

# A Study on the Current Status and Correlations of Knowledge, Beliefs, and Practices Regarding Oral Health among College Students Based on Structural Equation Modeling

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## Abstract

**Objective:** To investigate the current status of college students' oral health knowledge, attitudes, and behaviors, and to explore the association pathways among these three factors and the mediating effect of attitudes using structural equation modeling, thereby providing empirical evidence for optimizing oral health education strategies in higher education institutions. **Methods:** A single-time-point cross-sectional questionnaire survey was conducted from October 2024 to October 2025 using convenience sampling, involving 927 students from a university. Students were invited to complete the survey once during their scheduled class periods to ensure a high response rate. The survey tool comprised four sections: general demographic characteristics, oral health knowledge (25 items), oral health attitudes (5 items), and oral health behaviors (10 items). The overall Cronbach's  $\alpha$  coefficient was 0.907, with a KMO value of 0.929. Bartlett's sphericity test ( $P < 0.001$ ) indicated suitability for factor analysis. Descriptive statistics, correlation analysis, and reliability/validity testing were performed using R Studio software. A structural equation model was constructed using the Diagonally Weighted Least Squares (DWLS) estimator to account for mixed item types (dichotomous and Likert-scale), and the significance of the mediating effect was tested using the bias-corrected Bootstrap method (5000 repeated samples). **Results:** A total of 927 valid question-

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naires were collected. College students' oral health knowledge, attitude, and behavior scores were  $12.62 \pm 3.06$ ,  $16.55 \pm 4.45$ , and  $33.82 \pm 8.26$ , respectively. Correlation analysis revealed significant positive correlations between knowledge, attitude, and behavior ( $r = 0.453 - 0.551$ , all  $P < 0.001$ ). The structural equation model demonstrated good fit ( $\chi^2/df = 2.501$ , CFI = 0.982, TLI = 0.979, RMSEA = 0.040, SRMR = 0.025). Path analysis revealed significant positive associations of knowledge on attitude ( $\beta = 0.521$ ,  $P < 0.001$ ), attitude on behavior ( $\beta = 0.279$ ,  $P < 0.001$ ), and knowledge on behavior ( $\beta = 0.426$ ,  $P < 0.001$ ). Mediation analysis indicated that attitude partially mediated the relationship between knowledge and behavior, with an indirect effect size of 0.038 (95% CI: 0.025 - 0.053). The mediating effect accounted for 25.5% of the total effect. **Conclusion:** Oral health knowledge is significantly associated with behavior both directly and indirectly through partial mediation by attitude. Oral health education in higher education institutions should prioritize both knowledge dissemination and attitude internalization, while strengthening environmental support and behavioral skill training to promote effective knowledge-to-behavior conversion.

## Keywords

College Students, Oral Health, Knowledge-Attitude-Practice Model, Structural Equation Modeling, Mediating Effect, Health Education

## 1. Introduction

Oral health is an integral component of overall health and quality of life, and also serves as a key indicator for assessing public health status in populations (Zhang, 2023; Hao et al., 2023). The World Health Organization has highlighted in multiple reports that oral diseases, represented by dental caries and periodontal disease, exhibit high prevalence rates and constitute major chronic noncommunicable diseases affecting human health. It emphasizes the importance of prevention and early intervention (WHO, n.d.). College students are in a critical transitional phase from youth to adulthood, where their health perceptions and behavioral patterns exhibit significant plasticity, profoundly influencing their long-term future health (Yang, 2018). Therefore, systematically understanding this group's oral health status and its influencing factors is crucial for implementing targeted health promotion initiatives.

In health behavior research, the Knowledge-Attitude-Behavior (KAB) theory model provides a classic analytical framework for understanding the emergence and modification of individual health behaviors (Duan et al., 2026). This model posits that knowledge forms the foundation for positive attitudes, while attitudes serve as the key mediators driving behavioral change (Ma, 2002). In recent years, academic attention to college students' oral health status has grown significantly. Existing studies have conducted status surveys and analyses from single dimensions—knowledge, attitude, or behavior—or examined partial relationships among

them (Wang et al., 2021; Yuan et al., 2021; Su et al., 2023). However, existing studies predominantly employ traditional descriptive or correlational statistical methods, making it challenging to simultaneously and systematically examine the complex path relationships and underlying mechanisms among knowledge, attitudes, and behaviors. In particular, empirical research utilizing advanced statistical models to effectively integrate and test comprehensive theoretical hypotheses regarding these three components remains relatively scarce. This limitation has, to some extent, constrained the theoretical depth and specificity of related health education intervention strategies.

Given this, the present study aims to systematically analyze the current status and intrinsic associations of oral health knowledge, attitudes, and behaviors among college students using structural equation modeling. Specific research objectives include: First, describing the current levels of oral health knowledge, attitudes, and behavioral practices among college students; Second, construct and validate a structural equation model with knowledge as the exogenous latent variable, attitude as the mediating latent variable, and behavior as the endogenous latent variable, quantitatively analyzing direct and indirect effect pathways among variables; Third, based on the model's empirical findings, provide scientific references for developing more targeted and theoretically grounded oral health education models and intervention measures for higher education institutions.

This study employs a cross-sectional survey design, selecting a representative sample of university students through convenience sampling. Data collection utilizes a self-report questionnaire validated for reliability and validity. Data analysis will integrate descriptive statistics, confirmatory factor analysis, and structural equation modeling. The anticipated findings will deepen theoretical understanding of the “knowledge-belief-behavior” conversion mechanism in university students' oral health and provide methodological foundations and practical guidance for advancing health promotion efforts in higher education toward greater scientific rigor and precision.

## 2. Objects and Methods

### 2.1. Objects

From October 2024 to October 2025, this study employed a self-designed questionnaire to conduct a blended online and offline survey. The study utilized a single-time-point cross-sectional design where participants completed the questionnaire only once. Convenience sampling was used to select undergraduate and vocational college students in Yunnan Province as research subjects. Participants were selected from various majors and academic years to ensure broad representation. Researchers approached students through departmental coordinators and administered the survey during collective class sessions. Structural equation modeling analysis requires a sample size of 10 to 20 times the number of items. With 40 observed variables (25 for knowledge, 5 for attitudes, and 10 for behaviors), at least 400 to 800 questionnaires needed to be collected. A total of 984 question-

naires were collected, with 927 valid responses yielding a response rate of 94.21%, meeting the minimum sample size requirement.

## 2.2. Methods

### 2.2.1. Survey Methodology

Referencing the Fourth National Oral Health Epidemiological Survey (Wang, 2018) and the Basic Methods for Oral Health Surveys (WHO, 2017), as well as domestic and international research literature (Feng et al., 2020; Liao et al., 2020; Wang et al., 2020; Zhang et al., 2022), we independently designed and compiled a questionnaire for an anonymous online survey. The questionnaire primarily comprised four sections: basic information, oral health knowledge, oral health attitudes, and oral health behaviors. Basic information included gender, family residence, whether parents were healthcare workers, and history of oral health education. Oral health knowledge covered topics such as dental caries, periodontal disease, gingival bleeding, oral hygiene, and management of oral health issues. This section comprised 25 questions, with each correct answer scoring 1 point and incorrect answers scoring 0 points, yielding a maximum score of 25 and a minimum of 0. The oral health attitudes section comprises 5 questions designed around self-health awareness and perception, evaluation and demand for health education, and attitudes toward seeking medical care and willingness to respond. Scoring follows the Likert scale method, with each question scored from 1 to 5 points based on the degree of positive attitude, ranging from low to high. This section has a minimum score of 5 points and a maximum score of 25 points. Oral health behaviors primarily cover brushing techniques, toothpaste selection, flossing and mouthwash usage, as well as behaviors and dietary habits detrimental to oral health. This section includes 10 questions scored using the Likert scale, with each item rated from 1 to 5 points based on the positive degree of the behavior. The minimum score for this section is 10 points, and the maximum is 50 points. Prior to the survey, the questionnaire was entered into the Wenshu Xing system and refined through a pilot study.

### 2.2.2. Quality Control

A preliminary survey was conducted prior to the formal investigation to revise the questionnaire and enhance its rationality, feasibility, and validity. During the questionnaire survey, all questions were designated as mandatory to prevent omissions, and each device was restricted to a single response. Researchers received standardized training to clarify the survey's purpose and significance, with particular emphasis on prohibiting leading questions. During data collection, instructions for completing the questionnaire were explained to participants by class. After obtaining informed consent, participants anonymously completed the questionnaire independently. Following collection via the QuestionStar, raw data was processed and quality-controlled by research team members not involved in questionnaire design or data collection. Questionnaires with logical inconsistencies or other disqualifying issues were excluded.

### 2.2.3. Statistical Analysis

Data was audited and organized using Microsoft Excel for subsequent statistical analysis; statistical analysis was conducted using R Studio software. For quantitative variables, t-tests and F-tests were applied to compare differences in oral health knowledge, attitude, and behavior scores among students with varying characteristics, based on their normality. Pearson correlation analysis was performed using R Studio to examine correlations among students' oral health knowledge, attitude, and behavior, with scatter plots generated. A structural equation model was constructed and path analysis conducted. Due to the inclusion of both dichotomous items (oral health knowledge) and 5-point Likert items (attitudes and behaviors), the Diagonally Weighted Least Squares (DWLS/WLSMV) estimator was employed. This approach is more robust than standard Maximum Likelihood for categorical and non-normal data, providing more accurate parameter estimates and fit indices. Model fit was assessed using indicators such as the chi-square value/degrees of freedom (CMIN/DF), root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), and adjusted goodness-of-fit index (AGFI). A CMIN/DF < 5, RMSEA < 0.08, GFI < 0.9, and AGFI < 0.9 indicated good model fit. The significance level was set at  $\alpha = 0.05$ .

## 3. Result

### 3.1. Basic Information

A total of 927 students were surveyed, including 338 males (36.46%) and 589 females (63.54%); 655 (70.66%) resided in urban areas, while 272 (29.34%) lived in rural areas; 61 (6.58%) had one parent working in healthcare, 36 (3.88%) had both parents working in healthcare, and 830 (89.54%) had neither parent working in healthcare; 398 (42.93%) reported never receiving oral health education, while 529 (57.07%) reported having received oral health education.

### 3.2. Validity and Reliability Testing

Cronbach's alpha coefficients were used to assess the internal consistency reliability of the scale and its dimensions. Confirmatory Factor Analysis (CFA) was conducted to evaluate the measurement model. The standardized factor loadings for all items ranged from 0.65 to 0.88, exceeding the threshold of 0.50. The Composite Reliability (CR) for knowledge, attitudes, and behaviors was 0.82, 0.89, and 0.94 respectively, and the Average Variance Extracted (AVE) values ranged from 0.48 to 0.62, indicating acceptable convergent validity and internal consistency. Results showed that the total scale achieved a Cronbach's alpha coefficient of 0.907, indicating good overall reliability. Among the dimensions: the oral health behaviors dimension comprised 10 items with a Cronbach's  $\alpha$  coefficient of 0.93; and the oral health attitudes dimension comprised 5 items with a Cronbach's  $\alpha$  coefficient of 0.88. All dimension Cronbach's  $\alpha$  coefficients exceeded the acceptable threshold of 0.70, indicating the measurement tool possesses good internal consistency. Detailed results are presented in **Table 1**.

**Table 1.** Internal consistency reliability of the scale and subscales.

Dimension	Number of items	Cronbach's $\alpha$
Oral Health Knowledge	25	0.761
Oral Health Behaviors	10	0.93
Oral Health Attitudes	5	0.88
Total	40	0.907

The Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test were employed to evaluate the structural validity prerequisites of the scale. Results showed a KMO value of 0.929 and an approximate Bartlett's sphericity test chi-square value of 11999.045 ( $df = 780$ ,  $P < 0.001$ ), indicating strong correlations among observed variables and confirming data suitability for subsequent factor analysis. Detailed results are presented in **Table 2**.

**Table 2.** KMO and Bartlett's test of sphericity.

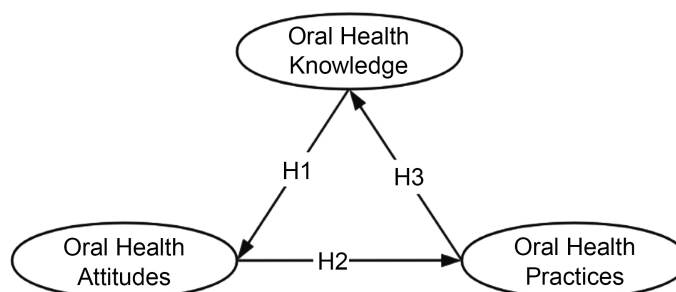
Indicator	Value
KMO Value	0.929
Approx. Chi-Square	11999.045
Bartlett's Test of Sphericity	$df$
	$P$
	780
	0

### 3.3. Model Assumptions

This study employs the "Knowledge-Attitude-Behavior" theory as its fundamental framework to construct a structural equation model examining the relationship between oral health knowledge, attitudes, and behaviors among college students. This theory posits that the formation of health-related behaviors typically follows a progressive path from knowledge acquisition, through attitude transformation, to behavioral practice. Knowledge serves as the foundation, attitude as the motivator, and behavior as the outcome. Specifically, the level of oral health knowledge influences attitudes, attitudes toward oral health influence behaviors, and knowledge can also directly impact oral health-related behaviors. To systematically examine the underlying mechanisms linking these three components, this study defines oral health knowledge, oral health attitudes, and oral health behaviors as latent variables, each measured through corresponding observed variables. Oral health knowledge serves as an exogenous latent variable, assessed via 25 observed indicators (B1 - B25); Oral health attitudes serve as the mediating latent variable, measured by 5 indicators (D1 - D5); Oral health behaviors function as the endogenous latent variable, measured by 10 indicators (C1 - C10). All observed variables were selected based on literature review and theoretical analysis, and validated

through pre-surveys and reliability/validity testing.

Based on this, the following hypotheses are proposed, as shown in **Figure 1**. H1: Oral health knowledge level has a significant positive effect on oral health attitudes. H2: Oral health attitudes have a significant positive effect on oral health behaviors. H3: Oral health knowledge level has a significant positive effect on oral health behaviors. H4: Oral health attitudes mediate the relationship between oral health knowledge and oral health behaviors.



**Figure 1.** Hypothesized structural equation model of knowledge, belief, and behavior in oral health.

### 3.4. Correlation Analysis of Knowledge, Attitudes, and Behaviors

Descriptive statistics and Pearson correlation analysis results for each dimension are presented in **Table 3**. The mean score for oral health knowledge was  $12.616 \pm 3.063$ , the mean score for oral health attitudes was  $16.549 \pm 4.445$ , and the mean score for oral health behaviors was  $33.82 \pm 8.261$ .

Correlation analysis revealed significant positive correlations: oral health knowledge was positively correlated with oral health attitudes ( $r = 0.490$ ,  $P < 0.001$ ); oral health knowledge was positively correlated with oral health behaviors ( $r = 0.551$ ,  $P < 0.001$ ); and oral health attitudes were positively correlated with oral health behaviors ( $r = 0.453$ ,  $P < 0.001$ ). The correlation coefficients among all variables ranged from 0.45 to 0.55, indicating moderate positive correlations, all statistically significant. See **Table 3**.

**Table 3.** Correlation analysis of oral health knowledge, attitudes, and behavior scores.

	Mean	SD	Oral Health Knowledge	Oral Health Attitudes	Oral Health Practices
Oral Health Knowledge	12.616	3.063	1		
Oral Health Attitudes	16.549	4.445	0.490***	1	
Oral Health Practices	33.82	8.261	0.551***	0.453***	1

\* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ .

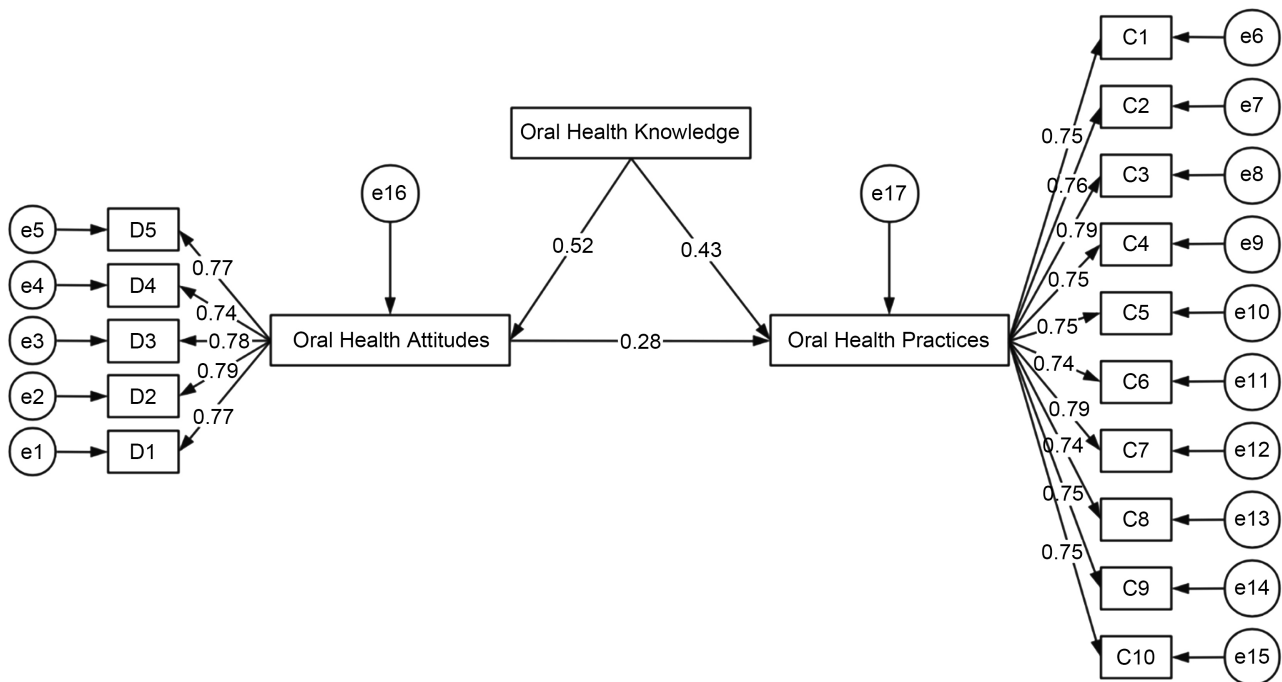
### 3.5. Structural Equation Model Construct

This study constructs a structural equation model with oral health knowledge as

the exogenous latent variable, oral health attitudes as the mediating latent variable, and oral health behaviors as the endogenous latent variable. In the measurement model, oral health knowledge was measured by 25 observed variables (B1 - B25), oral health attitudes by five observed variables (D1 - D5), and oral health behaviors by ten observed variables (C1 - C10). Model parameters were estimated using maximum likelihood estimation, yielding good model fit (fit indices shown in **Table 4**). All path coefficients and factor loadings reached statistical significance.

Path analysis among latent variables revealed: Oral health knowledge exerted a significant positive influence on oral health attitudes, with a standardized path coefficient of 0.52 ( $P < 0.001$ ); Oral health attitudes exerted a significant positive influence on oral health behaviors, with a standardized path coefficient of 0.43 ( $P < 0.001$ ); Oral health knowledge also exerted a significant positive direct influence on oral health behaviors, with a standardized path coefficient of 0.28 ( $P < 0.01$ ). Results indicate that oral health knowledge can both directly predict behaviors and indirectly influence them through the partial mediating effect of attitudes.

In the measurement model section, the standardized factor loadings for each observed variable of the latent variables (knowledge, attitude, and behavior) exceeded 0.60 (specific values shown in **Table 4**) and were statistically significant ( $P < 0.05$ ). Each observed variable demonstrated good explanatory power for its corresponding latent variable, indicating reliable measurement model quality. The standardized path coefficients for the final adjusted model are presented in **Figure 2**.



**Figure 2.** Structural equation model of knowledge, belief, and behavior in oral health.

Parameter estimation for the structural equation model was performed using maximum likelihood estimation, with multiple fit indices selected to comprehen-

sively evaluate the model-data fit. Results indicate: the chi-square-to-degrees-of-freedom ratio ( $\chi^2/df$ ) was 2.501, below the strict criterion of 3.00; The Goodness-of-Fit Index (GFI) was 0.967, the Normative Fit Index (NFI) was 0.970, the Tucker-Lewis Index (TLI) was 0.979, and the Comparative Fit Index (CFI) was 0.982, all exceeding the ideal threshold of 0.90; The Root Mean Square Residual (RMR) was 0.025, below 0.05; The root mean square error of approximation (RMSEA) was 0.040, below 0.08. All fit indices met the criteria for good model fit in structural equation modeling, indicating that the theoretical model constructed in this study exhibits good alignment with the observed data. Detailed fit results are presented in **Table 4**.

**Table 4.** Goodness-of-fit indices for the structural equation model.

Indicator	CMIN/DF	RMR	GFI	NFI	TLI	CFI	RMSEA
Optimal Metric	<3	<0.05	>0.9	>0.9	>0.9	>0.9	<0.08
Acceptable	<5	<0.08	>0.8	>0.8	>0.8	>0.8	<0.1
Measurement results	2.501	0.025	0.967	0.970	0.979	0.982	0.040

### 3.6. Structural Equation Modeling Path Analysis

This study employed maximum likelihood estimation to estimate path coefficients in the structural equation model. Unstandardized regression coefficients, standard errors, critical ratios, significance levels, and standardized regression coefficients are detailed in **Table 5**. Path analysis results indicate that oral health knowledge exerts a significant positive influence on oral health attitudes, with an unstandardized coefficient of 0.144 (S.E. = 0.009, C.R. = 15.561,  $P < 0.001$ ) and a standardized coefficient of 0.521. Oral health attitudes exerted a significant positive influence on oral health behaviors, with an unstandardized coefficient of 0.264 (S.E. = 0.035, C.R. = 7.576,  $P < 0.001$ ) and a standardized coefficient of 0.279; Oral health knowledge exerted a significant positive effect on oral health behaviors, with an unstandardized coefficient of 0.111 (S.E. = 0.009, C.R. = 12.083,  $P < 0.001$ ) and a standardized coefficient of 0.426. This indicates that oral health knowledge directly influences oral health behaviors and indirectly affects behaviors through the mediating role of oral health attitudes. All hypothesized pathways received statistical support.

**Table 5.** Path coefficient estimates of the structural equation model.

	Paths	Estimate	S.E.	C.R.	<i>P</i>	STD Estimate
Oral Health Attitudes	<--- Oral Health Knowledge	0.144	0.009	15.561	***	0.521
Oral Health Practices	<--- Oral Health Attitudes	0.264	0.035	7.576	***	0.279
Oral Health Practices	<--- Oral Health Knowledge	0.111	0.009	12.083	***	0.426

The mediating effect of oral health attitudes between knowledge and behavior was examined using the bias-corrected bootstrap method (5000 repeated samples), with 95% confidence intervals calculated. Results are presented in **Table 6**. Non-standardized effect estimates revealed that the direct effect of oral health knowledge on oral health behavior was 0.111 (95% *CI*: 0.089 - 0.133,  $P < 0.001$ ), the indirect effect was 0.038 (95% *CI*: 0.025 - 0.053,  $P < 0.001$ ), with a total effect of 0.149 (95% *CI*: 0.129 - 0.170,  $P < 0.001$ ). The Bootstrap confidence interval for the indirect effect did not include zero, indicating that the mediating effect accounted for 25.5% of the total effect.

**Table 6.** Bootstrap analysis results for the mediating effect of oral health attitudes.

Effect	Estimate	Lower	Upper	<i>P</i>
Direct effect	0.111	0.089	0.133	0.000
Indirect effects	0.038	0.025	0.053	0.000
Overall effect	0.149	0.129	0.17	0.000

## 4. Discussion

### 4.1. Current Status of Oral Health Knowledge, Attitudes, and Practices among College Students and Their Bivariate Correlations

This study found that college students' average oral health knowledge score was  $12.62 \pm 3.06$  (out of 25 points), with an accuracy rate of approximately 50.5%, indicating a moderate level. This result is similar to the findings reported by Ma Jieyu (Ma & Wang, 2024) but slightly lower than the report by Wang Jiaming (Wang et al., 2021) on medical students. This discrepancy may indicate the influence of professional background on oral health knowledge acquisition, or it could be related to differences in the difficulty and coverage of measurement items used across studies. The average score for oral health attitudes was  $16.55 \pm 4.45$  (out of 25 points), with an average item score of 3.31 (on a 5-point scale), indicating that students generally hold a positive attitude toward oral health, consistent with trends in previous studies (Liu et al., 2019; Zhao et al., 2023). The average score for oral health behaviors was  $33.82 \pm 8.26$  (out of 50), with an average item score of 3.38. However, the large standard deviation (8.26) indicates significant variation in behavioral practice levels among individuals. This outcome may reflect that although college students possess a certain level of oral health awareness, the translation of this awareness into behavior is constrained by factors such as self-management capabilities, accessibility of campus oral health services, and time costs.

Correlation analysis revealed significant positive associations between oral health knowledge, attitudes, and behaviors in all pairwise comparisons, with correlation coefficients ranging from 0.45 to 0.55 (all  $P < 0.001$ ), consistent with the

expected direction of the Knowledge-Attitude-Behavior Theory (KABT) model. Notably, the correlation coefficient between knowledge and behavior ( $r = 0.551$ ) exceeded that between attitude and behavior ( $r = 0.453$ ). This pattern mirrors findings from meta-analyses of chronic disease health behaviors (Wei et al., 2022). A possible explanation is that as a group with high cognitive resources, college students tend to base their behavioral decisions more on knowledge-based information—such as awareness of brushing frequency and regular check-ups—rather than solely through attitude internalization. Additionally, items like flossing and regular dental visits within oral health behaviors possess strong skill attributes, making the direct guidance role of knowledge more prominent. Compared to similar studies, the correlation coefficients in this research were moderately strong. Differences may stem from sample composition (63.54% female, 70.66% urban origin), cultural background, and health education exposure (57.07% had received oral health education).

These findings are further elucidated within the Knowledge-Belief-Behavior Theory framework. While classical theories typically assume knowledge influences behavior indirectly through attitudes, the bivariate correlation patterns in this study preliminarily indicate a potentially significant direct pathway from knowledge to behavior. This suggests that the “knowledge-belief-behavior” conversion pathway for oral health among college students is not a simple linear chain structure but exhibits more complex multi-path characteristics. It is necessary to systematically examine the direction of relationships and effect weights among variables through structural equation modeling.

#### 4.2. Path Relationships and Attitude Mediating Effects in a Structural Equation Model of Oral Health Knowledge, Beliefs, and Practices

The structural equation model constructed in this study achieved fit indices meeting or exceeding recommended standards ( $\chi^2/df = 2.501$ , CFI = 0.982, TLI = 0.979, RMSEA = 0.040, SRMR = 0.025), indicating good fit between the theoretical model and observed data. This provides a reliable foundation for subsequent path interpretation and hypothesis testing.

Path analysis results revealed that oral health knowledge significantly and positively influenced oral health attitudes ( $\beta = 0.521$ ,  $P < 0.001$ ). This indicates that higher knowledge levels correlate with more positive oral health beliefs, consistent with prior findings in health education research (Liu et al., 2016; Qiu & Liu, 2021; Ge & Tan, 2022). The standardized path coefficient for the relationship between oral health attitudes and oral health behaviors was 0.279 ( $P < 0.001$ ), statistically significant but with a relatively low effect size. This finding suggests that the translation of positive attitudes into actual behaviors is not inevitable, potentially involving mediating or moderating variables such as self-efficacy, social support, and behavioral skills. Notably, oral health knowledge exerted a significant direct effect on oral health behaviors ( $\beta = 0.426$ ,  $P < 0.001$ ), with an intensity markedly

higher than that of attitude. This suggests that the formation of oral health behaviors among college students does not rely solely on attitude mediation; knowledge itself can directly guide behavioral practices. Furthermore, the increasing diversification of health education approaches in higher education institutions has, to some extent, reinforced the direct promotional role of knowledge on behaviors.

Mediation analysis further elucidated the role of attitude in the knowledge-behavior relationship. Bootstrap results with bias correction revealed an indirect effect of oral health knowledge on behavior of 0.038 (95% *CI*: 0.025 - 0.053), with mediation accounting for 25.5% of the total effect. The confidence interval did not include zero, indicating that attitude partially mediated the relationship. The essence of partial mediation lies in knowledge indirectly promoting behavior through attitude improvement while also directly driving behavioral practice independently of attitude. In this study, the mediating contribution of attitude was relatively limited (25.5%), differing from the proportion of attitude mediation observed in some chronic disease health behavior studies (Li, 2025). This discrepancy can be understood from two perspectives. First, college students' oral health knowledge may not yet be fully internalized into stable, enduring health beliefs; Students' positive attitudes toward oral health are more often expressed as cognitive-level agreement, lacking sufficient emotional involvement and value commitment, which weakens the predictive power of attitudes on behavior. Second, oral health behaviors exhibit strong environmental dependence: factors such as the accessibility of oral healthcare services on campus, time costs, and peer norms may all constrain the conversion of attitudes into actions. These findings suggest that simply increasing attitude levels does not necessarily lead to behavioral change; concurrent optimization of the behavioral support environment is required.

### 4.3. Practical Implications, Research Limitations, and Future Directions in Oral Health Education

The findings of this study offer practical implications for oral health education in higher education institutions. First, at the knowledge level, although students' overall oral health knowledge is at a moderate level, knowledge exhibits a strong direct effect on behavior ( $\beta = 0.426$ ), suggesting that strategies for disseminating oral health knowledge should continue to be optimized. It is recommended to leverage new media platforms, general education elective courses, and campus health-themed activities to emphasize practical knowledge directly linked to behavioral change, such as the Bass brushing technique, flossing methods, and appropriate intervals for regular dental check-ups. Second, at the attitudinal level, knowledge exhibits a high standardized path coefficient ( $\beta = 0.521$ ) on attitudes, yet attitudes demonstrate relatively limited predictive power ( $\beta = 0.279$ ) on behaviors. This indicates weak links in the chain converting positive attitudes into actual actions. Therefore, attitude interventions should not be confined to cognitive persuasion but should incorporate strategies like role modeling and experiential learning to enhance students' emotional commitment to oral health values and

their sense of personal responsibility. Third, at the behavioral level, given the weak attitude-to-behavior pathway effect, relying solely on belief modification is insufficient to achieve behavioral improvement. Concurrent reinforcement of environmental support and behavioral skill training is essential. Specific measures may include establishing campus dental clinics or mobile service points, providing affordable oral care kits, integrating oral health behaviors into student comprehensive quality evaluation systems, and establishing peer mutual support incentive mechanisms. Additionally, the sample composition—63.54% female, 70.66% urban residents, and 57.07% with prior oral health education—suggests future interventions should account for subgroup characteristics through stratified, precision-targeted health education programs.

This study has several limitations. First, in terms of research design, cross-sectional surveys can only reveal associative relationships between variables and cannot infer causal sequences. Although structural equation modeling can test theoretical pathways, confirmation of causal direction still relies on longitudinal tracking designs or randomized controlled trials. Second, regarding sample representativeness, participants were drawn exclusively from a specific university with a higher proportion of female and urban students. Extrapolating findings to the broader national college student population requires caution. Future multi-center, multi-type (comprehensive, science/engineering, medical/pharmaceutical, vocational colleges) cross-institutional comparative studies are warranted to assess the model's robustness and generalizability. Third, regarding measurement, the internal consistency reliability (Cronbach's  $\alpha = 0.761$ ) for the oral health knowledge dimension, while within an acceptable range, remains relatively low. This may stem from the broad coverage of items within this dimension and the strong heterogeneity of knowledge types. Subsequent research could optimize the knowledge scale using item response theory or cognitive diagnostic models to enhance measurement precision. Fourth, regarding variable selection, this study incorporated only three core constructs—knowledge, attitude, and behavior—without considering potential moderators or mediators such as self-efficacy, subjective norms, perceived behavioral control, or oral health service accessibility. The model's overall explanatory power thus has room for improvement. Future research could integrate the Health Belief Model, Theory of Planned Behavior, or Social Cognitive Theory to construct a more systematic composite model.

Given these limitations, future research may explore the following directions. First, expand theoretical frameworks by integrating variables such as the Theory of Planned Behavior's subjective norms and perceived behavioral control, or social cognitive theory's self-efficacy, into the existing knowledge-attitude-behavior model to explore multi-theoretical integration pathways. Second, conduct cross-group comparative studies to examine model invariance across students with different professional backgrounds, academic years, and family economic conditions, identifying heterogeneous pathways to inform stratified interventions. Third, advance intervention research. Based on the pathway weights revealed in

this study (74.5% direct effects, 25.5% indirect effects), design composite intervention programs that equally emphasize knowledge reinforcement and attitude internalization, supplemented by environmental support. Validate intervention effectiveness and mediating mechanisms through randomized controlled trials to ultimately establish evidence-based oral health education strategies.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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