

Permanent Teeth Caries Status of 12- to 15-year-olds in China: Findings from the 4th National Oral Health Survey

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Objective: To investigate the dental caries status of teenagers in China by means of analysing national data from the 4th National Oral Health Survey of China.

Methods: Data for 12- to 15-year-olds participated in the 4th National Oral Health Survey of China were used for statistical analysis. Children who were recruited in the survey completed a dental examination and filled in a questionnaire. Social demographic factors, oral hygiene behaviours, sugar consumption habits, status of dental service utilisation, and pit-and-fissure sealant history were compared between adolescents with caries experiences and those without. For decayed, missing and filled permanent teeth (DMFT) and each of its components, mean values were statistically tested to see if significance existed between or among different categories of all involved variables.

Results: In total, data from 27,821, 30,961, 30,691 and 29,128 Chinese 12-, 13-, 14-, and 15-year-olds respectively, were analysed. Social demographic factors, sugar consumption and dental service utilisation showed statistical significance when compared between those with and without dental caries experience in the 12- and 15-year-old groups. Certain categories of these factors above also had important influence on the mean value of the number of decayed teeth (DT), filled teeth (FT) and DMFT, and they might be potential determinants of dental caries experience of permanent teeth for teenagers.

Conclusion: Dental caries in 12- and 15-year-old Chinese adolescents was impacted by certain social demographic and dental behavioural factors, which could provide some implications for policy makers and dental public health professionals when attempting to enhance oral health status for those teenagers in the early stages of permanent dentition.

Key words: adolescents, dental caries, dental behaviour, social demographic factor, 4th National Oral Health Survey
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Puberty is an important stage of children's growth and development, during which both their physical and mental status gradually mature¹. As an important part of general health, oral health is also a hot topic. After more than 6 years' replacement of primary teeth by their successors, the permanent dentition begins to take

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its function during the following decades of life. Thus, the World Health Organization (WHO) regards 12- to 15-year-olds as a reference group for oral health surveys among population, as an expansion of the 12-year-old group used previously².

Dental caries, or tooth decay, is the most common disease in the oral cavity among teenagers worldwide. In 1995 and 2005, the prevalence of permanent caries in 12-year-old Chinese children was 45.8% and 28.9%, respectively, while the mean number of decayed, missing (due to caries) and filled permanent teeth (mean DMFT) changed from 1.03 to 0.5 during the decade^{3,4}. The caries status in China exhibits characteristics typically found in developing countries, as in the year 2005, 89% of caries teeth in 12-year-old adolescents remained untreated^{3,4}. The geographic distribution of dental caries also showed an appearance of inequality in both DMFT and the number of decayed teeth (DT) among different regions of the whole country⁵. Meanwhile, the oral behaviours of these teenagers – including toothbrushing habits, consumption of sugary foods, and visits to the dentist – vary in different provinces and urban/rural areas^{6,7}.

China, as one of the largest developing countries in the world, has accomplished a great achievement in economic development during the past decade, however the unchanged family-planning policies started from 1980s mad the size of the young population still under strict control before the 4th National Oral Health Survey began. As the birth rate maintained at a lower level than ever before, children's wellbeing, especially for those of school age and who will become the backbone of society in about 2030, is emphasised by the government several times. As dental caries poses a great burden to the population^{4,8}, caries control has been put onto the government's agenda by carrying out national public health programmes with a broad application of appropriate preventative techniques for children. Under this condition, analysis of the most recent prevalence data of caries among children at teenage and its related factors will yield greater understanding of the current situation, and could provide more reasonable suggestions on the reformation and innovation of policies related to dental public health.

The aim of this study was to analyse data of caries status among 12- to 15-year-old adolescents in China, and to discover its relationships with certain influence factors, so as to comprehensively describe the current situation of dental caries in Chinese teenagers, as well as to lay the foundation for further in-depth analysis.

Materials and methods

Data resource

This cross-sectional study used data from the 4th National Oral Health Survey of China (2015–2016), which covered the four WHO index ages. All 31 provinces, autonomous regions and municipalities of the mainland of China participated in the survey. Participants were selected using a multistage stratified cluster sampling method. Firstly, each province was divided into two strata: urban and rural areas, then two districts or counties were randomly selected from each stratum. Secondly, three middle schools were randomly chosen from every district or county, respectively, from a list provided by the council. Thirdly, at each middle school, a random sample of 320 children aged 12, 13, 14, and 15 years was recruited using the list of enrollees, with 80 children enrolled for each age group. A target sample of 3,840 participants was initially set per province, for a total of 119,040 children nationally. Finally, a total of 118,601 school-age participants completed a clinical examination and questionnaire, and were enrolled for the present analysis. Ethical clearance was approved by the Stomatological Ethics Committee of Chinese Stomatological Association (Approval no. 2014-003).

Variable selection

Dental clinical examinations were carried out with participants seated on a chair, using artificial light, plane mouth mirrors and standard WHO CPI probes. All permanent teeth were examined and dental caries was diagnosed according to the WHO criteria. Before the national survey began, unified training sessions were provided to representative survey examiners from all the provinces. For reliability assessment, duplicate examinations were conducted during the main survey. Five percent of participants were re-examined to calculate inter-examiner reliability, and the Kappa score was 0.94 for the examination of dental caries in 12- to 15-year-olds.

The number of DMFT was calculated to show the overall caries status and experience. Each item of DMFT, namely the number of decayed permanent teeth (DT), missing permanent teeth (MT) and filled permanent teeth (FT), was also computed separately. These values could exhibit children's dental caries experience, and will be used as a grouping variable in the subsequent step of comparative analysis.

As well as the above, variables involved in the present study included five categories in total: social demographic factors, oral hygiene behaviours, sugar

Supplementary Table Variables involved in the present study

Categories	Sub-categories	Options	
Social demographic factors	Area	Urban/rural	
	Gender	Male/female	
	Number of children in the family	One/more than one	
	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)	
Oral hygiene behaviour	Frequency of toothbrushing	More than twice a day/once a day/less than once a day/seldom or never	
	Use of toothpaste	Yes/no	
	Use of fluoride paste	Yes/no	
	Use of dental floss	Never/occasionally/every week/every day	
Sugar consumption habits	Frequency of taking three typical categories of sweet things*	One to three times a month (score 1)/once a week (score 2)/two to six times a week (score 3)/once a day (score 4)/more than once a day (score 5)#	
Utilisation of dental services	The time of last dental visit	Within 6 months ago/6-12 months ago/more than 12 months ago/never	
	Purpose of that visit	Consulting and dental examination/prophylactic reasons/treatment	

* Three typical categories of sweet things: sweet foods, sweet drinks, and sweetened milk/yoghurt/tea/coffee.

Total score: 3–6, 7–10, 11–14, 15–18 were considered as low, relative low, middle, and high level of frequency.

consumption habits, utilisation of dental service, and pit-and-fissure sealants. Area, gender, number of children in the family, and paternal and maternal education levels were reported as social demographic factors. Oral hygiene behaviours were frequency of toothbrushing, use of toothpaste, use of fluoride paste, and use of dental floss. Sugar consumption habits refer to frequency of taking three typical categories of sweet things: sweet foods, sweet drinks, and sweetened milk/yoghurt/tea/coffee. Utilisation of dental services was measured by the date of last dental visit and purpose for that visit. The detailed information of grading standard of each variable is exhibited in the Supplementary table. All these variables extracted from the examination tables and questionnaires were representative of oral health-related factors, which will then be further statistically analysed of their relationships with dental caries experience.

Statistical analysis

First, a descriptive analysis of each factor involved was performed for the full study sample of 12- to 15-year-olds to show the number of children and percentage

of each category. Next, these factors were compared between children with permanent caries experience and those without (DMFT > 0) with a Chi-square test used to assess if statistical significance existed. Furthermore, the mean value of DMFT and its subcategories (DT, MT and FT) were compared among all categories of involved factors using a *t* test (for two-categorised variables under normal distribution), one-way analysis of variance (ANOVA, for these factors with three or more categories under normal distribution) or non-parameter tests (under non-normal condition, Mann-Whiney test for two-categorised variables, and the Kruskal-Wallis test for these factors with three or more categories). *P* < 0.05 was considered as statistically significant.

Results

In total, 27,821 12-year-olds, 30,961 13-year-olds, 30,691 14-year-olds and 29,128 15-year-olds were enrolled in this research. There was an equal male to female ratio, and in all age groups an even distribution for urban and rural areas. The distribution of all involved factors for the full study sample is presented in Table 1.

Table 1 Characteristics of the samples for Chinese 12- to 15-year-olds.

Variables		12-year-olds		13-year-olds		14-year-olds		15-year-olds		Total	
		N	%	N	%	N	%	N	%	N	%
Total		27,821	23.5	30,961	26.1	30,691	25.9	29,128	24.6	118,601	100.0
Social demographics											
Area											
	Urban	14,265	51.3	15,745	50.9	15,527	50.6	14,772	50.7	60,309	50.9
	Rural	13,556	48.7	15,216	49.1	15,164	49.4	14,356	49.3	58,292	49.1
Gender											
	Male	13,841	49.8	15,516	50.1	15,376	50.1	14,530	49.9	59,263	50.0
	Female	13,980	50.2	15,445	49.9	15,315	49.9	14,598	50.1	59,338	50.0
Number of children in the family											
	One child	10,011	36.0	11,281	36.4	11,154	36.3	11,092	38.1	43,538	36.7
	More than one child	17,806	64.0	19,678	63.6	19,534	63.7	18,036	61.9	75,054	63.3
Father's education level											
	Low level	4,756	19.7	5,574	20.5	5,863	21.5	5,717	21.6	21,910	20.8
	Middle level	16,263	67.2	18,231	66.9	18,186	66.6	17,454	66.1	70,134	66.7
	High level	3,164	13.1	3,441	12.6	3,256	11.9	3,251	12.3	13,112	12.5
Mother's education level											
	Low level	6,861	28.4	8,102	29.8	8,555	31.6	8,455	32.2	31,973	30.5
	Middle level	14,544	60.2	16,062	59.0	15,782	58.2	15,114	57.5	61,502	58.7
	High level	2,751	11.4	3,053	11.2	2,771	10.2	2,700	10.3	11,275	10.8
Oral hygiene habits											
Frequency of toothbrushing											
	More than twice a day	8,879	31.9	9,827	31.7	10,015	32.6	9,935	34.1	38,656	32.6
	Once a day	14,158	50.9	16,497	53.3	16,832	54.9	16,358	56.2	63,845	53.8
	Less than once a day	1,469	5.3	1,543	5.0	1,423	4.6	1,075	3.7	5,510	4.6
	Seldom or never	3,309	11.9	3,092	10.0	2,416	7.9	1,756	6.0	10,573	8.9
Toothpaste use											
	Yes	24,233	99.6	27,573	99.6	27,995	99.7	27,099	99.7	106,900	99.7
	No	86	0.4	98	0.4	77	0.3	88	0.3	349	0.3
Use of fluoride toothpaste											
	Yes	1,645	55.0	1,861	54.6	2,326	58.0	2,992	62.1	8,824	58.0
	No	1,346	45.0	1,547	45.4	1,683	42.0	1,826	37.9	6,402	42.0
Use of dental floss											
	No	25,149	90.4	27,753	89.7	27,710	90.3	26,470	90.9	107,082	90.3
	Occasionally	2,314	8.3	2,794	9.0	2,593	8.5	2,363	8.1	10,064	8.5
	Every week	188	0.7	218	0.7	205	0.7	142	0.5	753	0.6
	Everyday	164	0.6	191	0.6	177	0.6	147	0.5	679	0.6

Variables		12-year-olds		13-year-olds		14-year-olds		15-year-olds		Total	
		N	%	N	%	N	%	N	%	N	%
Sugar consumption habits											
	Low frequency	5,998	26.9	5,950	26.7	5,349	24.0	4,998	22.4	22,295	23.5
	Relative low frequency	10,827	24.1	11,710	26.1	11,568	25.8	10,760	24.0	44,865	26.1
	Middle frequency	8,490	21.6	10,223	25.4	10,458	26.6	10,144	25.8	39,315	25.9
	High frequency	2,505	20.7	3,072	14.3	3,310	27.3	3,221	26.6	12,108	24.6
Dental service utilisation											
Time from the last dental visit											
	Less than 6 months	3,646	13.1	3,890	12.6	3,582	11.7	3,206	11.0	14,324	12.1
	6-12 months	3,704	13.3	3,721	12.0	3,294	10.7	2,893	9.9	13,612	11.5
	More than 12 months	7,433	26.7	8,296	26.8	7,771	25.3	7,170	24.6	30,670	25.9
	Never	13,036	46.9	15,052	48.6	16,037	52.3	15,853	54.4	59,978	50.6
Purpose of the last dental visit											
	Consulting and dental examination	1,791	27.8	1,937	28.7	1,665	27.1	1,537	27.8	6,930	27.9
	Prophylactic reasons	1,380	21.4	1,270	18.8	1,026	16.7	810	14.7	4,486	18.0
	Treatment	3,272	50.8	3,542	52.5	3,446	56.2	3,181	57.5	13,441	54.1
Pit-and-fissure sealant history											
	Yes	1,918	6.9	1,901	6.1	1,563	5.1	1,405	4.8	6,787	5.7
	No	25,903	93.1	29,060	93.9	29,128	94.9	27,723	95.2	111,814	94.3

Table 2 shows the prevalence of permanent dental caries, as well as mean DMFT values, and its subgroup (DT, MT, and FT) values in 12- to 15-year-olds under different stratification of location and sex. Overall, 38.5% of 12-year-olds, 41.2% of 13-year-olds, 43.3% of 14-year-olds and 44.42% of Chinese 15-year-olds experienced permanent dental caries, which showed significant difference among age groups ($P < 0.001$). The strong relationship between age and caries prevalence was manifested not only in diverse locations, but also in different sex clusters ($P < 0.001$). The mean DMFT values of 12- to 15-year-old children were 0.86 ± 1.48 , 0.99 ± 1.67 , 1.10 ± 1.83 , 1.20 ± 1.99 , respectively. A remarkable difference ($P < 0.001$) was exhibited among age groups, indicating that age was an important associated factor with permanent dental caries experience in young Chinese people. Strikingly, 81.3% to 83.4% of permanent teeth with caries remained untreated in four age groups.

To explore the potential correlative factor of dental caries prevalence, a comparison of five categorised variables was made in the 12- and 15-year-old groups. Results from the Chi-square test exhibited that nine selected variables were significantly associated with the prevalence of caries in children aged 12, including location, sex, number of children in the family, paternal education level, maternal education level, use of toothpaste, sugar consumption habits, date of last dental visit, and purpose of the most recent dental visit. Analogously, there were also nine variables significantly associated with caries status in 15-year-olds, consisting of all factors in the categories of social demographic factors, sugar consumption habits and utilisation of dental service. Unlike the 12-year-olds, frequency of toothbrushing ($P < 0.001$), but not use of toothpaste ($P = 0.709$), exhibited an important influence on the prevalence of dental caries in the 15-year-old group (Table 3).

Table 2 Caries prevalence and DT, MT, FT, DMFT values among 12- to 15-year-olds.

Variables	12-year-olds					13-year-olds					14-year-olds					15-year-olds				
	Dental caries prevalence	DT (SD)	MT (SD)	FT (SD)	DMFT (SD)	Dental caries prevalence	DT (SD)	MT (SD)	FT (SD)	DMFT (SD)	Dental caries prevalence	DT (SD)	MT (SD)	FT (SD)	DMFT (SD)	Dental caries prevalence	DT (SD)	MT (SD)	FT (SD)	DMFT (SD)
Total	38.5%	0.71 (1.33)	0.00 (0.07)	0.14 (0.62)	0.86 (1.48)	41.2%	0.82 (1.49)	0.01 (0.09)	0.16 (0.70)	0.99 (1.67)	43.3%	0.90 (1.60)	0.01 (0.10)	0.19 (0.79)	1.10 (1.83)	44.4%	0.97 (1.72)	0.01 (0.10)	0.22 (0.88)	1.20 (1.99)
Area																				
Urban	37.0%	0.66 (1.28)	0.00 (0.07)	0.16 (0.68)	0.83 (1.48)	40.5%	0.75 (1.38)	0.00 (0.08)	0.19 (0.75)	0.95 (1.60)	42.2%	0.84 (1.52)	0.00 (0.08)	0.21 (0.84)	1.05 (1.78)	43.3%	0.90 (1.64)	0.01 (0.09)	0.25 (0.98)	1.16 (1.98)
Rural	40.0%	0.77 (1.38)	0.00 (0.08)	0.11 (0.54)	0.88 (1.49)	41.9%	0.88 (1.59)	0.01 (0.10)	0.14 (0.63)	1.03 (1.74)	44.5%	0.97 (1.68)	0.01 (0.12)	0.16 (0.72)	1.14 (1.88)	45.6%	1.04 (1.80)	0.01 (0.11)	0.18 (0.77)	1.23 (2.00)
Gender																				
Male	33.8%	0.59 (1.17)	0.00 (0.06)	0.10 (0.49)	0.70 (1.20)	36.2%	0.68 (1.31)	0.01 (0.08)	0.13 (0.57)	0.81 (1.47)	38.0%	0.75 (1.44)	0.01 (0.09)	0.13 (0.63)	0.89 (1.61)	39.1%	0.82 (1.58)	0.01 (0.09)	0.15 (0.68)	0.98 (1.76)
Female	43.1%	0.84 (1.46)	0.00 (0.08)	0.17 (0.72)	1.02 (1.63)	46.2%	0.96 (1.63)	0.01 (0.09)	0.20 (0.80)	1.16 (1.83)	48.7%	1.05 (1.74)	0.01 (0.11)	0.24 (0.91)	1.30 (2.00)	49.7%	1.12 (1.85)	0.01 (0.11)	0.28 (1.05)	1.42 (2.18)

Furthermore, univariate analyses for different categories of involved factors with DT, MT, FT, and DMFT in 12 and 15-year-olds were carried out. Results in Tables 4 and 5 exhibited that, similar to those related factors with caries prevalence, each variable under social demographic factors, sugar consumption habits, utilisation of dental service and partial variables under the category of oral hygiene behaviours has important influence on mean value of DMFT, DT and FT, but not MT. Overall, preliminary results indicated that these factors might be potential determinants of dental caries experience in the permanent teeth of young people in China.

Discussion

This study used data sourced from the 4th National Oral Health Survey of China, which was conducted in 2015 and covered all 31 provinces, municipalities and autonomous regions countrywide in mainland China. With the analysis in our present study, we have obtained the prevalence and associated factors of permanent dental caries in Chinese adolescents aged 12 to 15 years old, and a descriptive analysis of the current condition of dental caries was also exhibited from all aspects, providing a necessary basis for the health authorities to improve the dental health of the young Chinese population.

Over the past two decades, the prevalence of permanent caries in 12-year-old Chinese children fluctuated in 1995, 2005 and 2015 – by 45.8%, 28.9%, and 38.5%, respectively. A similar trend could be found in the change of mean DMFT – from 1.03, 0.5 to 0.86 – which always stayed at relative low levels, according to the WHO’s criteria^{3,4}. As according to its economic condition the People’s Republic of China is still a developing country, the proportion of untreated tooth decay remained at a high level, although a slight reduction could be found from 88.8% to 83.4% in the past decade⁴.

Our findings indicated that social geographical factors were strongly associated with not only the prevalence of permanent dental caries in all the 12- to 15-year-old groups, but also the DMFT values. Children in rural areas had a higher level of caries prevalence and a higher DMFT score compared with those from urban areas. Analogous correlation was also reported in similar national surveys in Australia⁹, Greece¹⁰, Cyprus¹¹, and Pakistan¹², as well as the investigation using partial data of the 3rd National Oral Health Survey of China⁵, implying more treatments were needed for the rural teenage population. Poor oral health behaviours and limited access to health services were supposed

Table 3 Prevalence and univariate variable analysis of related factors in 12- and 15-year-olds with and without permanent dental caries.

Variables		12-year-olds			15-year-olds		
		N	DMFT > 0 (%)	P value	N	DMFT > 0 (%)	P value
Total		27,821	38.5		29,128	44.4	
Social demographics							
Area							
	Urban	14,265	37.0	< 0.001	14,772	43.3	< 0.001
	Rural	13,556	40.0		14,356	45.6	
Gender							
	Male	13,841	33.8	< 0.001	14,530	39.1	< 0.001
	Female	13,980	43.1		14,598	49.7	
Number of children in the family							
	One child	10,011	36.9	< 0.001	11,092	43.0	< 0.001
	More than one child	17,806	39.4		18,036	45.3	
Father's education level							
	Low level	4,756	41.4	< 0.001 ^a	5,717	46.5	< 0.001 ^a
	Middle level	16,263	38.0		17,454	44.0	
	High level	3,164	34.6		3,251	41.9	
Mother's education level							
	Low level	6,861	38.9	< 0.001 ^a	8,455	45.1	0.005
	Middle level	14,544	38.9		15,114	44.5	
	High level	2,751	34.3		2,700	41.6	
Oral hygiene habits							
Frequency of toothbrushing							
	More than twice a day	8,879	38.8	0.428 ^a	9,935	46.1	< 0.001 ^a
	Once a day	14,158	38.4		16,358	43.9	
	Less than once a day	1,469	39.8		1,075	42.0	
	Seldom or never	3,309	37.6		1,756	40.9	
Toothpaste use							
	Yes	24,233	38.5	0.016	27,099	44.6	0.709
	No	86	51.2		88	46.6	
Use of fluoride toothpaste							
	Yes	1,645	36.5	0.524	2,992	43.9	0.193
	No	1,346	37.7		1,826	45.8	
Use of dental floss							
	No	25,149	38.3	0.436 ^a	26,470	44.3	0.136 ^a
	Occasionally	2,314	40.0		2,363	45.9	
	Every week	188	39.4		142	37.3	
	Everyday	164	39.6		147	46.9	

Variables		12-year-olds			15-year-olds		
		N	DMFT > 0 (%)	P value	N	DMFT > 0 (%)	P value
Sugar consumption habits							
	Low frequency	5,998	34.2	< 0.001 ^a	4,998	38.5	< 0.001 ^a
	Relative low frequency	10,827	37.8		10,760	42.8	
	Middle frequency	8,490	40.8		10,144	46.5	
	High frequency	2,505	38.5		3,221	44.4	
Dental service utilization							
Time from the last dental visit							
	Less than 6 months	3,646	48.6	< 0.001 ^a	3,206	58.2	< 0.001 ^a
	6-12 months	3,704	46.1		2,893	58.8	
	More than 12 months	7,433	40.2		7,170	47.5	
	Never	13,036	32.5		15,853	37.6	
Purpose of the last dental visit							
	Consulting and dental examination	1,791	39.3	< 0.001 ^a	1,537	46.5	< 0.001 ^a
	Prophylactic reasons	1,380	37.7		810	42.5	
	Treatment	3,272	56.6		3,181	70.4	
Pit-and-fissure sealant history							
	Yes	1,918	39.5	0.167	1,405	43.3	0.404
	No	25,903	38.3		27,723	44.5	

χ² test was performed to test between young Chinese people with experience of caries and those without.
^a χ² for trend

to be responsible for the inequalities of caries status in Chinese schoolchildren between urban and rural areas⁵, a fact that requires further exploration and research.

The variables of parental (paternal and maternal) education level showed to be probable influencing factors for caries in 12- and 15-year-olds. In the present study, dental caries prevalence varied widely under different parental education levels, ranging from 34.3% to 46.5%; while their DMFT and DT values were also statistically different. Interestingly, the national pathfinder survey in Greece also concluded that the level of paternal educational is a significant predictor of the extent of dental caries, which was negatively related to DMF values and to untreated dental caries¹⁰, providing supportive evidence for the findings of the present study.

As we know, an acknowledged consensus is that sugar products were implicated in several non-communicable diseases, undoubtedly including dental caries¹³. The cariogenic effects of sugar was further confirmed by well-conducted longitudinal studies in Brazil on the relationship between feeding practices and caries

experience, with the conclusion that the higher the life-course sugar consumption, the higher the increment of dental caries^{14,15}. Although no cause-and-effect relationship could be concluded from the findings of our present cross-sectional study, the prevalence of dental caries and DMFT values assumed an ascending trend from 12-year-olds to 15-year-olds. In evidence, we could still draw a close association between the frequency of all types of sugar consumption – sweet foods, sweet drinks, and sweetened milk/yogurt/tea/coffee – to the occurrence and development of permanent dental caries in young people.

Utilisation of dental services was also confirmed as an important factor associated with dental caries experience in the present study. With a certain degree of improvement achieved over the past 10 years, a problem needing urgent attention is that in 12- to 15-year-olds respectively there are still only 26.4%, 24.6%, 22.4% and 20.9% children reported to have visited a dental practitioner within the past year, while about 50% of teenage students had never visited a dentist before.

Table 4 Univariate variable analysis of related factors with DT, MT, FT and DMFT in 12-year-olds.

Variables	DT			MT			FT			DMFT		
	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value
Total	0.71	1.33		0.00	0.07		0.14	0.62		0.86	1.48	
Social demographics												
Area												
Urban	0.66	1.28	< 0.001	0.00	0.07	0.463	0.16	0.68	< 0.001	0.83	1.48	0.004
Rural	0.77	1.38		0.00	0.08		0.11	0.54		0.88	1.49	
Gender												
Male	0.59	1.17	< 0.001	0.00	0.06	0.052	0.10	0.49	< 0.001	0.70	1.30	< 0.001
Female	0.84	1.46		0.00	0.08		0.17	0.72		1.02	1.63	
Number of children in the family												
One child	0.60	1.20	< 0.001	0.00	0.06	0.082	0.21	0.76	< 0.001	0.82	1.45	< 0.001
More than one child	0.78	1.39		0.00	0.08		0.10	0.51		0.88	1.50	
Father's education level												
Low level	0.86	1.49	< 0.001 ^a	0.01	0.11	0.011	0.06	0.36	< 0.001 ^a	0.93	1.55	< 0.001 ^a
Middle level	0.71	1.30		0.00	0.06		0.13	0.60		0.84	1.46	
High level	0.49	1.09		0.00	0.05		0.27	0.90		0.77	1.44	
Mother's education level												
Low level	0.80	1.45	< 0.001 ^a	0.01	0.09	< 0.001 ^a	0.06	0.40	< 0.001 ^a	0.87	1.52	< 0.001 ^a
Middle level	0.71	1.30		0.00	0.07		0.15	0.65		0.86	1.48	
High level	0.48	1.11		0.00	0.04		0.27	0.84		0.76	1.39	
Oral hygiene habits												
Frequency of toothbrushing												
More than twice a day	0.66	1.30	< 0.001	0.00	0.06	0.145	0.23	0.83	< 0.001	0.90	1.55	0.148
Once a day	0.73	1.33		0.00	0.07		0.10	0.51		0.84	1.45	
Less than once a day	0.78	1.30		0.00	0.06		0.08	0.43		0.86	1.39	
Seldom or never	0.75	1.40		0.01	0.09		0.06	0.39		0.82	1.47	
Toothpaste use												
Yes	0.71	1.32	0.033	0.00	0.07	0.49	0.15	0.64	0.886	0.86	1.48	0.038
No	1.17	2.00		0.01	0.11		0.14	0.53		1.33	2.05	
Use of fluoride toothpaste												
Yes	0.62	1.25	0.011	0.00	0.06	0.750	0.16	0.61	0.427	0.79	1.38	0.048
No	0.75	1.41		0.00	0.05		0.14	0.57		0.89	1.53	
Use of dental floss												
No	0.72	1.33	0.158	0.00	0.07	0.886	0.12	0.59	< 0.001	0.85	1.47	0.093
Occasionally	0.69	1.33		0.00	0.05		0.27	0.84		0.96	1.60	
Every week	0.68	1.29		0.01	0.07		0.27	0.78		0.95	1.62	
Every day	0.69	1.27		0.01	0.08		0.24	0.80		0.94	1.52	

Variables	DT			MT			FT			DMFT		
	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value
Sugar consumption habits												
Low frequency	0.60	1.18	< 0.001	0.00	0.08	0.051	0.12	0.62	< 0.001	0.72	1.34	< 0.001
Relative low frequency	0.69	1.30		0.00	0.07		0.13	0.61		0.83	1.46	
Middle frequency	0.77	1.40		0.00	0.07		0.15	0.59		0.93	1.53	
High frequency	0.90	1.52		0.01	0.07		0.17	0.72		1.07	1.71	
Dental service utilisation												
Time from the last dental visit												
Less than 6 months	0.80	1.47	< 0.001	0.01	0.11	< 0.001	0.46	1.17	< 0.001	1.27	1.87	< 0.001
6 to 12 months	0.83	1.38		0.00	0.08		0.26	0.79		1.09	1.64	
More than 12 months	0.74	1.34		0.00	0.08		0.14	0.55		0.89	1.48	
Never	0.64	1.26		0.00	0.05		0.01	0.18		0.66	1.27	
Purpose of the last dental visit												
Consulting and dental examination	0.67	1.23	< 0.001	0.00	0.09	< 0.001	0.19	0.72	< 0.001	0.87	1.44	< 0.001
Prophylactic reasons	0.65	1.33		0.00	0.05		0.20	0.73		0.86	1.56	
Treatment	0.95	1.53		0.01	0.12		0.57	1.25		1.53	1.96	
Pit-and-fissure sealant history												
Yes	0.40	0.88	< 0.001	0.01	0.08	0.573	0.37	0.98	< 0.001	0.77	1.35	< 0.001
No	0.74	1.35		0.00	0.07		0.12	0.58		0.86	1.49	

t test or Mann-Whiney test for two-categorised variables, one-way analysis of variance or Kruskal-Wallis H test were used for analysis of these factors with three or more categories. Abbreviations: decayed teeth (DT), filled teeth (FT), missing teeth (MT) and that of decayed, missing and filled teeth (DMFT), standard deviation (SD)

Fortunately, the percentage of children wanting a consulting or dental examination and prophylactic applications for the last dental visit was approximately 43.5% to 49.2%, which increased visibly during the most recent decade⁴. However, enhancement of parental awareness of their children’s oral health and the importance of visiting a dentist still requires more efforts to fulfil.

Some limitations need to be remembered when extrapolating the findings to further applications. Firstly, this was a cross-sectional study, which could not represent casual relationships between dental caries and the related factors. Secondly, only methods of single factor analyses were applied, which could not avoid the mutual effects between different variables. Multiple factor analyses were needed for further exploration.

Nevertheless, this study could provide some helpful suggestions for policy makers. People’s awareness of maintaining oral and dental health still has a long way to go in China, since a large proportion of dental caries remained untreated in young people, and a number

of students had no history of dental attendance at all. It is recommended that health authorities strengthen people’s perception of the significance of regular professional dental care and adopting appropriate self-care measures. Oral and dental health education and promotion should be more comprehensively integrated into school courses for these adolescents. Under the ambitious goal of “Healthy China 2030”, oral and dental health should be a greater priority for the wellbeing of these school children, who by that date will become the pillar of the state.

Conclusions

Dental caries in teenage Chinese adolescents was impacted by certain social demographic and dental behavioural factors, which could provide some implications for policy makers and dental public health professionals when attempting to enhance oral health status for those teenagers in the early stage of permanent dentition.

Table 5 Univariate variable analysis of related factors with DT, MT, FT and DMFT in 15-year-olds.

Variables	DT			MT			FT			DMFT		
	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value
Total	0.97	1.72		0.01	0.10		0.22	0.88		1.20	1.99	
Social demographics												
Area												
Urban	0.90	1.64	< 0.001	0.01	0.09	0.182	0.25	0.98	< 0.001	1.16	1.98	0.001
Rural	1.04	1.80		0.01	0.11		0.18	0.77		1.23	2.01	
Gender												
Male	0.82	1.58	< 0.001	0.01	0.09	0.002	0.15	0.68	< 0.001	0.98	1.76	< 0.001
Female	1.12	1.85		0.01	0.11		0.28	1.05		1.42	2.18	
Ethnicity												
Han	0.90	1.64	< 0.001	0.01	0.10	< 0.001	0.23	0.92	< 0.001	1.14	1.95	< 0.001
Zhuang	1.50	2.16		0.02	0.16		0.09	0.51		1.61	2.24	
Hui	0.76	1.34		0.00	0.06		0.09	0.53		0.85	1.47	
Manchu	1.10	1.81		0.01	0.09		0.41	1.05		1.52	2.24	
Uygur	1.90	2.39		0.01	0.08		0.08	0.41		1.98	2.44	
others	1.70	2.33		0.02	0.17		0.09	0.50		1.81	2.39	
Number of children in the family												
One child	0.83	1.60	< 0.001	0.01	0.10	0.229	0.33	1.10	< 0.001	1.16	2.00	0.029
More than one child	1.06	1.79		0.01	0.10		0.15	0.71		1.22	1.99	
Father's education level												
Low level	1.17	1.93	< 0.001	0.01	0.12	< 0.001	0.11	0.62	< 0.001	1.29	2.06	< 0.001
Middle level	0.96	1.70		0.01	0.09		0.20	0.85		1.17	1.97	
High level	0.69	1.38		0.01	0.08		0.42	1.20		1.12	1.89	
Mother's education level												
Low level	1.11	1.86	< 0.001	0.01	0.12	0.004	0.10	0.61	< 0.001	1.23	2.01	0.009
Middle level	0.94	1.67		0.01	0.10		0.24	0.92		1.19	1.98	
High level	0.67	1.41		0.00	0.07		0.44	1.22		1.12	1.92	
Oral hygiene habits												
Frequency of toothbrushing												
More than twice a day	0.92	1.68	< 0.001	0.01	0.11	0.075	0.38	1.22	< 0.001	1.31	2.15	< 0.001
Once a day	1.00	1.74		0.01	0.10		0.14	0.65		1.15	1.91	
Less than once a day	0.98	1.83		0.00	0.03		0.12	0.56		1.10	1.97	
Seldom or never	0.98	1.76		0.01	0.11		0.09	0.51		1.07	1.87	
Toothpaste use												
Yes	0.97	1.71	0.108	0.01	0.10	0.771	0.22	0.90	0.655	1.20	2.00	0.167
No	1.39	2.41		0.01	0.11		0.18	0.92		1.58	2.55	

Variables	DT			MT			FT			DMFT		
	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value	Mean	SD	P value
Use of fluoride toothpaste												
Yes	0.84	1.57	0.006	0.01	0.09	0.739	0.33	1.10	0.017	1.18	1.97	0.271
No	0.98	1.74		0.01	0.08		0.26	0.95		1.25	2.03	
Use of dental floss												
No	0.98	1.73	< 0.001	0.01	0.10	0.780	0.19	0.82	< 0.001	1.18	1.98	0.075
Occasionally	0.87	1.64		0.01	0.11		0.44	1.35		1.33	2.18	
Every week	0.73	1.38		0.01	0.08		0.42	1.22		1.15	2.03	
Everyday	0.73	1.27		0.00	0.00		0.50	1.17		1.23	1.74	
Sugar consumption habits												
Low frequency	0.81	1.58	< 0.001	0.01	0.09	0.004	0.15	0.68	< 0.001	0.96	1.75	< 0.001
Relative low frequency	0.92	1.65		0.01	0.10		0.20	0.87		1.13	1.93	
Middle frequency	1.03	1.77		0.01	0.10		0.25	0.94		1.28	2.07	
High frequency	1.21	1.96		0.02	0.15		0.28	1.00		1.51	2.25	
Dental service utilisation												
Time from the last dental visit												
Less than 6 months	1.19	2.03	< 0.001	0.03	0.19	< 0.001	0.76	1.62	< 0.001	1.98	2.64	< 0.001
6 to 12 months	1.28	2.04		0.02	0.13		0.61	1.50		1.90	2.63	
More than 12 months	0.99	1.70		0.01	0.09		0.24	0.83		1.25	1.95	
Never	0.86	1.58		0.00	0.07		0.02	0.25		0.89	1.61	
Purpose of the last dental visit												
Consulting and dental examination	1.00	1.83	< 0.001	0.01	0.09	< 0.001	0.30	1.11	< 0.001	1.31	2.14	< 0.001
Prophylactic reasons	0.88	1.65		0.00	0.06		0.31	1.15		1.19	2.05	
Treatment	1.47	2.17		0.03	0.21		1.04	1.83		2.55	2.87	
Pit-and-fissure sealant history												
Yes	0.53	1.09	< 0.001	0.01	0.10	0.858	0.58	1.36	< 0.001	1.12	1.87	0.138
No	0.99	1.75		0.01	0.10		0.20	0.85		1.20	2.00	

t test or Mann-Whiney test for two-categorised variables, one-way analysis of variance or Kruskal-Wallis H test were used for analysis of these factors with three or more categories. Abbreviations: decayed teeth (DT), filled teeth (FT), missing teeth (MT) and that of decayed, missing and filled teeth (DMFT), standard deviation (SD)

Conflicts of interest

The authors reported no conflicts of interest related to this study.

Author contribution

Dr Jun Kang QUAN participated in the study design, drafted and revised the manuscript; Dr Xiao Zhe WANG

participated in the study design, contributed to the epidemiological data collection and analyses, revised the manuscript, Dr Xiang Yu SUN drafted the manuscript; Dr Chao YUAN contributed to the epidemiological data collection and analyses, drafted the manuscript; Drs Xue Nan LIU, Xing WANG, Xi Ping FENG, Bao Jun Tai, De Yu HU, Huan Cai LIN, Bo WANG, Yan SI, Chun Xiao WANG, Wei Jian WANG, Wen Sheng RONG and Shu Guo ZHENG, trained the investigators, designed and

supervised the survey; Dr Shu Guo ZHENG conceived and supervised the study, provided valuable guidance in study design and editorial review. All authors had read and approved the final manuscript for submission.

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References

1. Chulani VL, Gordon LP. Adolescent growth and development. *Prim Care* 2014;41:465–487.
2. WHO: Oral health surveys: Basic methods, 5th ed. Geneva: World Health Organization; 2013.
3. Hu DY, Hong X, Li X. Oral health in China--trends and challenges. *Int J Oral Sci* 2011;3:7–12.
4. National Committee for Oral Health (NCOH): In third national epidemiological survey of oral health [In Chinese]. Beijing: People's Medical Publishing House; 2008.
5. Shen A, Zeng X, Cheng M, Tai B, Huang R, Bernabé E. Inequalities in dental caries among 12-year-old Chinese children. *J Public Health Dent* 2015;75:210–217.
6. Peng B, Petersen PE, Fan MW, Tai BJ. Oral health status and oral health behaviour of 12-year-old urban schoolchildren in the People's Republic of China. *Community Dent Health* 1997;14:238–244.
7. Zhu L, Petersen PE, Wang HY, Bian JY, Zhang BX. Oral health knowledge, attitudes and behaviour of children and adolescents in China. *Int Dent J* 2003;53:289–298.
8. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of untreated caries: a systematic review and metaregression. *J Dent Res* 2015;94:650–658.
9. Christian B, Blinkhorn AS. A review of dental caries in Australian Aboriginal children: the health inequalities perspective. *Rural Remote Health* 2012;12:2032.
10. Oulis CJ, Tsinidou K, Vadiakas G, Mamai-Homata E, Polychronopoulou A, Athanasouli T. Caries prevalence of 5, 12 and 15-year-old Greek children: a national pathfinder survey. *Community Dent Health* 2012;29:29–32.
11. Panagidis D, Schulte AG. Caries prevalence in 12-year-old Cypriot children. *Community Dent Health* 2012;29:297–301.
12. Sufia S, Chaudhry S, Izhar F, Syed A, Mirza BA, Khan AA. Dental caries experience in preschool children: is it related to a child's place of residence and family income? *Oral Health Prev Dent* 2011;9:375–379.
13. Sheiham A, James WP. A new understanding of the relationship between sugars, dental caries and fluoride use: implications for limits on sugars consumption. *Public Health Nutr* 2014;17:2176–2184.
14. Peres MA, Sheiham A, Liu P, et al. Sugar Consumption and Changes in Dental Caries from Childhood to Adolescence. *J Dent Res* 2016;95:388–394.
15. Sugar consumption and changes in dental caries from childhood to adolescence. *Br Dent J* 2017;222:260.

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