

Health Behaviors and Tooth Retention among Older Adults in China: Findings from the 4th Chinese National Oral Health Survey

Xiaoyan Ou

Affiliated Stomatological Hospital of Nanchang University Key Laboratory of Oral Biomedicine

Liwei Zeng

Affiliated Stomatological Hospital of Nanchang University Key Laboratory of Oral Biomedicine

Yixuan Zeng

Affiliated Stomatological Hospital of Nanchang University Key Laboratory of Oral Biomedicine

Yaolin Pei

Rory Meyers College of Nursing and NYU Aging Incubator, New York University

Xiujuan Zhang

Affiliated Stomatological Hospital of Nanchang University Key Laboratory of Oral Biomedicine

Wei Wu

Affiliated Stomatological Hospital of Nanchang University Key Laboratory of Oral Biomedicine

Shahrzad Siamdoust

Rory Meyers College of Nursing and NYU Aging Incubator, New York University

Bei Wu (✉ bei.wu@nyu.edu)

Rory Meyers College of Nursing and NYU Aging Incubator, New York University

Research Article

Keywords: tooth loss, oral health behavior, ageing, China

Posted Date: August 23rd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-820638/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background

This study aimed to examine the association between oral health behaviors and tooth retention among Chinese older adults.

Methods

Data were used from the 4th Chinese National Oral Health Survey, a nationally representative sample. The sample included 9054 older adults aged 55 to 74. A chi-square test was used for univariate analysis. Multivariate Logistic regression was used to explore the association between health behaviors and the number of remaining teeth.

Results

The average number of remaining teeth in the sample was 24.4 ± 7.8 . There was a higher proportion of residents living in urban areas with ≥ 20 teeth than rural residents (83.2% vs 79.4%, $\chi^2 = 20.862$, $p = 0.000$); and a higher proportion of individuals with high education levels with ≥ 20 teeth compared to those with low education levels ($\chi^2 = 148.168$, $P = 0.000$). Logistic regression models showed that older adults who used toothpicks (OR = 3.37, 95% CI: 2.94–3.85), dental floss (OR = 1.93, 95%CI: 1.05–3.53), toothpaste (OR = 3.89, 95%CI: 3.14–4.83); and never smoked (OR = 1.43 95%CI: 1.20–1.70) were more likely to retain 20 or more natural teeth; whereas older adults who had a dental visit were less likely to retain 20 or more natural teeth (OR = 0.45, 95% CI: 0.39-052).

Conclusion

This study did not find the association between frequency of tooth brushing and tooth retention. This study demonstrates that improvement of oral hygiene and preventive dental care are key for good oral health.

Background

The World Health Organization (WHO) stated that oral health is a key indicator of overall health [1]. According to the United Nations [2], the populations of countries throughout the world are ageing rapidly. In 2017, the global population aged 60 years or over was approximately 962 million. Increasing number of studies have shown the associations between tooth loss and many health outcomes including hypertension, cardiovascular disease, Alzheimer's disease, diabetes and mortality [3–8]. Severe tooth loss will cause the economic burden of disease on the population. One study found that oral diseases cause 15 million disability adjusted life-years(DALYs)globally. For severe periodontitis, untreated tooth decay and severe tooth loss, the disability weights are 0.0079, 0.012, and 0.073, respectively [9]. Despite the advancements of the research findings in this area, oral health is still neglected as an element of healthy aging [10]. Poor oral health among older people has been evident worldwide, and the main challenges include high caries experience, high prevalence rates of periodontal disease, severe tooth loss, dry mouth and oral precancer/cancer [11].

Tooth loss is a key indicator of oral health. The number of natural teeth provides a quantitative estimate of the accumulated burden of experienced oral disease, with lower numbers often reflecting tooth extractions as a consequence of severe dental caries or periodontal disease [12]. Extensive tooth loss impairs chewing efficiency [13] and has a negative impact on HRQoL [14, 15]. For increasing prevalence of chronic diseases, the promotion of a healthy lifestyle has become an important public health practice for ageing populations [16]. Meanwhile, scholars and professionals pay more attention to controlling the occurrence of oral diseases through lifestyle, as well as the control of common risk factors for oral health and general health [17]. Healthy lifestyles comprise of patterns of behavior to protect, promote, or maintain health and oral health [18]. Data from the 4th Chinese National Oral Health Survey showed that oral health problems were common in Chinese adults; only 13.8% had complete dentition, 84.4% had dentition defects, and 1.8% were edentulous [19]. Effective interventions to prevent and control oral disease have demonstrated that the major factors in the decline of tooth loss are the prevention and control of dental caries and periodontal infections [20]. Prevention and control largely depend on a person's lifestyle and behavior, and relevant studies were mostly conducted in Western countries [21–25]. Few studies examined the associations between health behaviors and oral health among the Chinese population. There are also differences among oral health behaviors and practices. In China, the practice of using toothpicks is common, which is different from the West [26]. In this study, we examined the associations between health behaviors and teeth retention among Chinese older adults. Loss of 8 teeth (excluding wisdom teeth) is commonly considered as significant tooth loss [27]. The retention of at least 20 natural teeth helps maintain functional dentition throughout life, which will contribute to good oral health and quality of life [28]. Based on previous studies, we hypothesized that older adults who demonstrate better health behaviors are more likely to have at least 20 natural teeth than those with worse health behaviors.

Methods

Sampling method

Cross-sectional data from the 4th National Oral Health Survey of China conducted in 2015–2016 was used in this study. The survey included oral health status and health behaviors among participants. A multi-stage cluster sampling method was adopted for the identification of participants. All 31 provinces, autonomous regions and municipalities of Mainland China were included. First, two urban and two rural districts (defined by the National Bureau of Statistics of China) were selected in each province using a probability proportional to size (PPS) sampling. The local Centre for Disease Control and Prevention of each province was responsible for the identification of the districts. In total, 62 urban and 62 rural districts were selected. Then, 3 sub-districts (referred to as “streets” in urban districts and as “townships” in rural districts) were then selected using the PPS sampling method in each district. In brief, a total of 186 streets and 186 townships were selected. The following age groups: 35 to 44; 55 to 64; and 65 to 74 years, were consecutively recruited. There were 36 local residents with a male to female ratio of 1:1 [29]. The study sample included 9054 older adults aged between 55 and 74 years old.

Dental examination

Each participant was asked to undergo a professional oral examination. The examiners were dental professionals who had engaged in oral clinical work for more than 3 years and were qualified as dental practitioners; and the recorders were clinicians and/or nurses with relevant clinical experience. A disposable dental mirror, an intraoral light-emitting diode light and a ball-ended WHO Community Periodontal Index (CPI) probe were used in the examination. The diagnostic criteria were based on the WHO recommendations [30]. Before the on-site

investigation began, the investigation plan and the training of investigators were unified. The Kappa value of each examiner's caries status was above 0.8, and the periodontal pocket depth Kappa value was above 0.6. Periodontal health was defined as no bleeding, no periodontal pockets, and no loss of attachment greater than 3 mm of all remaining teeth. That means bleeding, periodontal pockets, and loss of attachment were all scored as 0.

Measures

Dependent variable: Many studies [31] have shown that to obtain satisfactory function and aesthetics, at least 20 natural teeth are required, so participants were categorized as those with at least 20 or more natural teeth and those with less than 20 natural teeth. In this study (0 = number of remaining teeth < 20, 1 = number of remaining teeth \geq 20).

In-person structured questionnaire interviews were conducted by trained interviewers. In this study, we included the following measures:

Demographics: gender, age, residence, educational level, occupation etc. Education level was divided into quartiles equal or less than 6 years (< 6), 7 to 9 years (7–9), 10 to 12 years (10–12), and equal or more than 13 years (\geq 13) of education. These quartiles represent elementary school, middle school, high school, and university respectively. Occupation was divided into white-collar and blue-collar. Heads of state organs, party and mass organizations, enterprises and institutions, professional and technical personnel, and military personnel were white-collar, the rest were defined as blue-collar. In addition, we obtained self-reported oral health and general health information through the questionnaire.

Health behaviors included frequency of tooth brushing, use of dental floss, use of toothpicks, toothpaste and fluoride toothpaste, dental visit, tooth scaling, smoking and alcohol intake. The frequency of tooth brushing was counted by the number of times of brushing each day. Use of dental floss, use of toothpicks, toothpaste and fluoride toothpaste, dental visit, tooth scaling, alcohol intake was analyzed using binary variables (Never/Ever). The codes of smoking was current smokers, never smokers, and ex-smokers.

Statistical analysis

The description of measurement data was expressed as mean \pm standard error (SE). A chi-square test was used for univariate analysis of general characteristics, health behaviors, self-reported oral health, self-reported general health, and number of remaining teeth. Multivariate Logistic regression was used to explore the association between health behaviors and the number of remaining teeth. The odds ratios (OR), 95% confidence intervals (CI), and the p-value were used to indicate the degree of association between the independent variable and the dependent variable. This study established three models to explore the association between health behaviors and the number of remaining teeth. Model 1 was Univariate logistic regression, Model 2 was Multivariate logistic regression analysis, Model 3 was Multivariate logistic regression analysis after adjusting age, gender, residence, region, education level, occupation, periodontal health, self-reported dental health, and self-reported general health. The statistical analysis of this study was performed using IBM SPSS statistics 19.0 software, using alpha level of 0.05.

Results

Table 1 shows participants characteristics by the number of remaining teeth. The average age was 64.4 ± 5.4 . The average number of remaining teeth in 9054 cases was 24.4 ± 7.8 . The percent of remaining teeth being greater

than or equal to 20 accounts was 81.3%. There were more urban residents(51.8%) with ≥ 20 teeth than rural(48.2%) ($\chi^2 = 20.862, P = 0.000$). As education levels increased, the proportion of participants in the > 20 teeth group increased while the < 20 teeth group decreased (all p-values and p for trends < 0.001).

Table 1
Participants general characteristics according to number of retention teeth

Variable	Category	No. of population	Ratio	Number of retention teeth < 20		Number of retention teeth ≥ 20		χ^2	P-Value
				n	%	n	%		
Age(yr)	55–64	4623	51.1	503	29.7	4120	56.0	379.840	0.000
	65–74	4431	48.9	1190	70.3	3241	44.0		
Gender	Male	4514	49.9	865	51.1	3649	49.6	1.273	0.135
	Female	4540	50.1	828	48.9	3712	50.4		
Residence	Urban	4587	50.7	773	45.7	3814	51.8	20.862	0.000
	Rural	4467	49.3	920	54.3	3547	48.2		
Region	Eastern	3196	35.3	598	35.3	2598	35.3	8.562	0.014
	Western	3565	39.4	709	41.9	2856	38.8		
	Central	2293	25.3	386	22.8	1907	25.9		
Education level (yrs)	≤ 6	4803	53.1	1116	65.9	3687	50.1	148.168	0.000
	7–9	2370	26.2	359	21.2	2011	27.3		
	10–12	1387	15.3	168	9.9	1219	16.6		
	13≤	494	5.5	50	3.0	444	6.0		
Occupation	Blue collar	8490	93.8	1605	94.8	6885	93.5	3.792	0.027
	White collar	564	6.2	88	5.2	476	6.5		
Periodontal health	No	8411	92.9	1330	78.6	7081	96.2	649.000	0.000
	Yes	643	7.1	363	21.4	280	3.8		
Self-reported oral health	Fair/poor	6734	74.4	1450	85.6	5284	71.8	138.801	0.000
	Good	2320	25.6	243	14.4	2077	28.2		
Self-reported general health	Fair/poor	5485	60.6	1067	63.0	4418	60.0	5.205	0.012
	Good	3569	39.4	626	37.0	2943	40.0		
Total		9054	100.0	1693	100.0	7361	100.0		

Table 2 presents the comparison results in health behaviors between participants who had more than 20 teeth and those who had less than 20 teeth. Participants had significant differences in the frequency of brushing, whether or not they used toothpicks, dental floss, toothpaste, fluoride toothpaste, smoking, drinking, and dental visits. Figure 1 shows the reasons of dental visits. Treatment rather than prevention was the major reason for dental visits, xx% reported the reason for the last dental visit was for treatment.

Table 2
The number of remaining teeth in Chinese old adults and their health behaviors

Variable	Category	No. of population	Ratio	Number of retention teeth < 20		Number of retention teeth ≥ 20		χ^2	P-Value
				n	%	n	%		
Toothbrushing frequency	< 1/day	1503	16.6	473	27.9	1030	14.0	193.501	0.000
	1/day	4802	53.0	782	46.2	4020	54.6		
	≥ 2/day	2749	30.4	438	25.9	2311	31.4		
Using tooth picks	Never	5029	55.5	1338	79.0	3691	50.1	465.202	0.000
	Ever	4025	44.5	355	21.0	3670	49.9		
Frequency of using dental floss	Never	8874	98.0	1680	99.2	7194	97.7	15.912	0.000
	Ever	180	2.0	13	0.8	167	2.3		
Using toothpaste	Never	704	7.8	352	20.8	352	4.8	491.963	0.000
	Ever	8350	92.2	1341	79.2	7009	95.2		
Fluoride toothpaste	Never	8063	89.1	1574	93.0	6489	88.2	32.769	0.000
	Ever	991	11.0	119	7.0	872	11.8		
Smoking	Current smokers	2316	25.6	481	28.4	1835	24.9	13.629	0.001
	Never	5606	61.9	982	58.0	4624	62.8		
	Ex-smokers	1132	12.5	230	13.6	902	12.3		
Drinking alcohol	Ever	2983	33.0	483	28.5	2500	34.0	18.394	0.000
	Never	6071	67.1	1210	71.5	4861	66.0		
Dental visit	Never	3008	33.2	394	23.3	2614	35.5	92.938	0.000
	Ever	6046	66.8	1299	76.7	4747	64.5		
Tooth scaling	Never	8792	97.1	1653	97.6	7139	97.0	2.090	0.171
	Ever	262	2.9	40	2.4	222	3.0		
Total		9054	100.0	1693	100.0	7361	100.0		

Table 3 shows the multivariate analysis of the association between oral health behaviors and number of teeth retained. In Model 1, univariate logistic regression shows that all of the health behaviors in this study were associated with the number of remaining teeth without controlling for any other variables. When adding all of the health behaviors in Model 2, each health behavior was still significantly associated with the number of remaining teeth. However, when adding age, gender, residence, region, education level, occupation, periodontal health, self-reported dental health, and self-reported general health in Model 3, the frequency of toothbrushing, the use of fluoride toothpaste, drinking and tooth scaling were no longer significantly associated with the number of remaining teeth. We only found that the use of toothpicks (OR = 3.37, 95% CI: 2.94–3.85), dental floss (OR = 1.93, 95%CI: 1.05–3.53), toothpaste (OR = 3.89, 95%CI: 3.14–4.83), smoking (OR = 1.43, 95%CI: 1.20–1.70), and dental visits (OR = 0.45, 95%CI: 0.39–0.52) were significantly associated with the number of remaining teeth.

Table 3

Multivariate analysis of health behaviors affecting the number of teeth retained in Chinese old adults

Variable	Category	retention teeth	Model1		Model2		Model 3	
			OR	95%CI	OR	95%CI	OR	95%CI
toothbrushing frequency	< 1/day	21.5 ± 9.7	1		1		1	
	1/day	24.9 ± 7.1	5.14 ^{***}	4.76–5.55	1.30 ^{**}	1.09–1.54	1.17	0.98–1.41
	≥ 2/day	24.9 ± 7.2	5.28 ^{***}	4.76–5.84	1.33 ^{**}	1.1–1.60	1.21	0.98–1.49
using tooth picks	Never	22.7 ± 9.0	1		1		1	
	Ever	26.4 ± 5.1	10.34 ^{***}	9.27–11.53	3.56 ^{***}	3.13–4.05	3.37 ^{***}	2.94–3.85
Using dental floss	Never	24.3 ± 7.8	1		1		1	
	Ever	26.4 ± 4.7	12.85 ^{***}	7.31–22.59	2.36 ^{**}	1.31–4.24	1.93 [*]	1.05–3.53
Using toothpaste	Never	17.0 ± 11.0	1		1		1	
	Ever	25.0 ± 7.1	5.23 ^{**}	4.93–5.54	4.78 ^{***}	3.95–5.78	3.89 ^{***}	3.14–4.83
Fluoride toothpaste	Never	24.2 ± 7.9	1		1		1	
	Ever	25.8 ± 6.1	7.33 ^{***}	6.05–8.88	1.42 ^{**}	1.15–1.75	1.18	0.94–1.47
Smoking	Current Smokers	23.8 ± 8.0	1		1		1	
	Never	24.6 ± 7.5	4.71 ^{***}	4.40–5.04	1.50 ^{***}	1.31–1.73	1.43 ^{***}	1.20–1.70
	Ex-smokers	24.0 ± 8.1	3.92 ^{***}	3.39–4.53	1.11	0.92–1.34	1.16	0.95–1.42
Drinking alcohol	Ever	25.0 ± 7.4	1		1		1	
* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$								
Model1: Univariate logistic regression								
Model2: Multivariate logistic regression analysis,								
Model3: Multivariate logistic regression analysis, Adjusted age, gender, residence, region, education level, occupation, periodontal health, Self-reported dental health, Self-reported general health								
FigureLegends:								

Variable	Category	retention teeth	Model1		Model2		Model 3	
			OR	95%CI	OR	95%CI	OR	95%CI
	Never	24.0 ± 7.9	2.26 ^{***}	2.19–2.33	0.85 ^{***}	0.77–0.93	0.93	0.81–1.06
Dental visit	Never	26.1 ± 7.1	1		1		1	
	Ever	23.5 ± 7.9	3.65 ^{***}	3.44–3.89	0.42 ^{***}	0.37–0.48	0.45 ^{***}	0.39–0.52
Tooth scaling	Never	24.3 ± 7.7	1		1		1	
	Ever	25.0 ± 7.8	5.55 ^{***}	3.96–7.77	1.25	0.87–1.79	1.10	0.75–1.61
* <i>p</i> < 0.05 ** <i>p</i> < 0.01 *** <i>p</i> < 0.001								
Model1: Univariate logistic regression								
Model2: Multivariate logistic regression analysis,								
Model3: Multivariate logistic regression analysis, Adjusted age, gender, residence, region, education level, occupation, periodontal health, Self-reported dental health, Self-reported general health								
FigureLegends:								

Discussion

By using the 4th Chinese National Oral Health Survey, the study aimed to investigate the association between tooth retention and health behaviors among Chinese older adults. We found that participants who had more than 20 teeth were more likely to have healthy behaviors than those who had less than 20 teeth. Moreover, we found that the use of toothpicks, dental floss, toothpaste, smoking, and dental visits were significantly associated with the number of remaining teeth. The frequency of brushing was not significantly related to the number of remaining teeth in adults, which was different from the foreign study that showed that higher frequency of toothbrushing was associated with more remaining teeth [32]. This may be because respondents did not brush their teeth properly and/or the frequency of toothbrush was low [33], therefore, their oral health status is not ideal. Some Chinese scholars have found that Chinese adults' attention to oral health is behind developed countries, good oral hygiene behaviors were not formed [34]. This may explain why the frequency of toothbrushing was not associated with the number of remaining teeth in China. This suggests that when we want to enhance people's awareness of oral health, especially for those over aged 55 or older, proper brushing techniques should be pointed out. The use of toothpicks, dental floss, and toothpaste is conducive to the retention of teeth. As toothpicks and dental floss are used to get rid of food debris between teeth, toothpaste as a cleaning agent can better help clean teeth and remove plaque and slow down the accumulation of dental calculus. Good oral hygiene can effectively keep or improve periodontal health, as periodontitis is mainly accountable for tooth loss in adults.

Older adults who never smoked were more likely to have more than 20 remaining teeth than those who were current smokers. Tobacco contains a variety of harmful substances that can directly stimulate periodontal tissues

or enter the bloodstream, causing periodontal damage. Azodo's research on Nigeria residents' smoking and oral health behaviors found that smokers had poorer subjectively rated periodontal health and poorer oral selfcare behavior [35] which is similar to our study.

People who had more dental visits were less likely to have more than 20 remaining teeth. This may be because Chinese adults seek dental services for treatment rather than prevention and patients who seek dental consultations have poor oral conditions [36], which is different from what is seen in studies from developed countries [37]. Secondly, Chinese scholars have found that 28% of Chinese older adults have no remaining teeth and that only 19% had dental care in the past year [38]. This shows that people with dental problems are not active in seeking dental care. The third reason is that the treatment is not performed at the optimal time, resulting in pain and lack of other treatment options as the main reasons for tooth extraction [39]. Murakami and other scholars reported that once oral diseases occur, due to lack of dental insurance and costly treatments, older adults are reluctant to seek timely dental treatment [40]. This finding indicates that increase access to dental care is critical for improving timely dental care and regular dental visits. At the same time advocate restoration projects for missing teeth to maintain oral function.

The average life expectancy of a Chinese resident is increasing every year. According to the data released by National Health Commission of the People's Republic of China [41], the average life expectancy of a Chinese resident in 2018 was 77.0 years. Multidimensional improvement of the quality of life of older adults has become a research priority [11]. However, oral health is an important part of general health, and oral diseases such as missing teeth, are inextricably linked to the occurrence of other diseases [42]. Based on this, it is necessary to start with oral hygiene behaviors to improve the life of natural teeth and maintain oral function, therefore improving the overall health and quality of life of older adults. Health administrative departments should continue to promote the construction of medical associations when implementing the 'Healthy oral action plan' (2019–2025) [43]; formulate regional oral health development plans for older adults in different regions, especially for those from rural areas; and provide quantitative oral health funding subsidies to low-income people to improve access to health care, promote the transformations of disease treatments in health management [44]. To help residents to acknowledge better oral health behaviors and save more teeth, their communities should increase the accessibility of oral health education to instruct residents to keep or develop a healthy lifestyle.

There are several limitations in this study. First, due to the cross-sectional research design of this study, we cannot identify causal relationships between health behaviors and the number of remaining teeth. Second, there may have bias in the oral health related oral hygiene behavior due to self-reported nature of the study. partial dependent variable, because it was self-reported by the participants. However, this study also has strengths. We used a representative sample of the whole Chinese population using the 4th Chinese National Oral Health Survey. This oral health survey is the only large national study that includes clinical examinations of oral health in older adults. Also, we controlled for both the subjective and objective oral health statuses in this study.

In conclusion, the use of toothpicks, dental floss, and toothpaste were protective factors to the number of remaining teeth, whereas smoking and dental visits were risk factors to the number of remaining teeth among Chinese adults. It is important to promote proper health behaviors to prevent tooth loss. Future studies are needed to develop interventions to help people retain more teeth.

Abbreviations

The World Health Organization (WHO)

Probability proportional to size (PPS)

Community Periodontal Index (CPI)

Standard Error (SE)

Odds Ratios (OR)

Confidence Intervals (CI)

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ethics Committee of the Chinese Stomatological Association (Approval no. 2014003) prior to the implementation of the study. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by “Scientific Research Fund of National Health Commission of the People’s Republic of China (201502002)”.

Authors' contributions

X.Y. Ou and L.W. Zeng wrote the paper. Y.X. Zeng and Y.L. Pei collected the data and revised the manuscript. X.J. Zhang and W Wu conducted the statistical analysis. SS and B Wu modified the paper and designed the study concepts. All authors read and approved the final manuscript.

Acknowledgments

The survey is supported by the technical group of the 4th National Oral Health Survey of China. The authors would like to express their gratitude to the investigative staff. They would also like to thank the participants in this study.

References

1. World Health Organization. Oral Health [on-line]. Available at https://www.who.int/health-topics/oral-health/#tab=tab_1.
2. United Nations. World Population Ageing 2017. New York: Department of Economic and Social Affairs, Population Division, 2017.
3. Singh A, Gupta A, Peres MA, Watt RG, Tsakos G, Mathur MR. Association between tooth loss and hypertension among a primarily rural middle aged and older Indian adult population. *J Public Health Dent.* 2016 Jun;76(3):198–205.
4. Kossioni AE. The Association of Poor Oral Health Parameters with Malnutrition in Older Adults: A Review Considering the Potential Implications for Cognitive Impairment. *Nutrients.* 2018 Nov 8;10(11):1709.
5. Liccardo D, Cannavo A, Spagnuolo G, Ferrara N, Cittadini A, Rengo C, Rengo G. Periodontal Disease: A Risk Factor for Diabetes and Cardiovascular Disease. *Int J Mol Sci.* 2019 Mar 20;20(6):1414.
6. Pietropaoli D, Del Pinto R, Ferri C, Wright JT Jr, Giannoni M, Ortu E, Monaco A. Poor Oral Health and Blood Pressure Control Among US Hypertensive Adults. *Hypertension.* 2018 Dec;72(6):1365–1373.
7. Takeuchi K, Ohara T, Furuta M, Takeshita T, Shibata Y, Hata J, Yoshida D, Yamashita Y, Ninomiya T. Tooth Loss and Risk of Dementia in the Community: the Hisayama Study. *J Am Geriatr Soc.* 2017 May;65(5):e95-e100.
8. Lee HJ, Choi EK, Park JB, Han KD, Oh S. Tooth Loss Predicts Myocardial Infarction, Heart Failure, Stroke, and Death. *J Dent Res.* 2019 Feb;98(2):164–170.
9. Marcenes W, Kassebaum NJ, Bernabé E, Flaxman A, Naghavi M, Lopez A, Murray CJ. Global burden of oral conditions in 1990–2010: a systematic analysis. *J Dent Res.* 2013 Jul;92(7):592–7.
10. World Health World Health Organization. World Report on Ageing and Health. Geneva: World Health Organization, 2015 [on-line]. Available at [http://apps.who.int/iris/bitstream/10665/186463/1/9789240694811\\$4eng.pdf](http://apps.who.int/iris/bitstream/10665/186463/1/9789240694811$4eng.pdf). Accessed July 11, 2017
11. Petersen PE, Ogawa H. Promoting Oral Health and Quality of Life of Older People - The Need for Public Health Action. *Oral Health Prev Dent.* 2018;16(2):113–124.
12. Watt RG, Sheiham A. Integrating the common risk factor approach into a social determinants framework. *Community Dent Oral Epidemiol.* 2012 Aug;40(4):289–96.
13. Sarita PT, Witter DJ, Kreulen CM, Van't Hof MA, Creugers NH. Chewing ability of subjects with shortened dental arches. *Community Dent Oral Epidemiol.* 2003 Oct;31(5):328–34.
14. Haag DG, Peres KG, Balasubramanian M, Brennan DS. Oral Conditions and Health-Related Quality of Life: A Systematic Review. *J Dent Res.* 2017 Jul;96(8):864–874.
15. Tan H, Peres KG, Peres MA. Retention of Teeth and Oral Health-Related Quality of Life. *J Dent Res.* 2016 95(12):1350–1357.
16. Åström AN, Gülcan F, Ekbäck G, Ordell S. Long-term healthy lifestyle patterns and tooth loss studied in a Swedish cohort of middle-aged and older people. *Int J Dent Hyg.* 2015 Nov;13(4):292–300.
17. Feng XP. Oral preventive medicine, People's Health Publishing House, Beijing, vol. 7, 2020, 14–16.
18. Abel T. Measuring health lifestyles in a comparative analysis: theoretical issues and empirical findings. *Soc Sci Med.* 1991;32(8):899–908.

19. Guo J, Ban JH, Li G, Wang X, Feng XP, Tai BJ, Hu Y, Lin HC, Wang B, Si Y, Wang CX, Rong WS, Wang WJ, Zheng SG, Liu XN, Wang SC. Status of Tooth Loss and Denture Restoration in Chinese Adult Population: Findings from the 4th National Oral Health Survey. *Chin J Dent Res.* 2018;21(4):249–257.
20. Griffin SO, Jones JA, Brunson D, Griffin PM, Bailey WD. Burden of oral disease among older adults and implications for public health priorities. *Am J Public Health.* 2012 Mar;102(3):411–8.
21. Burt, Eklund. Dentistry, Dental Practice, and the Community. *Journal of Prosthodontics.* 2010 9:113–114.
22. Gorsuch MM, Sanders SG, Wu B. Tooth loss in Appalachia and the Mississippi delta relative to other regions in the United States, 1999–2010. *Am J Public Health.* 2014 May;104(5):e85-91.
23. Wu B, Hybels C, Liang J, Landerman L, Plassman B. Social stratification and tooth loss among middle-aged and older Americans from 1988 to 2004. *Community Dent Oral Epidemiol.* 2014 Dec;42(6):495–502.
24. Luo H, Pan W, Sloan F, Feinglos M, Wu B. Forty-Year Trends in Tooth Loss Among American Adults With and Without Diabetes Mellitus: An Age-Period-Cohort Analysis. *Prev Chronic Dis.* 2015 Dec 3;12:E211.
25. Li J, Xu H, Pan W, Wu B. Association between tooth loss and cognitive decline: A 13-year longitudinal study of Chinese older adults. *PLoS One.* 2017 Feb 3;12(2):e0171404.
26. Sun HY, Jiang H, Du MQ, Wang X, Feng XP, Hu Y, Lin HC, Wang B, Si Y, Wang CX, Zheng SG, Liu XN, Rong WS, Wan WJ, Tai BJ. The Prevalence and Associated Factors of Periodontal Disease among 35 to 44-year-old Chinese Adults in the 4th National Oral Health Survey. *Chin J Dent Res.* 2018;21(4):241–247.
27. Parker ML, Thornton-Evans G, Wei L, Griffin SO. Prevalence of and Changes in Tooth Loss Among Adults Aged ≥ 50 Years with Selected Chronic Conditions - United States, 1999–2004 and 2011–2016. *MMWR Morb Mortal Wkly Rep.* 2020 May 29;69(21):641–646.
28. Petersen PE, Yamamoto T. Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol.* 2005 33(2):81–92.
29. Lu HX, Tao DY, Lo ECM, Li R, Wang X, Tai BJ, Hu Y, Lin HC, Wang B, Si Y, Wang CX, Zheng SG, Liu XN, Rong WS, Wang WJ, Feng XP. The 4th National Oral Health Survey in the Mainland of China: Background and Methodology. *Chin J Dent Res.* 2018;21(3):161–165.
30. Bala SV, Appukuttan D, Subramaniam S, Prakash PSG, Cholan PK, Victor DJ. Association of Receptor for advanced glycation end products G82S polymorphism with chronic periodontitis in type II diabetic and non-diabetic South Indians. *Gene.* 2019 Aug 5;708:30–37.
31. Kim YH, Han K, Vu D, Cho KH, Lee SH. Number of remaining teeth and its association with socioeconomic status in South Korean adults: Data from the Korean National Health and Nutrition Examination Survey 2012–2013. *PLoS One.* 2018 May 10;13(5):e0196594.
32. Avenetti D, Lee HH, Pugach O, Rosales G, Sandoval A, Martin M. Tooth Brushing Behaviors and Fluoridated Toothpaste Use Among Children Younger Than Three Years Old in Chicago. *J Dent Child (Chic).* 2020 Jan 15;87(1):31–38.
33. Xu W, Lu H X, Li C R, et al. Dental caries status and risk indicators of dental caries among middle-aged adults in Shanghai, China. *Journal of Dental Sciences,* 2014, 9(2):151–157.
34. WANG CX, BAO HL, SHEN T et al. The status and distributions of three preventive oral health behaviors among adults in China. *Chinese Journal of Health Education.* 2013,29(06):489–491 + 506.
35. Azodo CC, Umoh A. Dental caries, missing teeth, and oral health behavior among smokers. *New Nigerian Journal of Clinical Research.* 2020 9(15):7.

36. Qu X, Qi X, Wu B. Disparities in Dental Service Utilization among Adults in Chinese Megacities: Do Health Insurance and City of Residence Matter? *Int J Environ Res Public Health*. 2020 Sep 19;17(18):6851.
37. Aron, Naimi-Akbar, Barbro et al. Attitudes and lifestyle factors in relation to oral health and dental care in Sweden: a cross-sectional study. *Acta Odontol Scand*. 2019 77(4):282–289.
38. Li C, Yao N A. Socio-economic disparities in dental health and dental care utilisation among older Chinese. *International Dental Journal*. 2020(1):67–75.
39. Junior MFS, Sousa ACCD, Batista MJ et al. Oral health condition and reasons for tooth extraction among an adult population (20–64 years old). *Cien Saude Colet*. 2017 22(8):2693–2702.
40. Murakami K, Hashimoto H. Wealth-related versus income-related inequalities in dental care use under universal public coverage: A panel data analysis of the Japanese Study of Aging and Retirement. *BMC Public Health*. 2016 Jan 12;16:24.
41. China planning development and Information Technology Department. 2018 statistic-al bulletin of China's health development [EB/OL]. [2019-05-22].
<http://www.nhc.gov.cn/guihuaxxs/s10748/201905/9b8d52727cf346049de8acce25ffcbd0.shtml>
42. Sabharwal A, Gomes-Filho IS, Stellrecht E, Scannapieco FA. Role of periodontal therapy in management of common complex systemic diseases and conditions: An update. *Periodontol 2000*. 2018 Oct;78(1):212–226.
43. National health Commission of the people's Republic of China. Healthy oral actionplan (2019–2025) [EB/OL]. [2019-02-16]. http://www.gov.cn/xinwen/2019-02/16/content_5366239.htm
44. Nasseh K, Vujcic M. The impact of the affordable care act's Medicaid expansion on dental care use through 2016. *J Public Health Dent*. 2017 77(4):290–294.

Figures

Reasons for dental visit

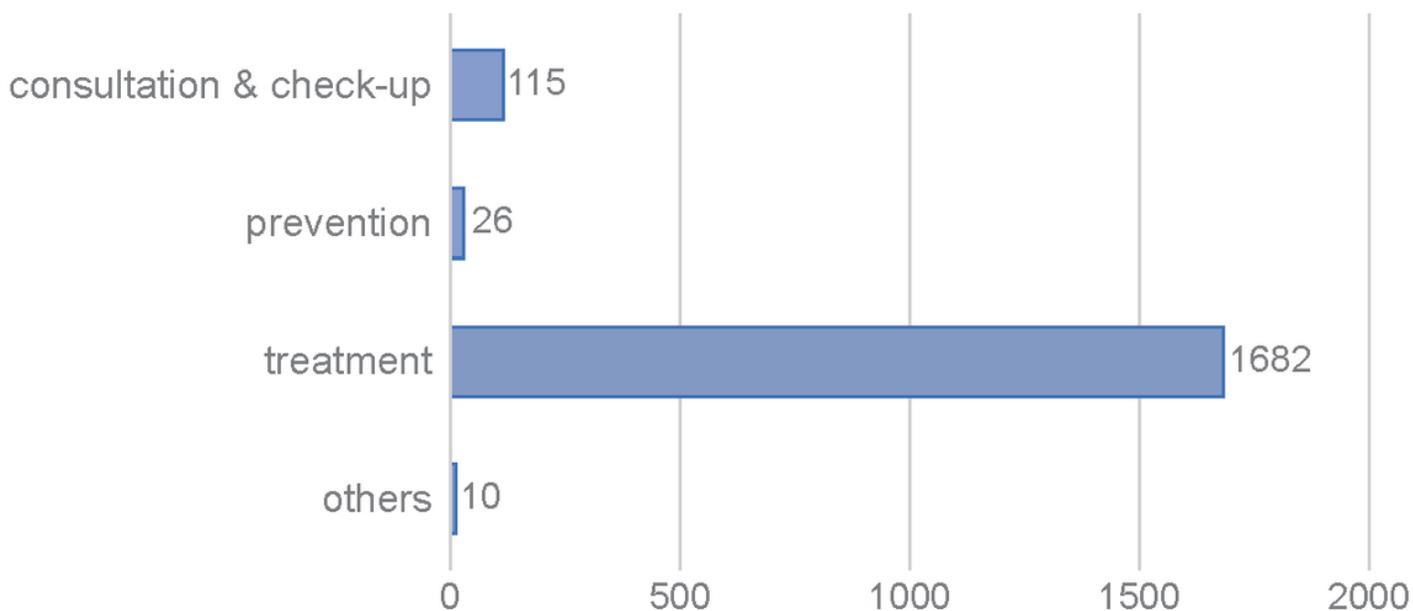


Figure 1

reasons for dental visit (N =1833)