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Knowledge, attitude, and practice of orthodontic treatment among student patients preparing for or undergoing treatment

Yaping Zhang^{1,2}, Liangmei Gu^{1,2}, Bingxue Du^{1,2}, Jia Xu^{1,2}✉ & Shufang Du^{1,2}✉

This study aimed to investigate the levels of knowledge, attitude and practice (KAP) of orthodontic treatment among student patients either preparing for or actively undergoing orthodontic treatment. This cross-sectional study was conducted at a tertiary dental hospital in southwest China between August, 2023 and February, 2024. Demographic characteristics and KAP scores were collected using a self-reported questionnaire. A total of 431 valid questionnaires were included, with a mean participant age of 15.25 ± 4.47 years. The mean scores for knowledge, attitude, and practice scores were 13.53 ± 5.36 (possible range: 0–22), 28.18 ± 5.17 (possible range: 8–40), and 33.07 ± 6.81 (possible range: 9–45), respectively. Path analysis indicated that knowledge directly influenced attitude ($\beta = 0.22$, $P < 0.001$) and practice ($\beta = 0.47$, $P < 0.001$), while attitude directly influenced practice ($\beta = 0.24$, $P < 0.001$). Knowledge also indirectly influenced practice via attitude ($\beta = 0.05$, $P < 0.001$). Student patients preparing for or undergoing orthodontic treatment demonstrated moderate KAP scores related to the treatment. Efforts should focus on enhancing patient understanding to improve overall KAP scores and optimize orthodontic treatment outcomes.

Keywords Knowledge, Attitude, Practice, Orthodontic treatment, Student

Dental malocclusion is an increasingly prevalent stomatognathic disorder among children and adolescents today¹. It is characterized by misalignment of the teeth between the upper and lower arches², which can impact the patient's facial appearance, chewing function, and mental health³. The global prevalence of malocclusion in children and adolescents estimated a worldwide prevalence of approximately 56%⁴. Orthodontic treatment remains a highly effective method to address the health and aesthetic issues stemming from malocclusion⁵. Adolescence is widely regarded as the optimal period for such treatment, and many teenagers with both deciduous and young permanent dentition seeking orthodontic care during middle and high school years⁶. In a cross-sectional study conducted among Chinese university students, it was found that 88.33% of the 3308 freshmen surveyed were aware of "orthodontics," and 48.64% (1609 participants) had previously undergone orthodontic treatment⁷. While objective needs for orthodontic treatment needs are determined through clinical assessments by specialists, subjective needs are influenced by various factors, including the patient's self-perception of treatment necessity⁸.

The Knowledge Attitude Practice (KAP) theory plays a critical role in shaping health behaviors⁹. It is often used with KAP questionnaires to assess knowledge, attitude, and practice within a target healthcare population while also measuring the demand and acceptance of relevant healthcare topics¹⁰. While KAP studies are based on self-reported data, they offer unique advantages in healthcare research. KAP surveys provide valuable insights into the cognitive, affective, and behavioral dimensions of health-related issues, enabling researchers to understand not only what people know, but also how their knowledge translates into attitudes and ultimately behaviors¹¹. This comprehensive approach is particularly valuable in orthodontic care, where treatment success heavily depends on patient understanding, acceptance, and compliance¹². Furthermore, KAP studies can effectively identify knowledge gaps, belief patterns, and behavioral tendencies that may not be apparent through clinical observations alone, thereby informing targeted interventions and educational strategies. Central to developing health literacy, this model is based on the premise that knowledge positively influences

¹State Key Laboratory of Oral Diseases and National Clinical Research Center for Oral Diseases, Department of Orthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu 610041, China. ²West China School of Nursing, Sichuan University, Chengdu 610041, China. ✉email: 287309710@qq.com; ainqihai79@126.com

attitude, which in turn shape individual practice¹³. Adolescents and young adults often represent the ideal age group for orthodontic intervention because of their mix of deciduous and permanent dentition. Considering the increased risk of dental caries associated with orthodontic treatments, which rises to 72% two years after starting the treatment and directly correlates with the duration of treatment, understanding the KAP levels of student patients is crucial¹⁴. This insight helps clarify their awareness, motivation, expectations, and adherence to clinical advice tailored to the specific challenges faced by students undergoing orthodontic care. Identifying gaps or misconceptions allows for customized intervention programs that enhance treatment outcomes and promote better self-management among students. This approach supports patient-centered care and boosts the overall effectiveness of orthodontic treatments for students, supporting their mental health and quality of life by addressing common issues such as discomfort, concerns about appearance, and the extended duration of treatment in this vulnerable group.

Although previous research has investigated the KAP regarding orthodontic treatment¹¹, none specifically addressed the student patients. Understanding KAP levels specifically among student patients is crucial for several reasons. First, students represent a significant proportion of orthodontic patients, with treatment often coinciding with critical periods of academic development. Second, their unique lifestyle patterns, time constraints, and social environment may influence treatment adherence and outcomes. Third, evaluating students' KAP helps orthodontists identify specific challenges and barriers to treatment compliance in this population, enabling the development of targeted interventions and education strategies. Therefore, this study aimed to investigate the KAP of orthodontic treatment among student patients preparing for or currently undergoing treatment.

Materials and methods

Study design and participants

This cross-sectional study was conducted at the Orthodontics Department of West China Hospital of Stomatology, Sichuan University, between August 2023 and February 2024, and student patients preparing for or currently undergoing orthodontic treatment were recruited as participants. As the first specialized stomatology hospital and a national center for oral disease treatment and clinical training in Western China, this tertiary, Grade A hospital provides dental medical services for patients from the Southwest region, as well as patients with complex orthodontic issues requiring specialized treatment from other parts of China. This made it a robust setting for our study. The Orthodontics Department, staffed by 92 healthcare professionals and serving approximately 200,000 patients annually, attracted a diverse range of cases, further enriching our study population. Participants were recruited through a convenience sampling method. The inclusion criteria were: (1) patients who were either preparing for or undergoing orthodontic treatment, (2) individuals enrolled as students, and (3) individuals who provided informed consent. For participants under 18 years of age, informed consent from their legal guardians was also required. The exclusion criteria included: (1) patients who had completed their treatment, and (2) individuals not enrolled as students. Eligibility for patients preparing for orthodontic treatment was determined by either their expression of willingness to undergo treatment or their completion of initial examinations and modeling before starting treatment. The study was approved by the Institutional Review Board of West China Hospital of Stomatology (approval number: WCHS-IRB-CT-2023-182). All participants were informed about the study protocol and provided written informed consent to participate in the study. I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Questionnaires were administered using "Wenjuanxing" platform. The electronic questionnaire was uploaded to the platform and a QR code was generated, which was distributed to the participants during their outpatient visits.

Sample size calculation

The required sample size was calculated using Cochran's sample size estimation equation ($n = z^2 pq/e^2$), where $z = 1.96$ (95% confidence interval), $p = 50\%$ (maximum variance as no previous studies reported KAP on this specific population), $q = 1 - p$, and $e = 5\%$ margin of error. Based on this calculation, the minimum required sample size was 384. Our final sample size of 431 valid responses exceeded this requirement, ensuring adequate statistical power.

Questionnaire

The questionnaire was developed based on relevant literature¹⁵ and revised following feedback from two senior experts in dentistry. And a pilot test with 64 responses yielded a Cronbach's $\alpha = 0.877$, indicated an acceptable internal consistency.

The final version of the questionnaire, in Chinese, covers four domains: demographic characteristics, knowledge, attitude, and practice. The knowledge section includes 11 questions, with responses rated as "Understanding," "Partial understanding," and "Don't know" worth 2, 1, and 0 points, respectively, resulting in a possible score range of 0–22 points. The attitude section contains 8 questions on a five-point Likert scale. For the first three questions are scored positively, ranging from "Strongly agree" (5 points) to "Strongly disagree" (1 point), while the remaining questions are reverse-scored. The overall score range for this section is 8–40 points. The practice section comprises 9 questions on a five-point Likert scale, with scores ranging from 9 to 45 points. Participants scoring above 80% of the total were considered to have adequate knowledge, a positive attitude, and proactive practice. Those scoring between 60% and 80% were classified as having moderate knowledge, attitude, and practice. Scores below 60% indicated inadequate knowledge, negative attitude, and inactive practice¹⁵.

Statistical analysis

Data analysis was conducted using Stata 17.0 (Stata Corporation, College Station, TX, USA). Continuous data are presented as mean \pm standard deviation (SD), while categorical data are expressed as n (%). Normally distributed continuous variables were compared by *t*-test or ANOVA, and those confirmed to skewed distribution were compared by the Wilcoxon Mann–Whitney test or Kruskal–Wallis test. Spearman's correlation was used to analyze the relationships between knowledge, attitude, and practice scores. Path analysis was conducted to explore the interactions among KAP, and subgroup analyses were performed among those preparing for orthodontic treatment with those undergoing orthodontic treatment. A two-sided *P*-value of less than 0.05 was considered statistically significant.

Results

Participant characteristics

Initially, a total of 482 questionnaires were collected. Of these, 26 were excluded due to insufficient response times, 4 due to outliers, and 21 due to obvious response patterns. This left 431 valid questionnaires, yielding a validity rate of 89.42%. Among the respondents, 251 (58.24%) were female, with a mean age of 15.25 ± 4.47 years. A majority, 358 (83.06%), lived in urban areas, 122 (28.31%) were currently enrolled in high school, and 287 (66.59%) were undergoing orthodontic treatment. Additionally, 304 (70.53%) chose metal brackets for their treatment, and 238 (55.22%) began orthodontic treatment based on encouragement from family members. A total of 183 (42.46%) gained orthodontic knowledge through medical education (Table 1).

N=431	N (%)	Knowledge score		Attitude score		Practice score	
		Mean \pm SD	P	Mean \pm SD	P	Mean \pm SD	P
Total score		13.53 \pm 5.36		28.18 \pm 5.17		33.07 \pm 6.81	
Gender		0.384		0.166		0.316	
Male	180 (41.76)	13.2 \pm 5.52		27.76 \pm 5.33		32.61 \pm 7.28	
Female	251 (58.24)	13.76 \pm 5.23		28.47 \pm 5.03		33.39 \pm 6.43	
Age, years	15.25 \pm 4.47	13.2 \pm 5.52		27.76 \pm 5.33		32.61 \pm 7.28	
Residence		0.047		< 0.001		0.110	
Rural or suburban	73 (16.94)	12.27 \pm 5.36		25.91 \pm 4.61		31.78 \pm 7.61	
Urban	358 (83.06)	13.78 \pm 5.33		28.63 \pm 5.15		33.33 \pm 6.60	
Education		0.127		0.161		0.092	
Primary school students	96 (22.27)	12.52 \pm 5.90		28.41 \pm 5.77		33.09 \pm 7.36	
Junior high school student	122 (28.31)	13.39 \pm 5.53		28.99 \pm 5.48		33.99 \pm 7.26	
High school student	100 (23.2)	14.03 \pm 4.78		28.16 \pm 4.73		32.62 \pm 6.14	
Vocational students	4 (0.93)	19.25 \pm 4.85		24.5 \pm 5.44		40 \pm 8.67	
College student	11 (2.55)	14.27 \pm 5.64		26.45 \pm 4.65		31.72 \pm 6.35	
Undergraduate students	78 (18.1)	13.56 \pm 4.74		27.39 \pm 4.58		31.70 \pm 6.21	
Master's degree students and above	20 (4.64)	14.95 \pm 5.89		26.85 \pm 3.81		34.3 \pm 5.23	
Current orthodontic treatment		< 0.001		0.001		< 0.001	
Preparing for orthodontic treatment (not yet started)	144 (33.41)	11.39 \pm 5.47		26.95 \pm 4.87		30.97 \pm 7.70	
Orthodontic treatment	287 (66.59)	14.59 \pm 4.98		28.79 \pm 5.20		34.12 \pm 6.05	
The type of appliance		0.533		0.404		0.125	
Metal brackets (non-self-locking, self-locking, personalized metal)	304 (70.53)	13.74 \pm 5.32		28.28 \pm 5.26		33.56 \pm 6.54	
Ceramic brackets (non-self-locking, self-locking ceramic)	22 (5.1)	13.72 \pm 4.82		28.86 \pm 4.49		33.13 \pm 5.66	
Lingual appliance	3 (0.7)	11 \pm 6.24		28.33 \pm 7.50		26 \pm 5.56	
Removable appliance	23 (5.34)	11.65 \pm 4.94		25.86 \pm 4.77		32.13 \pm 7.65	
Invisible braces (such as: Angel of the Times/Invisalign)	79 (18.33)	13.29 \pm 5.73		28.22 \pm 4.96		31.70 \pm 7.60	
Who initiated orthodontic treatment		0.222		0.148		0.879	
Family members	238 (55.22)	13.41 \pm 5.65		28.55 \pm 5.52		33.07 \pm 6.97	
Ask for it yourself	143 (33.18)	14.11 \pm 5.09		27.99 \pm 4.62		33.20 \pm 6.68	
Doctor's advice	50 (11.6)	12.38 \pm 4.45		26.9 \pm 4.70		32.68 \pm 6.46	
Information source about orthodontics		0.002		0.548		0.019	
Medical education	183 (42.46)	14.63 \pm 5.38		28.40 \pm 5.26		34.03 \pm 6.81	
Parent explanation	99 (22.97)	12.22 \pm 5.55		28.33 \pm 5.52		32.62 \pm 7.08	
Student promotion	29 (6.73)	14.41 \pm 5.33		28.55 \pm 4.46		34.31 \pm 5.72	
Internet	120 (27.84)	12.69 \pm 4.83		27.6 \pm 4.88		31.66 \pm 6.58	

Table 1. Baseline characteristics and KAP scores.

Knowledge, attitude, and practice

The mean KAP scores were 13.53 ± 5.36 (possible range: 0–22), 28.18 ± 5.17 (possible range: 8–40), and 33.07 ± 6.81 (possible range: 9–45), respectively. Demographic analysis indicated that participants living in urban areas ($P=0.047$), undergoing orthodontic treatment ($P<0.001$), and those who obtained relevant knowledge through medical education and student promotions ($P=0.002$) had significantly higher knowledge scores. Similarly, those living in urban areas ($P<0.001$) and undergoing orthodontic treatment ($P=0.001$) had higher attitude scores. Higher practice scores were found among those undergoing orthodontic treatment ($P<0.001$) and those gaining knowledge through medical education and student promotions ($P=0.019$) (Table 1). When comparing primary school students to other groups, the analysis showed that primary school students had lower knowledge scores (12.52 ± 5.90 vs. 13.81 ± 5.17 , $P=0.037$) but similar scores in attitude (28.41 ± 5.77 vs. 28.10 ± 4.98) and practice (33.09 ± 7.36 vs. 33.06 ± 6.64 , $P=0.824$).

The distribution of knowledge dimension revealed that the three questions with the lowest percentage of “Very knowledgeable” option were “During orthodontic treatment, the reduction in masseter muscle activity may lead to a slight hollowing of the cheeks, a condition sometimes referred to as “brace face.” This effect is temporary and typically resolves on its own after the braces are removed.” (K8) with 27.61%, “Clear aligners should be worn for at least 20 hours per day. After fitting the aligners, bite down on chewies to ensure a better fit—each tooth position should receive 10 to 15 bites, moving from one side of the posterior teeth to the other. Each session should last 3 to 5 minutes. Replace chewies when they lose elasticity, and avoid soaking aligners in hot water or organic solvents to prevent deformation.” (K10) with 27.84%, and “The primary cause of tooth mobility is various periodontal issues. Therefore, patients with periodontitis must undergo comprehensive periodontal treatment and achieve a stable condition before beginning orthodontic treatment. During the course of wearing braces, it is also essential to continuously monitor periodontal health to prevent secondary periodontal problems from affecting the orthodontic outcome.” (K6) with 32.48% (Table 2).

Responses to the attitude dimension showed that 15.55% strongly agreed and 22.51% agreed that orthodontic treatment requires a long time and causes impatience and anxiety for those wanting it to be completed as soon as possible (A4). Meanwhile, 15.31% strongly agreed and 26.68% agreed that orthodontic treatment takes time and effort and they are worried that it will affect their studies and life (A5). In addition, 13.46% strongly agreed and 22.51% agreed that the cost of orthodontic treatment was expensive, which caused great financial pressure on them (A6) (Table 3).

Responses to the practice dimension showed that 17.4% rarely and 11.83% never avoided foods that stain easily such as coffee and strong tea (P2.1), 16.47% rarely and 12.3% never used orthodontic protective wax (P3.2), and 14.15% rarely and 8.58% never used Bass brushing (P1.2) (Table 4).

Knowledge	N (%)		
	Very knowledgeable	Have heard of it	c. Unclear
1. Orthodontic treatment is not merely about aligning the teeth; it can even improve facial aesthetics and address functional issues caused by dental misalignment and malocclusion	181 (42)	229 (53.13)	21 (4.87)
2. Crooked teeth can create numerous “hygiene blind zones” in the oral cavity, where food debris tends to accumulate over time, fostering bacterial growth and increasing the risk of dental caries and periodontal disease	192 (44.55)	205 (47.56)	34 (7.89)
3. Severe dental malocclusion can impact overall facial development, leading to facial deformities such as underbite, overbite, or protrusive lips, which may exacerbate feelings of low self-esteem	232 (53.83)	185 (42.92)	14 (3.25)
4. The optimal time to begin orthodontic treatment is during the early permanent dentition stage (around 12 years old). In adults, orthodontic treatment tends to be more challenging, with increased risks and longer treatment duration compared to children. However, there are no strict age limits for orthodontics. Generally speaking, as long as periodontal health and temporomandibular joint conditions are suitable, orthodontic treatment can be undertaken at any age	149 (34.57)	246 (57.08)	36 (8.35)
5. During orthodontic treatment, the corrective forces exerted by braces induce remodeling of both hard tissues, such as the alveolar bone, and soft tissues, including the periodontal ligament and gums, thereby allowing the teeth to move to new positions. This process does not impair chewing function or overall health	158 (36.66)	215 (49.88)	58 (13.46)
6. The primary cause of tooth mobility is various periodontal issues. Therefore, patients with periodontitis must undergo comprehensive periodontal treatment and achieve a stable condition before beginning orthodontic treatment. During the course of wearing braces, it is also essential to continuously monitor periodontal health to prevent secondary periodontal problems from affecting the orthodontic outcome	140 (32.48)	223 (51.74)	68 (15.78)
7. Tooth extraction does not harm adjacent teeth, and any extraction gaps will gradually close during orthodontic treatment. This process does not compromise chewing function or overall health	168 (38.98)	214 (49.65)	49 (11.37)
8. During orthodontic treatment, the reduction in masseter muscle activity may lead to a slight hollowing of the cheeks, a condition sometimes referred to as “brace face.” This effect is temporary and typically resolves on its own after the braces are removed	119 (27.61)	199 (46.17)	113 (26.22)
9. Orthodontic braces, also known as orthodontic appliances, come in various types. Common examples include traditional metal braces, ceramic braces, self-ligating braces, labial fixed appliances, lingual fixed appliances, and clear aligners without brackets	145 (33.64)	232 (53.83)	54 (12.53)
10. Clear aligners should be worn for at least 20 h per day. After fitting the aligners, bite down on chewies to ensure a better fit—each tooth position should receive 10 to 15 bites, moving from one side of the posterior teeth to the other. Each session should last 3 to 5 min. Replace chewies when they lose elasticity, and avoid soaking aligners in hot water or organic solvents to prevent deformation	120 (27.84)	177 (41.07)	134 (31.09)
11. After removing the braces, it is important to wear a retainer to maintain the results of orthodontic treatment. It is generally recommended to wear the retainer for two years: during the first year, it should be worn full-time, and during the second year, only at night	150 (34.8)	197 (45.71)	84 (19.49)

Table 2. Participants’ knowledge responses.

Attitude	Strongly agree	Agree	Generally agree	Disagree	Strongly disagree
1. Before opting for orthodontic treatment, I believe it is essential that my doctor has made me fully understand the various procedures and precautions. P	178 (41.3)	214 (49.65)	34 (7.89)	4 (0.93)	1 (0.23)
2. When choosing orthodontic treatment, I know clearly that this is what I need, rather than blindly following other people's opinions. P	214 (49.65)	183 (42.46)	29 (6.73)	5 (1.16)	-
3. I am eagerly anticipating the outcomes of orthodontic treatment, as it holds the potential to significantly improve both my oral health and aesthetics, consequently bolstering my self-confidence. P	202 (46.87)	199 (46.17)	29 (6.73)	1 (0.23)	-
4. Orthodontic treatment takes a long time, and I feel impatient and anxious. I just hope it can be completed as soon as possible. N	67 (15.55)	97 (22.51)	126 (29.23)	93 (21.58)	48 (11.14)
5. Orthodontic treatment requires time and energy, and I am worried that it will affect my studies and life. N	66 (15.31)	115 (26.68)	134 (31.09)	81 (18.79)	35 (8.12)
6. The cost associated with orthodontic treatment is relatively high, contributing to increased financial strain in my view. N	58 (13.46)	97 (22.51)	160 (37.12)	75 (17.4)	41 (9.51)
7. During orthodontic treatment, daily care and food restrictions need to be paid attention to. I think this has caused a lot of inconvenience to me and I feel tired. N	41 (9.51)	99 (22.97)	164 (38.05)	80 (18.56)	47 (10.9)
8. I strongly believe that extracting teeth before orthodontic correction is entirely unreasonable. N	25 (5.8)	49 (11.37)	123 (28.54)	140 (32.48)	94 (21.81)

Table 3. Participants' attitude responses.

Practice	Always	Often	Sometimes	Rare	Never
1. Brush your teeth carefully and maintain good oral hygiene					
1.1 Select a toothbrush featuring a compact brush head and bristles of moderate firmness, or alternatively, opt for a specialized orthodontic gap brush. P	143 (33.18)	142 (32.95)	103 (23.9)	32 (7.42)	11 (2.55)
1.2 Use the Bass brushing method, with moderate intensity, for 3 to 5 min each time P You can also use an electric toothbrush and a tooth rinse to improve the cleaning effect. After brushing, look in the mirror to check whether it is clean.	92 (21.35)	125 (29)	116 (26.91)	61 (14.15)	37 (8.58)
1.3 Brush your teeth after three meals P It is particularly important to refrain from eating after brushing your teeth before bedtime. If immediate brushing after meals is not feasible at other times, rinsing the mouth with water is recommended.	107 (24.83)	132 (30.63)	119 (27.61)	54 (12.53)	19 (4.41)
2. Diet					
2.1 Do not eat hard or sticky food P Such as ribs, beef jerky, nuts, sticky cakes, etc. Apples, peaches, corn, etc. cannot be chewed. They can be cut into small pieces and chewed with the back teeth.	94 (21.81)	129 (29.93)	118 (27.38)	69 (16.01)	21 (4.87)
2.2 Eat less coffee, strong tea and other foods that are easy to stain P	124 (28.77)	90 (20.88)	91 (21.11)	75 (17.4)	51 (11.83)
3. Relief of pain and discomfort					
3.1 If pain persists or worsens, contact your doctor promptly for examination P Experiencing mild discomfort in the teeth following initial application and subsequent follow-up visits is common. Typically, this discomfort resolves on its own within a week	119 (27.61)	110 (25.52)	109 (25.29)	67 (15.55)	26 (6.03)
3.2 Use orthodontic protective wax when necessary P Some patients who are wearing braces for the first time may experience "mouth grinding" of the brackets or mild oral ulcers, which can be alleviated by using orthodontic protective wax	114 (26.45)	91 (21.11)	102 (23.67)	71 (16.47)	53 (12.3)
4. Adhere to the instructions provided by the doctor for follow-up appointments and actively engage in the treatment process. P	263 (61.02)	139 (32.25)	20 (4.64)	8 (1.86)	1 (0.23)
5. Actively understand and learn oral health knowledge P	162 (37.59)	139 (32.25)	96 (22.27)	27 (6.26)	7 (1.62)

Table 4. Participants' practicee responses.

Interaction among KAP

Correlation analysis revealed significant positive relationships between knowledge and attitude ($r=0.2331$, $P<0.001$), and between knowledge and practice ($r=0.4063$, $P<0.001$). There was also a significant correlation between attitude and practice ($r=0.2632$, $P<0.001$) (Supplementary Table 1). Path analysis indicated that knowledge directly influenced attitude ($\beta=0.22$, $P<0.001$) and practice ($\beta=0.47$, $P<0.001$), while attitude directly influenced practice ($\beta=0.24$, $P<0.001$). Knowledge also had an indirect effect on practice via attitude ($\beta=0.05$, $P<0.001$) (Table 5).

Subgroup analysis was conducted to analysis the interaction among participants preparing for orthodontic treatment and those already undergoing treatment, respectively. For participants preparing for treatment, path analysis showed that knowledge ($\beta=0.51$, $P<0.001$) and attitude ($\beta=0.25$, $P=0.038$) directly influenced practice, with other effects not reaching statistical significance (Table 5). Meanwhile, path analysis for participants already undergoing treatment demonstrated consistent relationships aligned with the entire population's results (Table 5).

Model paths		Total effects		Direct Effect		Indirect effect		
		β (95% CI)	P	β (95% CI)	P	β (95% CI)	P	
Overall population								
Asum <-								
	Ksum	0.22 (0.13, 0.31)	<0.001	0.22 (0.13, 0.31)	<0.001			
Psum <-								
	Asum	0.24 (0.13, 0.35)	<0.001	0.24 (0.13, 0.35)	<0.001			
	Ksum	0.52 (0.41, 0.63)	<0.001	0.47 (0.36, 0.58)	<0.001	0.05 (0.02, 0.08)	0.001	
Subgroup of participants preparing for orthodontic treatment								
Asum <-								
	Ksum	0.14 (-0.00, 0.28)	0.054	0.14 (-0.00, 0.28)	0.054			
Psum <-								
	Asum	0.25 (0.01, 0.48)	0.038	0.25 (0.01, 0.48)	0.038			
	Ksum	0.55 (0.34, 0.76)	<0.001	0.51 (0.30, 0.72)	<0.001	0.03 (-0.01, 0.08)	0.158	
Subgroup of participants undergoing orthodontic treatment								
Asum <-								
	Ksum	0.23 (0.11, 0.35)	<0.001	0.23 (0.11, 0.35)	<0.001			
Psum <-								
	Asum	0.22 (0.10, 0.35)	<0.001	0.22 (0.10, 0.35)	<0.001			
	Ksum	0.45 (0.32, 0.58)	<0.001	0.39 (0.26, 0.53)	<0.001	0.05 (0.01, 0.09)	0.009	

Table 5. Path analysis. The arrows " $<-$ " represent hypothesized directional relationships in the path analysis.

Discussion

Student patients preparing for or undergoing orthodontic treatment exhibited moderate KAP towards the treatment. Enhancing educational interventions aimed at improving knowledge and fostering positive attitude among student patients may lead to better adherence to orthodontic practice, potentially improving treatment outcomes.

Student patients showed varying levels of knowledge across different age groups, particularly between primary school students and older students, while maintaining consistent attitudes and practices towards treatment. These differences reflect the influence of age, education level, and developmental stage on orthodontic care engagement. Primary school students, typically in the mixed dentition stage or early permanent dentition stage, may have reduced exposure to orthodontic education, potentially affecting their understanding of treatment processes¹⁶. However, this developmental stage presents a critical window for orthodontic interventions, as early guidance can help prevent more severe malocclusions¹⁷.

Patients in middle school and beyond, predominantly having permanent dentition, face different treatment considerations focusing on comprehensive alignment and correction of established dental or skeletal issues. The observation that younger students maintain similar treatment adherence despite knowledge differences suggests they may compensate through increased reliance on parental or professional guidance¹⁸. These age-related variations underscore the importance of developing targeted patient education and treatment protocols that account for patients' specific developmental stages, potentially improving understanding and adherence to clinical recommendations¹⁹.

The findings of this study align with prior research conducted in the Federal Territories of Kuala Lumpur and Putrajaya, which similarly identified adequate knowledge but noted areas needing improvement in attitude and orthodontic-related practices¹¹. Interestingly, no statistically significant differences were observed in KAP scores among urban and rural students or between students preparing for orthodontic treatment versus those undergoing treatment. Urban-dwelling students exhibited higher scores in both knowledge and attitude dimensions compared to rural students. Similar to our findings, a previous study revealed that urban-dwelling individuals tended to have higher levels of orthodontic knowledge and more positive attitude towards treatment compared to rural residents, likely due to differences in access to healthcare resources and education²⁰. The lack of significant differences in practice scores between these groups may reflect the universal applicability of orthodontic care recommendations and the role of professional guidance in standardizing practices across populations²¹.

The positive relationships observed between knowledge, attitude, and practice align with established theoretical frameworks such as the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB)²². These models posit that individuals with greater knowledge about a health issue tend to have more positive attitude towards preventive actions and are more likely to engage in recommended behaviors. The path analysis further supported these relationships, showing that knowledge directly influenced both attitude and practice, while attitude directly influenced practice as well. Additionally, knowledge had an indirect effect on practice through attitude, highlighting the mediating role of attitude in translating knowledge into practical behaviors related to orthodontic treatment.

The subgroup analysis revealed similar findings to the overall population. Among those preparing for treatment, both knowledge and attitude demonstrated direct positive effects on orthodontic practices, with

higher levels of knowledge and more positive attitude associated with greater engagement in orthodontic practices. In contrast, participants already undergoing treatment showed stronger direct effects of knowledge on practice, suggesting that ongoing orthodontic care provides opportunities for experiential learning, enhancing practical adherence. These differences may stem from the distinct phases of the orthodontic journey. Preparing for treatment requires a focus on understanding and readiness, where knowledge acquisition and positive attitude play pivotal roles in shaping patient practice²³. Once treatment commences, patients may already have established attitude and practice, with the treatment experience itself influencing the strength and direction of these relationships. Moreover, factors such as treatment satisfaction, comfort, and perceived efficacy of practices during treatment may further modulate the influence of knowledge and attitude on actual practice²⁴.

Participants generally displayed moderate levels of knowledge regarding orthodontic treatment, with notable variations across specific items. While awareness of the aesthetic and functional benefits of orthodontics was relatively high, there were areas of lesser understanding, such as the impact of orthodontic treatment on facial development and the importance of periodontal health in orthodontic planning. To address these deficiencies, educational interventions should focus on enhancing awareness of the comprehensive nature of orthodontic treatment and the importance of maintaining periodontal health throughout the treatment process²⁵. Additionally, utilizing multimedia resources and interactive educational platforms may improve knowledge retention and engagement among orthodontic patients²⁶.

Most participants displayed positive attitudes towards orthodontic treatment, expressing confidence in their understanding of treatment procedures and their commitment to informed decision-making. However, concerns regarding treatment duration, financial implications, and lifestyle disruptions were evident among a significant portion of respondents. Such concerns may impact treatment acceptance and adherence, potentially compromising treatment outcomes²⁷. Interventions aimed at addressing these concerns should focus on providing comprehensive pre-treatment counseling, including transparent discussions regarding treatment duration, financial options, and strategies for managing lifestyle adjustments during treatment. Additionally, fostering a supportive treatment environment and implementing patient-centered communication strategies may help alleviate patient anxieties and improve treatment satisfaction²⁸.

Participants displayed varying levels of adherence to orthodontic care practices, with notable inconsistencies in oral hygiene maintenance and dietary habits. While a majority reported regular tooth brushing and compliance with follow-up appointments, suboptimal dietary choices and inadequate pain management practices were evident among some respondents. These findings echo previous research highlighting challenges in maintaining optimal oral hygiene and dietary habits during orthodontic treatment, which may contribute to increased risk of dental complications and treatment delays²⁹. To address these challenges, comprehensive patient education programs should emphasize consistent oral hygiene practices, provide practical guidance on dietary modifications, and offer strategies for managing treatment-related discomfort. Additionally, leveraging digital health technologies, such as mobile applications and telehealth platforms, may facilitate remote monitoring and support, enhancing patient compliance and treatment outcomes³⁰.

The findings of this study have important clinical implications for orthodontic practice. First, identified knowledge gaps about periodontal health during treatment highlight areas where targeted education can improve outcomes. Second, similar practice behaviors between primary school students and older groups suggest that simplified education approaches work effectively for younger patients. Third, the correlation between knowledge and practice emphasizes the value of thorough pre-treatment education. Additionally, poor adherence to dietary restrictions and oral hygiene techniques offers specific areas to address during follow-up appointments. Finally, variations in attitude across educational levels suggest clinicians should tailor communication based on the patient's background, while reinforcing education throughout treatment may significantly improve compliance.

This study had several limitations. Firstly, the study was conducted in a single tertiary dental hospital in southwest China, with the questionnaire administered in Chinese, which significantly limits the generalizability of the findings. While our findings provide valuable insights for the local healthcare community, their applicability to broader populations with different cultural backgrounds, languages, or healthcare systems may be limited. The cultural and linguistic specificity of our questionnaire, although appropriate for our target population, may not capture nuances that could be relevant in other cultural contexts. The use of convenience sampling rather than randomized sampling, despite our large patient population base, might have introduced selection bias. Secondly, the data were collected through self-administered questionnaires, which may be subject to response bias and social desirability bias, potentially affecting the accuracy of the reported KAP scores. Thirdly, the cross-sectional design of the study allows only for the observation of associations rather than causation, limiting the ability to draw definitive conclusions about the causal relationships between knowledge, attitude, and practice towards orthodontic treatment among student patients. However, our use of path analysis provides a statistical framework for inferring potential causal relationships, although these inferences must be interpreted with caution as they are statistically derived rather than directly observed. The ability of path analysis to simultaneously account for multiple relationships and measurement error strengthens our findings within the constraints of cross-sectional data.

Conclusion

This study reveals moderate KAP levels among student orthodontic patients, with positive correlations between knowledge, attitude, and practice dimensions. Knowledge directly influences both attitude and practice. These findings underscore the importance of comprehensive patient education and positive attitude formation as critical components for improving treatment adherence and outcomes.

Data availability

All data generated or analysed during this study are included in this published article.

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Author contributions

Liangmei Gu and Bingxue Du carried out the studies, participated in collecting data, and drafted the manuscript. Yaping Zhang and Jia Xu performed the statistical analysis and participated in its design. Yaping Zhang and Shufang Du participated in acquisition, analysis, or interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

Declarations

Ethics approval and consent to participate

The study was approved by the Institutional Review Board of West China Hospital of Stomatology (approval number: WCHS-IRB-CT-2023-182). All participants were informed about the study protocol and provided

written informed consent to participate in the study. I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to J.X. or S.D.

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