm$ 1.01, with the majority of participants classified as having a moderate level of oral hygiene (56.9%). Univariate analysis showed that several behavioral factors were associated with dental caries. However, in the multivariate logistic regression model, only the habit of using toothpicks was identified as an independent factor; students who did not use toothpicks or used them only occasionally had a significantly lower risk of dental caries compared to those who used them regularly (OR = 0.55 and 0.50, respectively; $p < 0.05$), while acidic food/drink consumption was independently associated with OHI-S. These findings suggest that toothpick use and consumption of acidic foods and drinks are modifiable behavioral targets for oral health promotion among Vietnamese university students.*

Keywords: dental caries, DMFT, OHI-S, oral hygiene behavior, risk factors, university students.

I. INTRODUCTION

Oral health is a fundamental component of overall health, with direct implications for quality of life, learning capacity, and social interaction [1]. Among oral diseases, dental caries and gingivitis are the most prevalent conditions, particularly among adolescents and university students, where behavioral and lifestyle factors play a decisive role [1, 2]. Despite global efforts in prevention, dental caries remains one of the most widespread non-communicable diseases, with an increasing burden in developing countries [1, 3]. University students represent a population undergoing significant transitions in lifestyle and health behaviors. Changes in dietary patterns, increased consumption of sugary and acidic foods, and suboptimal oral hygiene practices may elevate the risk of oral diseases [4, 5]. In Vietnam, national and regional epidemiological surveys have documented the oral health status of children and adults [6, 7], and one multi-country study has included Vietnamese undergraduates alongside students from four other ASEAN countries [8]; however, research focusing specifically on Vietnamese university students, especially in non-urban settings, using integrated multivariate approaches, remains limited.

Quang Binh University, a multidisciplinary institution in the Central region of Vietnam, hosts a diverse student population with varying socioeconomic backgrounds and lifestyle characteristics.

[1]University of Medicine and Pharmacy, Hue University, Vietnam
[2]Quang Binh University, Vietnam
*Corresponding author: ngaht@qbu.edu.vn
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These differences may influence oral health behaviors and outcomes [9–11]; however, systematic investigations in this context are still lacking. Therefore, this study aims to assess oral health status and identify behavioral and lifestyle factors associated with dental caries and oral hygiene among students at Quang Binh University. Using standardized indices, including the Decayed, Missing, and Filled Teeth (DMFT) index and the Simplified Oral Hygiene Index (OHI-S), the study further applies multivariate analytical models to determine independent risk factors. The findings are expected to provide a scientific basis for designing targeted interventions to improve oral health among university students.

II. LITERATURE REVIEW

Dental caries is a multifactorial disease resulting from the interaction of biological, behavioral, and environmental factors. It is widely recognized as a major public health issue, with a high prevalence across different populations worldwide [1, 3]. The World Health Organization has emphasized that dental caries remains one of the most common non-communicable diseases globally, especially in developing countries [2]. Among the key determinants of dental caries, dietary habits play a central role, notably the consumption of free sugars. Previous studies have demonstrated a strong and consistent association between sugar intake and the development of dental caries, with evidence supporting a dose–response relationship [4, 5]. These findings highlight the importance of dietary control in caries prevention strategies.

Oral hygiene behaviors are also critical in maintaining oral health and preventing disease progression. Regular toothbrushing, particularly when combined with fluoride use, has been shown to significantly reduce plaque accumulation and caries risk [12, 13]. Dental plaque has been identified as a major etiological factor in both dental caries and periodontal diseases, reinforcing the importance of effective plaque control [14]. Lifestyle factors further contribute to oral health outcomes. Behaviors such as frequent snacking, consumption of acidic foods and beverages, and tobacco use have been associated with increased risk of dental caries and periodontal conditions, and these factors may act synergistically with poor oral hygiene practices to accelerate disease progression [2]. Moreover, socioeconomic conditions and access to healthcare services can influence oral health behaviors and outcomes, with disadvantaged groups often experiencing poorer oral health status [9–11]. Access to dental care and preventive services is another important determinant; individuals who regularly attend dental check-ups are more likely to have better oral health outcomes, while barriers to accessing dental care may lead to delayed diagnosis and treatment [15, 16], especially among young adults, who often seek dental care only when symptoms become severe.

In oral epidemiology, standardized indices are widely used to assess disease burden and oral hygiene status. The DMFT index (also referred to in Vietnamese-language literature by the equivalent local abbreviation, SMT-R) is recommended by the World Health Organization as a reliable measure of cumulative caries experience in population-based studies [17]. Similarly, the OHI-S, developed by Greene et al. [18], provides a practical, widely used method for evaluating oral hygiene by assessing debris and calculus. The combined use of these indices allows for a comprehensive assessment of both clinical conditions and related behavioral factors.

A substantial proportion of these studies have relied on descriptive or univariate analyses, which may not adequately account for confounding variables or the complex interactions among multiple determinants [4, 5, 9–16]. Multivariate analytical models provide a more effective alternative, identifying independent risk factors while controlling for potential confounders [19]. However, research that integrates oral hygiene behaviors, lifestyle factors, and clinical indices such as DMFT, OHI-S, and GI within a single multivariate framework remains uncommon; the five-country ASEAN university-student survey is a notable exception [8]. This gap restricts a thorough understanding of how these factors in-

teract to shape oral health outcomes. The present study fills this gap by applying an integrated multivariate framework, combining clinical indices, including DMFT, OHI-S, and Gingival Index (GI), with a structured behavioral questionnaire in a university student population in a non-urban region of Vietnam. This approach is intended to provide new, context-specific data on the behavioral determinants of oral health among Vietnamese university students, complementing the broader picture offered by national surveys and multi-country comparisons [6–8].

III. MATERIALS AND METHODS

A. Study design

This study employed an analytical cross-sectional design to assess the current status of oral health and to examine behavioral and lifestyle factors associated with dental caries and oral hygiene among university students at Quang Binh University, Vietnam, conducted on 30 March 2026. The cross-sectional design allows for the simultaneous collection of data on exposures and outcomes, making it suitable for epidemiological studies aimed at identifying associated factors within a population [17].

B. Study participants

The study population consisted of students enrolled at Quang Binh University during the survey period. The required minimum sample size was estimated using Formula (1).

$$n = \frac{Z^2_{1-\alpha/2} \times p(1-p)}{d^2} \quad (1)$$

Based on an expected dental caries prevalence of p $\approx$ 0.75 reported in prior regional surveys, a 95% confidence level (Z = 1.96), and a marginal error d = 0.03, a minimum required sample size yields approximately 665 students; recruitment was extended to 707 students to allow for potential non-response and invalid records. Students were selected using a stratified random sampling method, with faculties/training programs and academic cohorts serving as strata, followed by simple random selection of classes within each stratum. A total of 707 students underwent clinical oral examination (DMFT, OHI-S, GI) and were included in the descriptive analyses of oral health status. Of these, 683 students also provided complete and valid responses to the behavioral/lifestyle questionnaire and were therefore included in the univariate and multivariate analyses of associated factors; the remaining 24 students had incomplete questionnaire data and were retained only for the clinical descriptive analyses.

Inclusion criteria

Participants were eligible for inclusion if they were enrolled as a student at Quang Binh University on 30 March 2026, provided voluntary consent to participate in the study, and had complete questionnaire data and clinical oral examination records.

Exclusion criteria

Participants were excluded if they were absent during the data collection period, had incomplete or invalid data records, or presented with special conditions affecting dental structure (e.g., cleft lip/palate, congenital enamel hypoplasia or amelogenesis imperfecta) or fixed orthodontic treatment that could interfere with accurate DMFT/OHI-S scoring.

Ethical considerations

The study protocol was reviewed and approved by the Institutional Scientific and Ethics Committee of Quang Binh University before data collection. All participants were informed of the study objectives and procedures and of their right to withdraw at any time without consequence, and written informed consent was obtained from each participant before the clinical examination and questionnaire administration. Data were collected anonymously and used solely for research purposes.

C. Study variables

Dependent variables

Dental caries status

Dental caries status was determined using the DMFT index, which reflects the total number of decayed teeth, teeth missing due to caries, and

filled teeth. This variable was analyzed in two forms: (i) as a binary variable, including DMFT = 0 (no dental caries) and DMFT > 0 (presence of dental caries); and (ii) as a continuous variable, expressed as the mean DMFT value.

Oral hygiene status

The OHI-S index was used to assess oral hygiene status. This variable was analyzed both as a continuous measure and as a categorical variable with three levels: good (0–1.2), moderate (1.3–3.0), and poor (3.1–6.0).

Independent variables

The independent variables were selected to comprehensively capture behavioral and lifestyle factors potentially influencing oral health, comprising three groups: oral self-care behaviors (frequency of toothbrushing, duration of each brushing episode, use of fluoride toothpaste, use of dental floss, and use of mouthwash); lifestyle factors (frequency of snacking, consumption of sugary foods, intake of acidic foods and beverages, and smoking status); and healthcare access factors (regular dental check-ups, history of dental visits, time since the most recent dental visit, and reasons for seeking dental care).

D. Measurement tools and indices

Dental caries index

Dental caries status was assessed using the DMFT index, following the guidelines of the World Health Organization. This index reflects the number of decayed, missing due to caries, and filled teeth, thereby providing a measure of the cumulative burden of dental caries in the study population [17].

Simplified Oral Hygiene Index

Oral hygiene status was evaluated using the OHI-S developed by Greene et al. [18]. This index consists of two components: the Debris Index – Simplified (DI-S) and the Calculus Index – Simplified (CI-S). The combined score provides an overall assessment of oral hygiene status.

Gingival Index

Gingival status was assessed using the GI, which was included as a supplementary indicator to evaluate the level of gingival inflammation. The integration of GI with DMFT and OHI-S offers a more comprehensive assessment of oral and periodontal health.

All clinical examinations (DMFT, OHI-S, GI) were performed by trained dental examiners who completed a standardized calibration session, using reference cases scored against a gold-standard examiner, prior to the start of data collection. Examiners repeated examinations on a 10% random subsample of participants to assess reliability; however, formal inter- and intra-examiner reliability coefficients (e.g., Cohen's Kappa or intraclass correlation) were not computed in this study.

E. Statistical analysis

Data were entered and analyzed using IBM SPSS Statistics software (version 26.0; IBM Corp., Armonk, NY, USA). Three main analytical approaches were applied in sequence: descriptive statistics to summarize sample characteristics, univariate analysis to screen candidate associated factors, and multivariate regression to identify independent associations after adjusting for confounders.

Descriptive statistics

Study variables were summarized using statistical methods appropriate to their data type. Categorical variables were presented as frequencies and percentages (%), while continuous variables were expressed as means and standard deviations (Mean $\pm$ SD). The DMFT, OHI-S, and GI indices were described to provide an overall picture of oral health status in the study population.

Univariate analysis

Univariate analysis was conducted to examine the association between each independent variable and the dependent variables. For categorical variables, the Chi-square (χ^2) test was used to compare differences in the prevalence of dental caries across groups. When the assumptions of the Chi-square test were not met, appropriate alternative tests were considered. For continuous variables, independent samples t-tests or one-way analysis of variance (ANOVA) were used to compare mean values between groups, depending

on the number of groups and data distribution. These analyses served to identify potential factors associated with dental caries and oral hygiene status, forming the basis for selecting variables to be included in the multivariate models.

Multivariate analysis

To identify independent associated factors and control for confounding, multivariate regression models were employed.

Multivariate logistic regression was applied with dental caries status (DMFT) as the dependent variable, dichotomized as DMFT > 0 and DMFT = 0. The results were presented as Odds Ratios (ORs) with 95% confidence intervals (95% CI), allowing for the assessment of the strength and direction of associations. Variables were entered into the model simultaneously using the Enter method; model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test and the Nagelkerke R^2. Multivariate linear regression, with OHI-S treated as a continuous outcome, was used to analyze factors associated with oral hygiene status. This approach enabled a more comprehensive evaluation of the effects of behavioral and lifestyle factors on oral hygiene status. Variables included in the multivariate models were selected based on the results of univariate analysis (typically with a threshold of $p < 0.2$) and their relevance in the literature. The use of multivariate models allows for better control of confounding and provides more accurate estimates of independent associations between study factors and oral health outcomes [19]. The level of statistical significance was set at $p < 0.05$.

IV. RESULTS AND DISCUSSION

A. General characteristics and oral hygiene practices of the study population

The survey of 707 students at Quang Binh University revealed an uneven gender distribution. Among the study participants, females accounted for the majority with 564 individuals (79.8%), while males comprised 143 individuals (20.2%) (Table 1). This imbalance reflects the academic structure of the university and should be taken into consideration when analyzing factors associated with oral health. A post-hoc comparison revealed that gender was not significantly associated with either dental caries status (χ^2 test, p = 0.63) or OHI-S score (independent-samples t-test, p = 0.22); gender was therefore not retained as a covariate in the final multivariate models, although the marked gender imbalance in the sample is acknowledged as a limitation affecting generalizability (see Section IV, Part F).

Table 1: Demographic characteristics of the study population (n = 707)

Characteristics	Category	n	%
Gender	Male	143	20.2
	Female	564	79.8
Total		707	100

Concerning oral hygiene practices, among the 683 questionnaire respondents, 681 provided a valid response to this specific item; the findings reveal that most students had relatively good toothbrushing habits. Specifically, 582 students (85.5%) reported brushing their teeth at least twice daily, whereas 94 (13.8%) brushed once daily, and 5 (0.7%) brushed only occasionally (Table 2). This suggests that the majority of students had established basic oral hygiene routines.

In terms of brushing duration, most students (59.8%) reported brushing their teeth for 2–3 minutes, which is consistent with dental recommendations. However, 22.9% brushed for less than 2 minutes, and 17.3% were unsure of their brushing duration, reflecting variability in awareness and practice regarding appropriate brushing time. The distribution of these toothbrushing behaviors is summarized in Figure 1.

Concerning brushing timing, Table 2 shows that 69.6% of students reported brushing their teeth at two key times: before breakfast and before bedtime. In contrast, 18.9% brushed only after waking up, and 11.3% brushed after breakfast and before bedtime. These findings highlight differences in oral hygiene practices among student groups.

Notably, awareness and use of fluoride toothpaste were limited. Only 20.3% of students re-

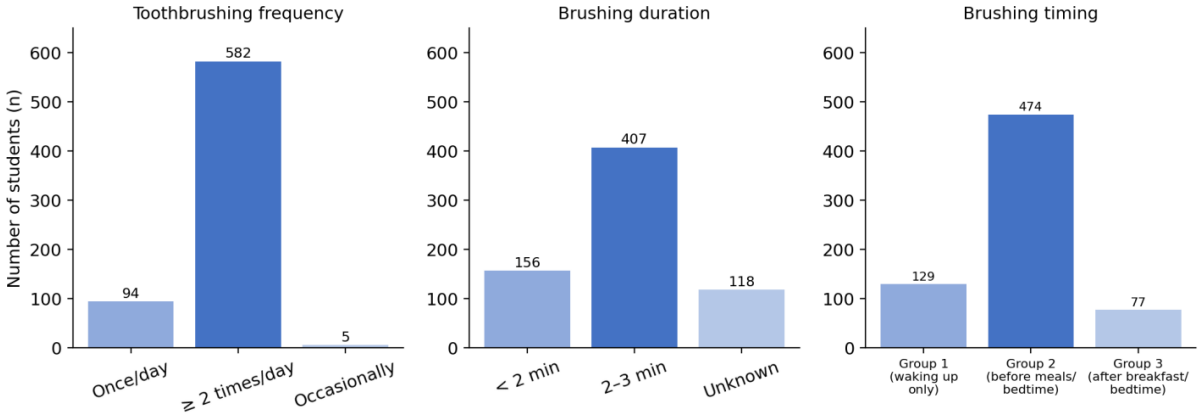

Fig. 1: Distribution of toothbrushing frequency, duration, and timing among students (n = 681)

ported using fluoride toothpaste, while 67.5% were unaware of whether their toothpaste contained fluoride, and 12.2% reported not using fluoride toothpaste (Table 2). This reflects a gap in knowledge and practice related to oral health care.

Table 2: Oral hygiene practices among students (n = 680–681)

Practice	Category	n	%
Toothbrushing frequency	Once daily	94	13.8
	≥ 2 times daily	582	85.5
	Occasionally	5	0.7
Brushing duration	< 2 minutes	156	22.9
	2–3 minutes	407	59.8
	Unknown	118	17.3
Brushing timing	Group 1 (only after waking up)	129	18.9
	Group 2 (before breakfast and before bedtime)	474	69.6
	Group 3 (after breakfast and before bedtime)	77	11.3
Fluoride toothpaste use	Yes	138	20.3
	No	83	12.2
	Unknown	459	67.5

In summary, although most students had established regular toothbrushing habits, there remain notable limitations in brushing duration, technique, and the use of supportive oral hygiene products, which may affect oral hygiene effectiveness and increase the risk of oral diseases.

B. Prevalence of dental caries and oral hygiene status

The study results reveal that oral health conditions among students remain a matter of concern, with a relatively high prevalence of dental caries. Among the 707 students surveyed, 557 students had dental caries (DMFT > 0), accounting for 78.8%, while only 150 students (21.2%) were caries-free (DMFT = 0) (Table 3). This finding reflects the substantial burden of dental caries within the student population.

Table 3: Prevalence of dental caries and DMFT index among students (n = 707)

Indicator	n	%
Caries-free (DMFT = 0)	150	21.2
With dental caries (DMFT > 0)	557	78.8

The mean DMFT value was 3.05 $\pm$ 2.59, indicating a moderate level of cumulative dental damage. When examining the components of the DMFT index, the mean number of decayed teeth (D) was 1.88 $\pm$ 2.08, which was higher than the mean number of missing teeth (0.32 $\pm$ 0.76) and filled teeth (0.85 $\pm$ 1.76). These results suggest a relatively high proportion of untreated carious lesions, reflecting limitations in access to dental care and oral health practices among students.

Oral hygiene status and gingival condition were further assessed using the DI-S, CI-S, OHI-S, and GI indices. The mean Debris Index (DI-

S) was 0.90 ± 0.49, while the mean Calculus Index (CI-S) was 0.74 ± 0.57. Combining these components, the mean OHI-S score was 1.64 ± 1.01, indicating a moderate level of oral hygiene (Table 4).

The mean GI was 0.70 ± 0.54, suggesting a mild to moderate level of gingival inflammation among the study participants. GI was retained as a descriptive indicator only and was not entered into the univariate or multivariate models because it correlates closely with the OHI-S components (DI-S/CI-S), and its inclusion alongside OHI-S would raise concerns of multicollinearity; modelling GI as an independent outcome is noted as a direction for future research.

Table 4: Oral hygiene and gingival indices among students

Index	n	Mean ± SD
DI-S	706	0.90 ± 0.49
CI-S	706	0.74 ± 0.57
OHI-S	707	1.64 ± 1.01
GI	707	0.70 ± 0.54

Note: One participant had a missing DI-S value in the original clinical worksheet while the corresponding OHI-S score had already been recorded; in the absence of the original paper form for re-verification, this single missing DI-S value was imputed as OHI-S - CI-S = 0.0 for completeness. This explains the minor difference in sample size between OHI-S (n = 707) and its two components, DI-S and CI-S (n = 706 each).

When classifying oral hygiene status based on the OHI-S index, only 34.4% of students were categorized as having good oral hygiene, while the majority (56.9%) were classified as moderate and 8.8% as poor (Table 5). This suggests that although most students reported regular toothbrushing habits, the effectiveness of oral hygiene practices remains suboptimal, possibly due to inadequate brushing techniques or insufficient use of supplementary oral hygiene measures.

Taken as a whole, the findings confirm that dental caries remains highly prevalent among students, while oral hygiene status is predominantly

Table 5: Classification of oral hygiene status based on OHI-S (n = 707)

Category	n	%
Good (0–1.2)	243	34.4
Moderate (1.3–3.0)	402	56.9
Poor (3.1–6.0)	62	8.8
Total	707	100

at a moderate level. The disparity between the number of decayed teeth and those that have been treated, together with the relatively low proportion of students achieving good oral hygiene, highlights important issues that should be addressed in oral health promotion and intervention programs for university students.

The high burden of dental caries observed in this study is consistent with global evidence indicating that oral diseases remain among the most prevalent non-communicable conditions worldwide [2, 3]. The persistence of moderate oral hygiene levels also aligns with a previous study demonstrating that the presence of dental plaque remains common even among individuals who report regular toothbrushing [14].

C. Behavioral and lifestyle factors associated with dental caries – univariate and multivariate analysis

The results of the univariate analysis examining associations between behavioral and lifestyle factors and dental caries status (DMFT) are presented in Table 6.

Taken together, most oral hygiene behaviors and lifestyle-related factors did not exhibit statistically significant associations with dental caries status ($p > 0.05$). These included toothbrushing frequency ($p = 0.258$), brushing duration ($p = 0.453$), brushing timing ($p = 0.509$), use of mouthwash ($p = 0.126$), snacking habits ($p = 0.384$), sugar consumption ($p = 0.935$), and intake of acidic foods and beverages ($p = 0.532$), none of which were significantly associated with the presence of dental caries.

However, the use of toothpicks was associated with dental caries at a statistically significant level ($p = 0.016$). In particular, the prevalence of

Table 6: Univariate analysis of factors associated with dental caries status among students

Factor	Category	DMFT = 0 n (%)	DMFT > 0 n (%)	Total (n)	p-value
Toothbrushing frequency (times/day)	Once	25 (18.1)	69 (12.7)	94	0.258
	≥ 2 times	112 (81.2)	470 (86.6)	582	
	Occasionally	1 (0.7)	4 (0.7)	5	
Brushing duration	< 2 minutes	32 (23.2)	124 (22.8)	156	0.453
	2–3 minutes	87 (63.0)	320 (58.9)	407	
	Unknown	19 (13.8)	99 (18.2)	118	
Brushing timing	Group 1 (only after waking up)	30 (21.9)	99 (18.2)	129	0.509
	Group 2 (before breakfast and before bedtime)	90 (65.7)	384 (70.7)	474	
	Group 3 (after breakfast and before bedtime)	17 (12.4)	60 (11.0)	77	
Fluoride toothpaste use	Yes	21 (15.3)	117 (21.5)	138	0.099
	No	13 (9.5)	70 (12.9)	83	
	Unknown	103 (75.2)	356 (65.6)	459	
Mouthwash use	Regularly	28 (20.4)	137 (25.2)	165	0.126
	Occasionally	63 (46.0)	269 (49.5)	332	
	Not used	46 (33.6)	137 (25.2)	183	
Type of mouthwash	Boiled water	39 (29.1)	170 (32.0)	209	0.559
	Saline solution	48 (35.8)	158 (29.8)	206	
	Commercial mouthwash	47 (35.1)	202 (38.0)	249	
Snacking frequency (per day)	> 2 times	31 (22.6)	153 (28.2)	184	0.384
	1–2 times	80 (58.4)	301 (55.5)	381	
	No snacking	26 (19.0)	88 (16.2)	114	
Sugar consumption	Frequent	48 (35.0)	199 (36.6)	247	0.935
	None	22 (16.1)	87 (16.0)	109	
	Occasional	67 (48.9)	257 (47.3)	324	
Acidic food/drink consumption	Frequent	14 (10.2)	75 (13.8)	89	0.532
	None	58 (42.3)	222 (41.0)	280	
	Occasional	65 (47.4)	245 (45.2)	310	
Toothpick use	Regularly	24 (17.5)	161 (29.7)	185	**0.016**
	Occasionally	75 (54.7)	247 (45.5)	322	
	Not used	38 (27.7)	135 (24.9)	173	
Dental floss use	Never used	37 (27.2)	150 (27.6)	187	0.912
	Regularly	34 (25.0)	124 (22.8)	158	
	Occasionally	65 (47.8)	268 (49.4)	333	
Smoking status	Regularly	1 (0.7)	13 (2.4)	14	0.105
	Occasionally	1 (0.7)	19 (3.5)	20	
	Non-smoker	134 (98.5)	510 (94.1)	644	

dental caries was higher among students who frequently used toothpicks compared to those who used them occasionally or not at all, suggesting that this behavior may represent a potential risk factor for dental damage.

Furthermore, several variables, although not reaching statistical significance, demonstrated a tendency toward association with dental caries. These included the use of fluoride toothpaste ($p = 0.099$) and smoking status ($p = 0.105$). These variables were therefore considered for inclusion in the multivariate logistic regression model to further evaluate their independent effects after controlling for potential confounders.

Based on the univariate analysis, variables with p-values < 0.20 were selected for inclusion in the multivariate logistic regression model to identify independent factors associated with dental caries, as presented in Table 7.

The absence of statistically significant associations between most behavioral factors (e.g., toothbrushing frequency, brushing duration, dietary habits) and dental caries in the univariate analysis suggests that oral health outcomes are shaped by complex, multifactorial interactions rather than isolated behaviors. This observation

aligns with the conceptual framework of oral disease etiology, which emphasizes the interplay between biological, behavioral, and environmental determinants [16].

Table 7: Multivariate logistic regression analysis of factors associated with dental caries (DMFT > 0)

Factor	Category	OR (Exp(B))	95% CI	p-value
Toothpick use	Occasionally	0.50	0.30 – 0.83	0.008
	Not used	0.55	0.31 – 0.98	0.043
Fluoride toothpaste use	No	1.18	0.54 – 2.59	0.682
	Unknown	0.68	0.41 – 1.15	0.150
Smoking status	Occasionally	1.15	0.06 – 20.62	0.926
	Non-smoker	0.30	0.04 – 2.31	0.245
Mouthwash use	Occasionally	0.94	0.57 – 1.56	0.808
	Not used	0.65	0.38 – 1.12	0.119

The results indicate that, after adjusting for behavioral and lifestyle factors, toothpick use remained significantly associated with dental caries. Compared with students who frequently used toothpicks (reference group), those who did not use toothpicks had a significantly lower likelihood of dental caries (OR = 0.55; 95% CI: 0.31–0.98; p = 0.043). Similarly, students who used toothpicks only occasionally also had a significantly lower likelihood of dental caries relative to regular users (OR = 0.50; 95% CI: 0.30–0.83; p = 0.008), suggesting a possible dose–response pattern in which any reduction from regular toothpick use is associated with lower caries risk.

A key finding of this study is the identification of toothpick use as an independent factor associated with dental caries in the multivariate model. This result suggests that not all oral hygiene practices are equally beneficial, and several culturally common behaviors may inadvertently contribute to adverse outcomes. It has been proposed (though not directly demonstrated by this study) that improper use of toothpicks could plausibly contribute to gingival trauma, enlargement of interdental spaces, or ineffective plaque removal, which might in turn facilitate caries development; this biological pathway remains speculative rather than proven and warrants direct investigation. This concern is broadly consistent with prior evidence on toothpick (woodstick) use that found only limited and inconsistent evidence that woodsticks reduce plaque or gingival inflammation compared with toothbrushing alone, alongside reports of gingival and interdental trauma associated with improper or forceful use [21]. Likewise, a Cochrane systematic review of interdental cleaning devices, including toothpicks/-woodsticks, found low- to very low-certainty evidence for their effect on caries incidence, noting that available trials were generally underpowered and of insufficient duration to detect an effect on this outcome [22], and a broader meta-review of interdental plaque-control methods similarly concluded that the evidence base for woodsticks is weaker and less consistent than for interdental brushes [23]. Against this backdrop, the present study contributes population-level epidemiological evidence – rather than small mechanistic or device-efficacy data – linking toothpick use to dental caries, and appears to be among the first studies to report this association specifically among Vietnamese university students. An equally plausible, and arguably more parsimonious, explanation is reverse causation: students who already have active caries lesions or food impaction may use toothpicks more frequently in an attempt to relieve discomfort or dislodge trapped food, rather than toothpick use itself causing new carious lesions. Because the cross-sectional design of this study captures behavior and disease status at a single point in time, it cannot establish the temporal sequence required to distinguish between these two explanations, and the association reported here should therefore be interpreted as a statistical, not necessarily causal, relationship. This finding underscores the importance of distinguishing between recommended and non-recommended oral hygiene practices in both research and intervention.

With respect to fluoride toothpaste use, although statistical significance was not reached, students who were unaware of their fluoride use exhibited a tendency toward a lower risk of dental caries (OR = 0.68; 95% CI: 0.41–1.15; p = 0.150). However, this association was not sufficiently strong to confirm an independent

effect in the model. Similarly, smoking status was not significantly associated with dental caries after adjusting for confounding factors ($p > 0.05$). Although fluoride use and smoking displayed trends in the univariate analysis, their lack of significance in the multivariate model suggests that their effects may be confounded by other variables or attenuated within this specific population. This reinforces the necessity of multivariate approaches in identifying independent risk factors.

The mouthwash-use variable ($p = 0.126$) was additionally entered into the multivariate model (Table 6). It was not independently associated with dental caries (Not used vs. Regularly: OR = 0.65; 95% CI: 0.38–1.12; $p = 0.119$). Model fit was satisfactory: the Hosmer–Lemeshow goodness-of-fit test was non-significant ($\chi^2 = 4.80$, df = 7, $p = 0.684$, indicating no evidence of lack of fit), and the model explained a modest proportion of variance in dental caries status (Nagelkerke $R^2 = 0.050$; Cox–Snell $R^2 = 0.032$), which is typical for models based on self-reported behavioral predictors.

However, the lack of association between sugar consumption and dental caries contrasts with well-established evidence from systematic reviews, which have identified free sugar intake as a major determinant of caries risk [4, 5]. This discrepancy may be explained by limitations in measurement (e.g., self-reported dietary data), reduced variability in sugar consumption among students, or the influence of unmeasured confounding factors. Similarly, the non-significant role of fluoride toothpaste in the multivariate model differs from extensive literature supporting its protective effect [12]. One plausible explanation is that the effectiveness of fluoride depends not only on usage but also on correct application and frequency, which were not fully captured in this study. The identification of toothpick use as an independent risk factor represents a novel and context-specific contribution. While previous studies have emphasized the benefits of controlled oral hygiene practices such as toothbrushing and professional plaque control [12, 13], limited attention has been given to traditional or habitual practices like toothpick use. This finding underscores the importance of incorporating culturally specific behaviors into oral health research frameworks.

D. Factors associated with oral hygiene status (OHI-S)

A multivariate linear regression was performed with the continuous OHI-S score as the dependent variable. Candidate predictors reaching $p < 0.20$ in univariate analysis (frequency of acidic food/drink consumption and toothbrushing duration) were entered simultaneously (Enter method). Results are presented in Table 8.

Table 8: Multivariate linear regression analysis of factors associated with oral hygiene status (OHI-S)

Factor	Category	B (coefficient)	95% CI	p-value
Acidic food/drink consumption	Frequent	−0.353	−0.594 to −0.113	0.004
	None (reference)	—	—	—
	Occasional	−0.057	−0.220 to 0.107	0.495
Brushing duration	< 2 minutes	+0.146	−0.040 to 0.332	0.124
	2–3 minutes (reference)	—	—	—
	Unknown	+0.171	−0.038 to 0.379	0.108

$R^2 = 0.017$ (adjusted $R^2 = 0.011$); model F = 2.94, $p = 0.020$; n = 675, meaning that in practical terms, the model statistically fits the data ($p = 0.020$), but the two predictors together account for only about 1.7% of the variation in OHI-S scores (1.1% after adjustment for the number of predictors), indicating very limited explanatory and predictive value. Frequent consumption of acidic foods/drinks was significantly associated with a lower OHI-S score (i.e., better oral hygiene) compared with no consumption (B = -0.353; $p = 0.004$); this counter-intuitive direction may reflect residual confounding (e.g., students who avoid acidic foods for other health reasons) or reverse behavioral association, and should be interpreted with caution given the modest explanatory power of the model. This finding is nonetheless broadly consistent with the

wider dental-erosion literature, which similarly identifies acidic food and beverage consumption as a determinant of tooth-surface condition, albeit typically assessed via erosive wear rather than the debris/calculus-based OHI-S index used here [20]. Brushing duration followed a non-significant trend in the expected direction. As a whole, behavioral and lifestyle factors explained only a small proportion of the variance in oral hygiene status, suggesting that other unmeasured determinants (e.g., brushing technique, manual dexterity, professional dental cleaning) may play a more important role in OHI-S than in DMFT.

In summary, the multivariate analysis demonstrates that toothpick use (both occasional and non-use, relative to regular use) was the only behavioral factor independently associated with dental caries among students in this study, suggesting a possible dose–response pattern; whereas other behavioral and lifestyle factors did not retain statistical significance after adjustment. With respect to oral hygiene status (OHI-S), only acidic food/drink consumption was significantly and independently associated in the multivariate linear regression model.

E. Practical and policy implications

The findings of this study carry several important implications regarding understanding oral health behavior among university students. First, the near-universal but only partially effective toothbrushing habits observed indicate that improving oral health requires more than promoting general behavioral frequency; the quality, technique, and appropriateness of practices likely matter more than simple adherence to broad behavioral categories, an interpretation reinforced by the non-significant associations found for brushing frequency and duration despite their high prevalence. Second, identifying toothpick use – rather than more extensively studied factors such as sugar intake or fluoride exposure – as the sole independent behavioral correlate of caries stresses the relevance of culturally specific, habitual practices that are often underrepresented in oral health research frameworks built primarily on evidence from other settings. Third, the limited explanatory power of behavioral and lifestyle factors for oral hygiene status suggests that hygiene status in this population may be driven less by conscious lifestyle choices than by technical or access-related factors, such as brushing technique, manual dexterity, or professional dental care – an interpretation that should inform how future interventions are designed and evaluated. Taken together, these findings show that oral health promotion for this population should move beyond generic behavioral messaging toward targeted, evidence-based, and culturally adapted strategies, consistent with broader public health approaches to reducing oral disease burden [17].

F. Strengths and limitations

A major strength of this study lies in its application of multivariate logistic regression to identify independent risk factors, thereby addressing limitations commonly associated with descriptive and univariate analyses, while also integrating behavioral, lifestyle, and clinical variables within a single comprehensive analytical framework. However, several limitations should be acknowledged. The cross-sectional design limits causal inference, and the use of self-reported data may introduce recall and reporting biases. Furthermore, the study was conducted within a single institution, which may affect generalizability. The omission of certain variables, such as detailed dietary patterns and socioeconomic status, may also limit the explanatory power of the model. Moreover, formal inter-/intra-examiner reliability statistics for the clinical indices were not computed, and the marked gender imbalance in the sample (79.8% female) may limit generalizability to male students; both are acknowledged as methodological limitations for future studies to address. Despite these limitations, the study contributes valuable evidence by identifying context-specific behavioral risk factors and demonstrating the importance of multivariate analysis in oral health research.

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

This study surveyed 707 students at Quang Binh University; of these, 683 completed the full behavioral/lifestyle questionnaire and were included in the analysis of associated factors. The findings reveal that oral health status remains a significant concern: the prevalence of dental caries was high (78.8%), with a relatively elevated mean DMFT index reflecting a considerable burden of oral disease within the study population, while oral hygiene status was predominantly moderate, suggesting that current oral care practices among students are not sufficiently effective. Several behavioral and lifestyle factors were associated with dental caries in the univariate analysis; however, after controlling for potential confounders in the multivariate logistic regression model, only toothpick use remained an independently associated factor, with students who did not use toothpicks or used them only occasionally showing a significantly lower risk of dental caries than those who used them regularly. These findings underscore the critical role of specific oral hygiene behaviors in the development and prevention of dental caries, and confirm the value of multivariate analytical approaches for identifying independent risk factors beyond what univariate associations alone can reveal.

B. Recommendations

Building on the implications outlined, the following concrete recommendations are proposed to improve oral health among university students. First, oral health education programs in university settings should be strengthened and implemented systematically and continuously. These programs should not only provide knowledge but also focus on modifying behaviors, particularly improper oral hygiene practices. Educational activities may be integrated into academic curricula, extracurricular programs, and digital communication platforms.

Second, targeted interventions are necessary to reduce toothpick use, which has been identified as an independent risk factor for dental caries. Instead, safer and more effective interdental cleaning methods, such as dental floss or interdental brushes, should be promoted, along with proper instruction on their use.

Third, preventive oral health practices should be encouraged, especially the use of fluoride-containing toothpaste and regular dental check-ups. Although these factors did not demonstrate independent statistical significance in the multivariate model, they remain essential for long-term oral health maintenance.

Fourth, universities should consider developing or strengthening campus-based oral health care systems. These may include periodic dental screenings, individualized counseling, and collaboration with dental care providers. Integrating such services into student health systems would facilitate early detection and timely intervention.

Finally, further studies using longitudinal or interventional designs are recommended to better establish causal relationships between behavioral factors and dental caries. Expanding research to other populations and settings would also enhance the generalizability of findings.

Collectively, these conclusions and recommendations provide a scientific foundation for designing effective interventions and policies aimed at improving oral health among university students.

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