Original Article

JHSMR Journal of Health Science and Medical Research

Prevalence and Associated Factors of Caries and Periodontal Diseases among Adolescents in Kunming: A Cross-sectional Study

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Received 20 June 2022 ● Revised 30 August 2022 ● Accepted 23 September 2022 ● Published online 21 October 2022

Abstract:

Objective: To investigate the prevalence of dental caries, and periodontal diseases among adolescents in urban high schools of Kunming and associated factors.

Material and Methods: This cross-sectional survey enrolled 560 adolescents (17.3±0.5 years old), with an equal gender ratio. Self-administered questionnaires obtained the sociodemographic and behavioral variables. All subjects were examined for their clinical parameters; including, Decayed, Missing, and Filled Teeth (DMFT), the Simplified Oral Hygiene Index (OHI-S), bleeding on probing (BOP), probing depth (PD) and clinical attachment level (CAL) by two dentists. The correlations of explanatory variables with dental caries and periodontal disease outcomes were investigated using bivariate analysis; via chi-square and t-test. Multivariate regression analysis; including linear regression and logistic regression models, were investigated for related factors of dental caries and periodontal diseases.

Results: The prevalence of caries was 72.5%, with a mean DMFT of 3.70±3.65. The DMFT of females was higher than males (p-value<0.001); approximately 12.3% were periodontal healthy. The prevalence of gingivitis and periodontitis was 80.4% and 7.3%, respectively; with no statistical difference between genders (p-value=0.221). Multivariate regression

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J Health Sci Med Res 2023;41(2):e2022903
doi: 10.31584/jhsmr.2022903
www.jhsmr.org

analysis showed that the prevalence of dental caries and periodontal diseases were associated with females and fair/poor oral hygiene. Additionally, high sugar consumption was a significant risk predictor for dental caries (p-value=0.008). **Conclusion:** The high prevalence of dental caries and periodontal disease in Kunming urban high school adolescents were associated with females and oral hygiene. Therefore, it is necessary for them to pay more attention to their oral health, and to focus on improving the efficiency of oral hygiene behavior.

Keywords: adolescents, associated factors, dental caries, periodontal disease, oral health

Introduction

Adolescents' oral health is a strong predictor of adult oral health, as most of these adolescents already have permanent dentition. Dental caries and periodontal diseases are the most common oral health problems worldwide. They are not only the leading cause of tooth loss, but are also a substantial economic burden; with an average dental cost of 850.83 Chinese Yuen (CNY) for individual adults.[1]

Caries and periodontal diseases negatively impact adolescent chewing function and longevity of permanent dentition.[2] The latest data from China shows that caries and periodontal disease rates in the 15 year-old age group are relatively high: 44.4% and 65.2%, respectively.[3,4] A study from Taiwan showed that caries and periodontal diseases in the 15-18 year-old age group were as high as 89% and 88.2%.[5] However, there is little epidemiological data on the 17-19 age group's oral health in China; even in Kunming city. Kunming is located in the Southwest of China, and belongs to relatively backwards economic areas. In addition, oral health awareness is relatively backwards; hence, we assumed that the oral health level would be lower than the national level.[6]

Adolescence is an important stage in forming oral habits and ideology as well as having implications for both current and future oral health.[7] Signs of oral disease in adolescents presents as high-risk factors in adulthood; however, further destruction of periodontal tissue can be avoided if appropriate interventions are provided.[8] Numerous epidemiological investigations have demonstrated that social behavior and environmental factors are risk factors of oral health problems.[2,9,10] Improper oral hygiene, dietary choices, and other behavioral factors; such as smoking, can directly affect oral health.[11]

This study aimed to investigate the oral health status of adolescents aged 17-19 in urban high schools of Kunming, and the factors related to caries and periodontal diseases. Such information will be helpful in formulating prevention programs.

Material and Methods

Study design and participants

This cross-sectional survey was carried out from the academic year of July 2019 to November 2020. Subjects aged 17-19 years of age, who had lived in Kunming city for more than one year were invited to participate in this study. Adolescent health status and history of dental visits were determined using a screening self-reported questionnaire. Adolescents with any systemic diseases, mixed dentition, history of periodontal treatment in the past six months or taking any antibiotics within the last two weeks were excluded. Based on the latest (2018) national survey data[4], the sample size was calculated with a 5% degree of accuracy and a 95% confidence interval (95% CI). This was increased by 10% for the attrition rate, giving a total sample size of at least 500. There are 82 public high schools in 5 districts of Kunming city, with each

school have approximately 200–300 students in our target age. All schools had been contacted and invited into this study; with the school that accepted first being included in this study. One public school was selected from each of the 5 urban districts. In the same way, all students in the selected school had been invited; the first 100 students who firstly accepted were included in this study. Prior to the investigation, the protocols had been approved by the Ethic Committee of both universities: Prince of Songkla University (EC6208–033) and Kunming Medical University (KY2020MEC019). All students and parents have signed the informed consents.

Questionnaire survey

We used, and modified, questionnaires from a recent national survey in China for this study (Supplementary Table 1). All students were asked to complete the questionnaire under the supervision of a research assistant to gather variables related to oral health.[3] The variables included: sociodemographic (gender, parental education level and household income level), oral hygiene behaviors (frequency of brushing, fluoride toothpaste and flossing), and health behaviors (smoking, sugar consumption habits and utilization of dental services).

The parents' education was classified as: 'low level' when lower than primary school or primary school; 'middle level' when junior middle school, senior middle school or technical secondary school; and 'high level' when junior college, university, postgraduate or higher. The total monthly household income was presented as: 'low level' when <6,000 CNY; 'middle level' when 6,000–12,000 CNY; and 'high level' when >12,000 CNY. Oral hygiene behaviors were presented as: 'brushing frequency' of 2 times/day or ≤1 times/day; while fluoridated paste, using of dental floss, and smoking were presented as 'Yes' or 'No'. Dental service utilization was based on the date of the last dental visit as: <6 months, 6–12 months, and >12 months. Sugar consumption habits were presented as: 'low level' when the total score=3–8; 'middle level' when the total score=9–14; and 'high level' when the total score=15–18; wherein, the total score were a result from the sum up in the frequency of consuming sweet food, sweet drinks, and sweetened milk/yogurt/tea/coffee. For example; if anyone consumed sweet food 1–3 times a month (score 2), sweet drinks once a week (score 3) and sweetened yoghurt/milk once a day (score 5); the total score was 10, and this was then classified as a 'middle level'. For the details on the grading criteria for variables in the questionnaire, please refer to Supplementary Table 1.

Clinical examination

Clinical examination was performed by two well–trained and qualified calibration dentists (Kappa value >0.8). The Decayed, Missing, and Filled Teeth (DMFT) index was used for assessment of dental caries, according to the World Health Organization (WHO).[12]

A full mouth clinical periodontal examination of all participants was carried out using a manual, rigid periodontal probe (PCPUNC15; Hu Friedy, Chicago, IL, USA).[13] The examination included assessments of bleeding on probing (BOP), probing depth (PD), and clinical attachment level (CAL), at six sites per tooth (mesio–buccal, mid–buccal, disto–buccal, mesio–lingual, mid–lingual and disto–lingual). PD was defined as the distance from the gingival margin to the base of the periodontal pocket, and CAL was measured as the distance from the cemento–enamel junction (CEJ) to the base of the pocket. If the CEJ was destroyed by restorative treatment, the restoration margin was taken as a reference. PD and CAL were measured using a manual, rigid periodontal probe to the highest score by the nearest millimeter. BOP was recorded 10–15 seconds after probing.[14] All clinical index examination information to be collected was recorded with a periodontal chart. To facilitate the subsequent study of periodontal pathogens,

a new classification of periodontal status, proposed by the American Academy of Periodontology (AAP) and the European Dental Federation (EFP) in 2018, was adopted in this study.[15]

In addition, the simplified Oral Hygiene Index (OHI-S) was used to assess oral hygiene status.[16] This included the presence of the simplified Debris Index (DI-S) and simplified calculus index (CI-S) of the following six index teeth: 16, 11, 26, 36, 31 and 46. The assessment was carried out using a dental mirror and a probe, on a scale from 0 to 3 (0=no debris/calculus visible, one=up to one-third of the tooth surface covered with debris/calculus, 2=one-third to two-thirds of the tooth surface covered with debris/calculus, 3=more than two-thirds of the tooth surface covered with debris/calculus). For each individual, the calculation of the indices DI-S and CI-S were obtained from the scores, which were then summed up and divided by the total number of teeth assessed. This resulted in values between 0 and 3. The sum of DI-S and CI-S resulted in the OHI-S. The OHI-S, therefore, assumed values between 0 and 6. During regression analysis, the OHI-S scores were graded into "Good" (OHI-S ≤1.2), "Fair" (>1.2 to ≤3.0), and "Poor" oral hygiene indices (>3.0 to ≤6.0); according to Wei and Lang.[17]

Statistical analysis

Descriptive statistics were used to describe caries and periodontal disease prevalence as well as frequency and means of the explanatory variables. Bivariate analyses were carried out to examine the association between the explanatory variables and the outcome. Depending on the type of outcome variables, the associations with dental caries outcome were analyzed using a t-test, one-way analysis of variance (ANOVA), the Mann-Whiney U test or the Kruskal-Wallis test. Wherein, the associations with the periodontal disease outcome were analyzed using the chi-square test.

For model building, the explanatory variables that were significantly associated with caries and periodontal disease from the bivariate analysis, or recognized as an important risk factor for caries or periodontal disease from the literature were included. The multivariate linear regression model and multivariate logistic regression model were performed for caries and periodontal disease, respectively. The significance level was set at p-value<0.05. All analyses were performed using IBM SPSS, version 22.0. (IBM, Armonk, NY, USA).

Results

A total of 560 adolescents (mean age, 17.3±0.5 years old), with the same ratio of gender, completed the oral examination and self-administered questionnaire survey.

Results showed that the prevalence of caries was 72.5%, with females having a significantly higher prevalence (82.5%) as well as mean DMFT (4.31±3.65) than males (p-value<0.001) (Table 1). Females had a significantly better OHI-S index than males (p-value=0.038), with 20.4% as good, 72.1% as fair and only 7.5% as poor. Only 12.3% were in good periodontal health, with the highest proportion of others having gingivitis at 80.4% (localized 52.7% and generalized 27.7%) and periodontitis at 7.3% (4.3% of stage I and 3% of stage II). There were no significant differences in PD, CAL, BOP or periodontal status between males and female (Table 2).

The results of potential correlates of caries and periodontal disease prevalence is shown in Table 3. There was a statistically significant difference between the DMFT, genders (p-value<0.001), OHI-S (p-value<0.001) and BOP (p-value=0.012). Moreover, household income (p-value=0.046), OHI-S (p-value<0.001) and BOP (p-value<0.001) were significantly associated with periodontal status as well.

Table 1 Gender-specific caries prevalence and mean decayed, missing and filled teeth (N=560)

Parameter	Total N=560	Male N=280	Female N=280	p-value
Caries (%)	406 (72.5)	175 (62.5)	231 (82.5)	<0.001
DMFT	3.70±3.65	3.09±3.54	4.31±3.65	<0.001
DT	3.17±3.48	2.74±3.33	3.60±3.58	0.003
MT	0.08±0.48	0.05±0.35	0.10±0.59	0.295
FT	0.46±1.33	0.30±1.06	0.61±1.53	0.006

DMFT=The Decayed, Missing, and Filled Teeth index, DT=Decayed teeth, MT=Missing teeth, FT=Filled teeth

Table 2 Gender-specific periodontal clinical parameters, oral hygiene and periodontal disease prevalence

Clinical parameter	Total N=560 (%)	Male N=280 (%)	Female N=280 (%)	p-value
CAL (mm)				0.879
0	513 (91.6)	256 (91.4)	257 (91.8)	
≥1	47 (8.4)	24 (8.6)	23 (8.2)	
PD (mm)				0.286
≤3	451 (80.5)	231 (82.5)	220 (78.6)	
>3	109 (19.5)	49 (17.5)	60 (21.4)	
BOP (%)				0.236
<10	69 (12.3)	35 (12.5)	34 (12.1)	
10-30	295 (52.7)	138 (49.3)	157 (56.1)	
>30	196 (35.0)	107 (38.2)	89 (31.8)	
OHI-S				0.038
Good (0-1.2)	98 (17.5)	41 (14.6)	57 (20.4)	
Fair (1.3-3.0)	405 (72.3)	203 (72.5)	202 (72.1)	
Poor (3.1-6.0)	57 (10.2)	36 (12.9)	21 (7.5)	
Periodontal diseases (AAP/EEP 2018)				
Periodontal health	69 (12.3)	35 (12.5)	34 (12.1)	0.221
Gingivitis				
Localized	295 (52.7)	138 (49.3)	157 (56.1)	
Generalized	155 (27.7)	88 (31.4)	67 (23.9)	
Periodontitis				
Stage I	24 (4.3)	13 (4.6)	11 (3.9)	
Stage II	17 (3.0)	6 (2.1)	11 (3.9)	

PD=probing depth, CAL=clinical attachment level, BOP=bleeding on probing, OHI-S=Simplified Oral Hygiene Index, the American Academy of Periodontology (AAP) and the European Dental Federation (EFP)

Table 3 Bivariate analyses of explanatory factors, with Decayed, Missing, and Filled Teeth (DMFT) index and periodontal status

Variables	DMFT				Periodontal status		
	N (%)	Mean	S.D.	p-value	Healthy N (%)	Periodontal diseases N (%)	p-value
Total	560	3.70	3.65		69	491	
Socioeconomic status							
Gender							
Male	280 (50.0)	3.09	3.54	<0.001	35 (12.5)	245 (87.5)	1.000
Female	280 (50.0)	4.31	3.65		34 (12.1)	246 (87.9)	
Father's education level							
Low level	30 (5.4)	2.97	4.16	0.134	2 (6.7)	28 (93.3)	0.555
Middle level	294 (52.5)	3.51	3.61		39 (13.3)	255 (86.7)	
High level	236 (42.1)	4.03	3.60		28 (11.9)	208 (88.1)	
Mother's education level							
Low level	58 (10.4)	3.84	3.62	0.805	5 (8.6)	53 (91.4)	0.663
Middle level	313 (55.9)	3.61	3.67		40 (12.8)	273 (2136.2)	
High level	189 (33.8)	3.80	3.63		24 (12.7)	165 (1299.4)	
Household income by month							
Low level	224 (40.0)	3.65	3.71	0.676	25 (11.2)	199 (88.8)	0.046
Middle level	266 (47.5)	3.85	3.71		29 (10.9)	237 (89.1)	
High level	70 (12.5)	3.27	3.16		15 (21.4)	55 (78.6)	
Oral health behavior							
Frequency of toothbrushing (times/day)							
≥2	385 (68.8)	3.71	3.67	0.245	45 (11.7)	340 (88.3)	0.499
≤1	175 (31.2)	3.68	3.63		24 (13.7)	151 (86.3)	
Use of dental floss							
Yes	133 (23.8)	3.30	3.12	0.352	18 (13.5)	115 (86.5)	0.626
No	427 (76.3)	3.82	3.79		51 (11.9)	376 (88.1)	
Fluoride toothpaste							
Yes	409 (73.0)	3.66	3.55	0.652	53 (13.0)	356 (87.0)	0.450
No	151 (27.0)	3.81	3.90		16 (10.6)	135 (89.4)	
Health behavior							
Sugar consumption habit							
High frequency	72 (12.9)	4.31	3.90	0.083	11 (15.3)	61 (84.7)	0.554
Middle frequency	356 (63.6)	3.78	3.72		40 (11.2)	316 (88.8)	
Low frequency	132 (23.6)	3.17	3.23		18 (13.6)	114 (86.4)	
Smoking							
Yes	18 (3.2)	2.28	3.36	0.092	4 (22.2)	14 (77.8)	0.260
No	542 (96.8)	3.75	3.65		65 (12.0)	477 (88.0)	
Dental service utilization (months)							
Never	100 (17.9)	3.73	4.04	0.723	10 (10.0)	90 (90.0)	0.231
>12	99 (17.7)	3.32	3.30		10 (10.1)	89 (89.9)	
6–12	186 (33.2)	3.77	3.76		20 (10.8)	166 (89.2)	
<6	175 (31.3)	3.82	3.48		29 (16.6)	146 (83.4)	
Oral hygiene State							
OHI-S							
Good (0–1.2)	98 (17.5)	2.23	2.5	<0.001	65 (66.3)	33 (33.7)	<0.001
Fair (1.3–3.0)	405 (72.3)	4.01	3.8		4 (1.0)	401 (99.0)	
Poor (3.1–6.0)	57 (10.2)	3.98	3.9		0 (0.0)	57 (100.0)	
BOP (%)							
<10	69 (12.3)	3.65	3.63	0.012	69 (100.0)	0 (0.0)	<0.001
10–30	295 (52.7)	4.17	3.95		0 (0.0)	295 (100.0)	
>30	196 (35.0)	3.02	3.03		0 (0.0)	196 (100.0)	

BOP=bleeding on probing, OHI-S=Simplified Oral Hygiene Index

From the multivariate linear regression results, the effects of gender (p-value<0.001), high frequency of sugar consumption habits (p-value=0.008) and OHI-S (p-value=0.006) on DMFT were statistically significant (Table 4). Compared with males, the β value (95% CI) of females was 1.28 (0.68, 1.88); in the sugar consumption habits, the β value (95% CI) were 1.41 (0.37, 2.45) compared with the high frequency and low frequencies; the β (95% CI) for poor oral hygiene, as compared to good oral hygiene, was 1.71 (0.50, 2.92).

Table 4 Multivariable linear regression analysis for Decayed, Missing, and Filled Teeth (DMFT) index (N=560)

Variable		Unstandardized coefficients		95% CI	
		B	SE		
Gender	Male				
	Female	1.28	0.30	0.68	1.88
Household income by month	High level				
	Middle level	0.91	0.49	-0.05	1.87
	Low level	0.68	0.50	-0.29	1.65
Tooth brushing frequency	≥2 times/day				
	≤1 times/day	0.30	0.33	-0.35	0.94
Sugar consumption habits	Low				
	Middle	0.60	0.37	-0.12	1.32
	High	1.41	0.53	0.37	2.45
OHI-S	Good				
	Fair/poor	1.71	0.62	0.50	2.92
BOP	<10%				
	10-30%	0.10	0.70	-1.26	1.47
	>30%	0.12	0.70	-1.26	1.49

Multivariable Linear Regression was used to analyze the factors associated with the degree of DMFT (continuous variable).
SE=standard error, CI=confidence interval, BOP=bleeding on probing, OHI-S=Simplified Oral Hygiene Index

Table 5 Multivariable logistic regression model for periodontal status (N=560)

Variable		OR	95% CI	
Gender	Male			
	Female	2.68	1.11	6.49
Household income by month	High level			
	Middle level	1.23	0.41	3.73
	Low level	1.85	0.60	5.71
Tooth brushing frequency	≥2 times/day			
	≤1 times/day	0.47	0.18	1.18
Smoking	No			
	Yes	0.61	0.09	3.94
OHI-S	Good			
	Fair/poor	1.59	1.28	3.18

Multivariable logistic regression was used to evaluate factors associated with periodontal diseases.
CI=confidence Interval, OR=odds ratio, BOP=bleeding on probing, OHI-S=Simplified Oral Hygiene Index

The results of multivariate logistic regression showed that gender (p-value=0.029) and OHI-S (p-value<0.001) were statistically significant (Table 5). The risk of periodontal diseases in females was 2.68 times higher than in males (OR=2.68, 95% CI: 1.11-6.49). In terms of oral hygiene, poorer OHI-S (OR=1.59, 95% CI: 1.28-3.18) had a 1.59-fold higher risk of periodontal diseases than better OHI-S.

Discussion

According to the latest national oral health survey in China, as reported in 2018, it was found that the prevalence of dental caries and periodontal diseases among the younger aged population were relatively high.[3,4] This study assessed the prevalence of dental caries and periodontal diseases among adolescents aged 17-19 in urban high schools in Kunming, and their correlation to variable factors; including, socioeconomics, oral health behaviors and sugar consumption habits being analyzed. As expected, the prevalence of these common oral diseases was higher than the national survey. According to the DMFT index used, both caries prevalence (43.3% to 72.5%) and DMFT in this present study (1.16±1.98 to 3.70±3.65) were higher compared with the national data of the 15-year-old age group.[3] Moreover, a healthy periodontal condition was found as only having a low prevalence (12.3%) compared to the national survey (35%), in which 87.7% of adolescents suffered from periodontal diseases; especially gingivitis.[4] These differences may be related to Kunming's economic regional location, adolescents' oral health behaviors and their eating habits. Hence, this study further explored and analyzed the related factors of caries and periodontal diseases.

The results of this study revealed that the prevalence and severity of dental caries in adolescent permanent teeth in Kunming were much higher than the survey results in the 12-year-old age group in economically developed provinces and regions; such as, Liaoning[18], Jilin[19], Sichuan[20] and Shenzhen.[21] The reason for this may be related to the fact that the age group of this study was higher than other surveyed groups. This is also in line with the trend of the burden of dental caries increasing with age.[22] In addition, the economic level of Kunming is lower than that of the above-mentioned regions. Similar to previous studies[3,23], the prevalence of dental caries in this study was found to be higher in females than males; although females had better oral hygiene habits than males. This may be due to the females' preference for sweets, which had been found in this study. Additionally, hormonal changes in puberty and menstruation[24] in combination with a diverse gender-based plaque microbiome were also possible causes.[25]

According to further adjustment, females were significantly associated with DMFT and periodontal diseases. Adolescents with poor oral hygiene and a high sugar consumption were also found to have higher DMFT. In adults, gender is also a significant risk factor for periodontal diseases, with males at higher risk of periodontal diseases than females.[26] However, in the adolescent group, earlier puberty and eruption of permanent teeth in females may contribute to a higher prevalence of periodontitis in females than in males. This effect diminishes with increasing of age.[27] Since the subjects of this study were all of the same age, and all came from urban high schools, there were no differences in either regions or ages.[4,19,23] However, this evidence more clearly illustrates the important role of maintaining oral hygiene for preventing oral diseases.

Although, the females' oral hygiene was better than that of the males; with calculus and debris detection rates of 61.8% and 99.3%, the data reflected that these adolescents did not pay enough attention to periodontal health. From the percentage of subjects, the detection rate of more serious clinical parameters is high. Still, from the distribution of the overall tooth site, the percentage of clinical attachment level, probing pocket depth >3 mm and bleeding on probing was only 4.5%, 0.8% and 12.8%, respectively.

This indicated that the extent of the disease was limited; however, this can still lead to rapid periodontal tissue loss in adolescents. Periodontal health in this study was poor compared to findings from other countries. In Japan, the gingival bleeding and calculus prevalence was 30.6% and 26.5%, respectively, in 15–19 year olds.[28] Botero et al. found that 34.7% of children and adolescents had gingivitis in Latin American countries.[29] In other parts of China, the prevalence of calculus and gingival bleeding in the 15–year–olds was 43.1% and 35% in Shandong Province[23], and 47.9% and 48.9% in Jilin Province.[19] The data of 18–year–olds in Taiwan was similar to this study, with a calculus detection rate of 79.2%, and wherein, 88.2% of the subjects had periodontal disease.[5] This vast difference indicates the lack of awareness of periodontal prevention among adolescents in China, and the urgent need for oral care. Having subjects with 7.3% of periodontitis indirectly explained the 60–fold increase in CAL in the 35–year–old age group compared to the 15–year–old age group.[4] Another possible reason was that we used a new classification of periodontal status for subsequent microbiological studies, which provided more objective diagnostic criteria. However, the new classification also requires longer clinical examination times.[6]

Tooth brushing is known to have positive effects on plaque removal and oral health maintenance.[30] However, like other studies, this study did not find an association between brushing and caries.[19,31,32] We speculate that this may be related to the individual's brushing efficiency and method. This explains that, although the adolescents in this study had good oral hygiene practices, the prevalence of dental caries and gingivitis remained high. Furthermore, girls preferred sweets, and even if they brushed their teeth twice a day, the prevalence of caries was still higher than males. Tooth brushing is already a common oral health behavior, but there is still a need to strive to improve efficiency in this direction. As plaque is a significant cause of the development of periodontal diseases, good oral hygiene can effectively prevent the development of periodontal diseases in both adolescents and adults.[8,33,34] Adolescents require early dental care; however and unfortunately, this care seems to have a long way to go in China; due to China still being a developing country with uneven economic development. Data shows that dental care is related to family economics in China, and receiving dental treatment is the most crucial visit factor. The number of the dental visits for preventive purposes is relatively small, which is also confirmed by this study.[1] Compared with the accurate diagnosis of dental caries, no accurate periodontal diagnosis was given in previous epidemiological surveys, so adolescents were not aware of the existence of periodontal diseases. Therefore, to avoid more serious periodontal problems, oral health education should also focus on healthy periodontal tissues.[35]

We acknowledge that our cross–sectional study has some limitations; such as, the inability to draw causal inferences as well as the lack of brushing efficiency and plaque index evaluation. Furthermore, because this study did not use random sampling for subject recruitment in addition to being conducted during the COVID–19 pandemic, there is a possibility of selection bias. As a result, generalizability to other populations is limited. However, the effect of selection bias on the prevalence of oral health problems (i.e., periodontal disease and dental caries) might be small in this study. As shown in Table 3, the frequency distribution for adolescents with their most recent dental service utilization, classified as never or >12 months; 6–12 months; and 6 months, appears to be similar (35.6%; 33.2%, and 31.3%, respectively). Dental utilization could reflect perceived oral health needs and barriers to access dental care services. The bivariate analysis also indicated that there was no significant difference in dental caries and periodontal health due to last–time dental service utilization. In addition, the COVID–19 pandemic had less of an impact on study sample recruitment, because the COVID–19

infected rate of the population in Kunming city during the study period was extremely low; which was 0.0003% (25 in 8,460,088).

The strength of this study is that it is the first start for exploring the oral health status of 18-year-old adolescents in Kunming. The limitation is that only 2.2% (500 of 22,534 adolescents) were included in the study, however, it could provide some information to understand the oral health status and relating factors e.g. their attitudes and behaviors in this age group. Most epidemiological studies of periodontal diseases used the community periodontal index (CPI); whereas, this study used the new classification system of periodontal status (2018 AAP/EEP). This enabled us to express the prevalence and extent of periodontal disease objectively as well as to conduct a subsequence study of periodontal pathogens and clinical stage of periodontal disease.

Conclusion

In conclusion, adolescents in Kunming urban high school have relatively poor oral health. The prevalence of periodontal diseases and dental caries is high, and the signs are not taken seriously. Females and poor oral hygiene are common risk factors for dental caries and periodontal diseases. Additionally, increased frequency of sugar consumption is also a risk factor for dental caries. Signs of oral diseases in adolescents are high-risk factors in adulthood; however, further destruction can be avoided if appropriate interventions are provided. Therefore, it is recommended that more attention be paid to the oral health of adolescents aged 17-19, which focuses on improving the efficiency of oral hygiene behavior.

Acknowledgement

The author would like to thank all those who were involved in this study; especially, Sichen Liu for the data analysis assistance for this article, Yi Peng for the clinical data collection.

Funding sources

This work was supported by a grant from the Prince of Songkla University (the Graduate Studies and the Common Oral Diseases and Epidemiology Research Center) for Ph.D. study of Jie Xu, and from the School of Stomatology, Kunming Medical University.

Conflict of interest

There are no conflicts of interest.

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Supplementary Table 1 Description of the variables used in the questionnaire

Variables group	Variables	Categories	
Social demographic factors	Paternal and maternal educational levels	Low level (lower than primary school, primary school) Middle level (junior middle school, senior middle school, technical secondary school) High level (junior college, university, postgraduate or higher)	
	Household income by month	Low level (<6,000 CNY) Middle level (6,000–12,000 CNY) High level (>12,000 CNY)	
Oral hygiene behavior	Frequency of toothbrushing	≥2 times/day ≤1 times/day	
	Fluoride paste	Yes/No	
	Use of dental floss	Yes/No	
	Smoking	Yes/No	
Sugar consumption habits	Frequency of taking three typical categories of sweet things: sweet foods, sweet drinks, and sweetened milk/yogurt/tea/coffee:	seldom/never (score 1)/one to three times a month (score 2)/ once a week (score 3)/two to six times a week (score 4)/ once a day (score 5)/more than once a day (score 6)	Low level: Total score 3–8 Middle level: Total score 9–14 High level: Total score 15–18
Dental service utilization	The time of the last dental visit	Never <6 months 6–12 months >12 months	

CNY=Chinese Yuen