How Root Caries Differs between Middle-aged People and the Elderly: Findings from the 4th National Oral Health Survey of China

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Objective: *To investigate the differences in distribution of root caries and related factors between middle-aged and elderly people in China.*

Methods: *In this cross-sectional study, a multistage, cluster strategy was used to recruit 4,410 participants (2,197 males and 2,213 females) aged 35 to 44 years and 4,431 participants (2,222 males and 2,209 females) aged 65 to 74 years from all 31 provinces, autonomous regions and municipalities of the mainland of China. The survey was conducted according to the basic methods proposed by the World Health Organization (WHO). Sociodemographic information, oral health behaviour, attitude and knowledge, history of dental prophylaxis and general health condition were collected with a closed questionnaire.*

Results: *A great increase in the occurrence of root caries in Chinese adults from 35 to 44-year-old to 65 to 74-year-olds, with the prevalence (DFR ≥ 1) from 25.4% to 61.9% and with the mean DFR score from 0.54 ± 1.34 to 2.63 ± 3.75. Filling rates were also very low, only 1.8% and 3.0%, respectively. Females and residents of rural areas were more likely to suffer from root caries. In both the middle-aged group and the elderly group, root caries related to gender, education level, sweet food/drinks consumption, oral health knowledge and status of root surface explosion. In 35 to 44 year olds, toothbrushing is a significant protection factor (OR = 0.88, 95%CI 0.81 ~ 0.96), while using toothpicks is a risk factor (OR = 1.06, 95%CI 1.02 ~ 1.10). In 65 to 74 year olds, not having dental had scaling in the past 12 months is a risk factor (OR = 1.66, 95%CI 1.09 ~ 2.53).*

Conclusion: *Root caries among middle-aged people and elderly people in China have different risk factors and need more attention in future research to develop proper prevention.*

Key words: *China, elders, middle-aged, risk factor, root caries, the 4th National Oral Health Survey*

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In recent decades there has been increased attention towards root caries[1]. According to the 6th National Population Census[2], the 60+ group in China accounts for 13.26% of the population. With the acceleration of

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the ageing process and the arrival of the ageing society, the oral health problems of the older groups need more attention. Longitudinal data from multiple countries indicated similar increases in tooth retention[3], which is associated with an increased risk for root caries, which is a debilitating disease[4].

Older adults will have a richer history of oral disease such as coronal caries and periodontitis and their treatment poses a risk of developing further chronic destructive conditions. Destruction of the periodontal tissues, including gingival recession, can be a part of the normal ageing process. Gingival recession puts the exposed root surfaces of teeth at risk of developing root caries[5]. As a consequence of ageing, root caries is expected to become a more significant oral health problem in middle-aged and elderly people.

A considerable percentage of adults is affected by root caries. The prevalence of root caries lesions reported by various studies ranged from 9.8% to 71%[6,7]. In the 3rd National Oral Health Survey of China in 2005, the prevalence of root caries was 32.7% in 35 to 44 year olds and 63.6% in 65 to 74 year olds, and the prevalence of untreated root caries was 97.2% and 98.1% respectively[8]. Untreated root caries lesions reflect experience of the disease and a lack of access to dental services.

The picture of root caries described from the 3rd National Survey of Oral Health in China in 2005 is incomplete. In the past 10 years, there has been rapid growth in various aspects in China, including dietary structure, nutritional status and psychosocial development[9]. Furthermore, awareness and affordability of oral health has been improved. Moreover, the government has increased activity aimed at preventing and curing oral disease. All of these factors influence oral health status.

Root caries is a complex disease that relates to multiple factors. A recent systematic review examined risk models[10] and identified the following factors as important correlates of root caries: sociodemographic (e.g. age, gender, race/ethnicity), systemic health (e.g. dementia), intraoral status (e.g. number of teeth, plaque, bacterial species, tooth decay, periodontal attachment loss, gingival recession, salivary flow), and behavioural habits (e.g. dental care use, toothbrushing, smoking). Subsequent studies have confirmed findings from the systematic review[11-13] and found additional factors related to root caries: poor self-reported oral health[14], living in rural areas[15], etc. Although age is an unequivocal risk factor for root caries in adults[16], few investigators to date have examined root caries risk factors cross-referencing for middle-aged and older adults.

Therefore, the aims of this study were to describe the prevalence and the severity of root caries among a representative sample of Chinese adults and explore the associations with socio-demographic, socio-economic, clinical and behavioural factors that influence root caries in these populations. The differences and similarities of the 35 to 44-year-old age group and the 65 to 74-year-old age group were also anticipated to be revealed. We expect to use these findings to develop relevant policies and interventions aimed at preventing root caries in adults.

Materials and methods

The study was revised and approved by the Stomatological Ethics Committee of Chinese Stomatological Association (Approval no. 2014-003).

Study design and sample selection

The retrospective survey was based on a cross-sectional national survey conducted between October 2015 and September 2016.

To obtain a representative sample of the national population in China, participants were chosen from all 31 provinces, autonomous regions and municipalities of the mainland of China. The probability proportional to size (PPS) method was used in the 4th National Oral Health Survey in China to make the sampling more credible.

Sample selection followed a multistage, cluster strategy. In the first stage, two districts and two counties of each province, autonomous region and municipality of the mainland of China were chosen randomly by the PPS method. In the second stage, three neighbourhood committees in each district and three village committees in each county were selected randomly. In the third stage, participants were recruited by quota sampling. The sample size was calculated by the formula:

$$n = \text{deff}\ \frac{\mu^2_{\alpha}\, p\,(1-p)}{\delta^2}$$

The design efficiency deff = 4.5, the level of confidence $\mu\alpha = 1.96$, the acceptable error $\delta = 10\%p$, according to the Third National Oral Health Survey in China, the prevalence of caries in people aged 65 to 74 years and 35 to 44 years were $P = 86.0\%$. Considering the non-response rate (20%) and stratification factors, a total of 4,410 35 to 44 year olds and 4431 65 to 74 year olds completed the survey.

Table 1 Variables related to dental caries.

Variable		Description
Gender	Male	
	Female	
Resident areas		
	Urban	
	Rural	
Educational level		
	Low	1/3 participants with the lowest level of education, most of whom are illiterate
	Medium	1/3 participants with a medium level of education
	High	1/3 participants with a high level of education
Income level		
	Low	1/3 participants with the lowest annual income, less than ¥5000/person
	Medium	1/3 participants with a medium annual income, ¥5000 to ¥15000/person
	High	1/3 participants with the highest annual income, more than ¥15000/person
Frequency of dessert consumption		
	High	Consuming sweet food or drinks ≥ twice a day
	Low	Consuming sweet food or drinks < twice a day
Frequency of toothbrushing		
	High	≥ Once a day
	Low	< Once a day
Frequency of toothpick use		
	High	≥ Once a day
	Low	< Once a day
Oral health attitude		
	Positive	Correct ≥ 2 questions out of 4
	Passive	Correct < 2 questions out of 4
Oral health knowledge		
	Low	Correct < 4 questions out of 8
	High	Correct ≥ 4 questions out of 8

Data collection

Data were collected through an oral examination conducted by trained and accredited dental practitioners. According to the diagnostic standard proposed by the WHO[17], 32 teeth were taken into consideration. The status of dental roots was examined under artificial light with a plane dental mirror and Community Periodontal Index (CPI) probe. Exposed root with no caries, decayed root, filled root with caries and unexposed root were judged and recorded. Root caries was recorded as present when a lesion felt soft or leathery on probing with the CPI probe. If a single caries lesion effected both crown and root including residual root, no matter where the caries originated, coronal and root caries were both recorded as present. The kappa values of the examiners were both 0.97.

A structured questionnaire including socioeconomic and demographic information, knowledge and attitude of oral health, and oral health-promoting behaviours were recorded by trained recorders in face-to-face interviews.

Data analysis

DR (decayed teeth with root caries) and FR (filled root without any primary or secondary caries) were employed to assess tooth status. Decayed and filled teeth (DFR – the sum of DR and FR) were also calculated. The prevalence of dental caries was counted as the percentage of respondents who suffered from root caries to the total number of respondents. The filling rate reflects the workload of caries filling and the level of oral health care. This index was calculated by the following formulate: (total number of FR/ total number of DR and FR) × 100%. Root caries index (RCI) was calculated in different gender and population group to show the rate of teeth with root caries compared with teeth with exposed root surface (RCI = number of teeth with root caries lesions/number of teeth with gingival recession × 100%).

For analysis of results, the sample was stratified in relation to the presence of teeth, in addition to socio-demographic variables such as gender, residential area, level of education, annual household income, and individual features – smoking, toothbrushing and use of toothpicks habits, dental appointments, attitude and knowledge level towards oral health, and general health (Table 1).

A descriptive analysis was used to analyse the severity of root decay. Multivariate binary logistic regression analysis was used to identify risk factors for high root caries.

The prevalence of dental caries and the filling rate are reported as percentages and compared by Pearson's χ^2 analysis.

Statistical analyses were performed by SPSS Statistics v. 19.0 (IBM, Armonk, NY, USA). $P < 0.05$ was considered to be significant.

Results

The root caries prevalence was 25.4% (DFR ≥ 1) in the 35 to 44 years age range. The mean DFR score was 0.57 ± 1.48, the mean DR score was 0.56 ± 1.46, and the mean FR score was 0.01 ± 0.22. The root caries prevalence was 61.9% (DFR ≥ 1) and the mean DFR score was 2.64 ± 3.76 in the 65 to 74 years age group. In both 35 to 44-year old group and 65 to 74 years group, female and elder people living rural areas would have higher prevalence of root caries. These differences are at a significant level, as shown in Table 2

Figure 1 describes the distribution of decay and filled root on all 32 teeth in the mandibular and maxillary arches. The number of subjects was very close in both the 35 to 44 and the 65 to 74-year-old groups and 32 teeth were examined and recorded for every subject.

Table 2 Root caries status by residential areas and gender in the 35 to 44 and 65 to 74-year-old group.

Age group	Variables	No.	Prevalence (DFR ≥ 1)	DRoot			FRoot		DFRoot	
				x	s		x	s	x	s
35-44	Urban	2,239	21.9%	0.45	1.33		0.02	0.28	0.44	1.39
	Rural	2,171	29.1 %	0.67	1.57		0.01	0.12	0.68	1.58
	Male	2,197	22.5 %	0.48	1.36		0.01	0.13	0.49	1.37
	Female	2,213	28.3 %	0.64	1.55		0.02	0.27	0.66	1.58
	Total	**4,410**	**25.4 %**	**0.56**	**1.46**		**0.01**	**0.22**	**0.57**	**1.48**
65-74	Urban	2,247	60.1 %	2.23	3.35		0.14	0.82	2.37	3.44
	Rural	2,184	63.9 %	2.90	4.04		0.03	0.25	2.93	4.04
	Male	2,222	59.2 %	2.36	3.50		0.08	0.57	2.44	3.54
	Female	2,209	64.7 %	2.76	3.92		0.09	0.66	2.85	3.95
	Total	**4,431**	**61.9 %**	**2.56**	**3.72**		**0.09**	**0.61**	**2.64**	**3.76**

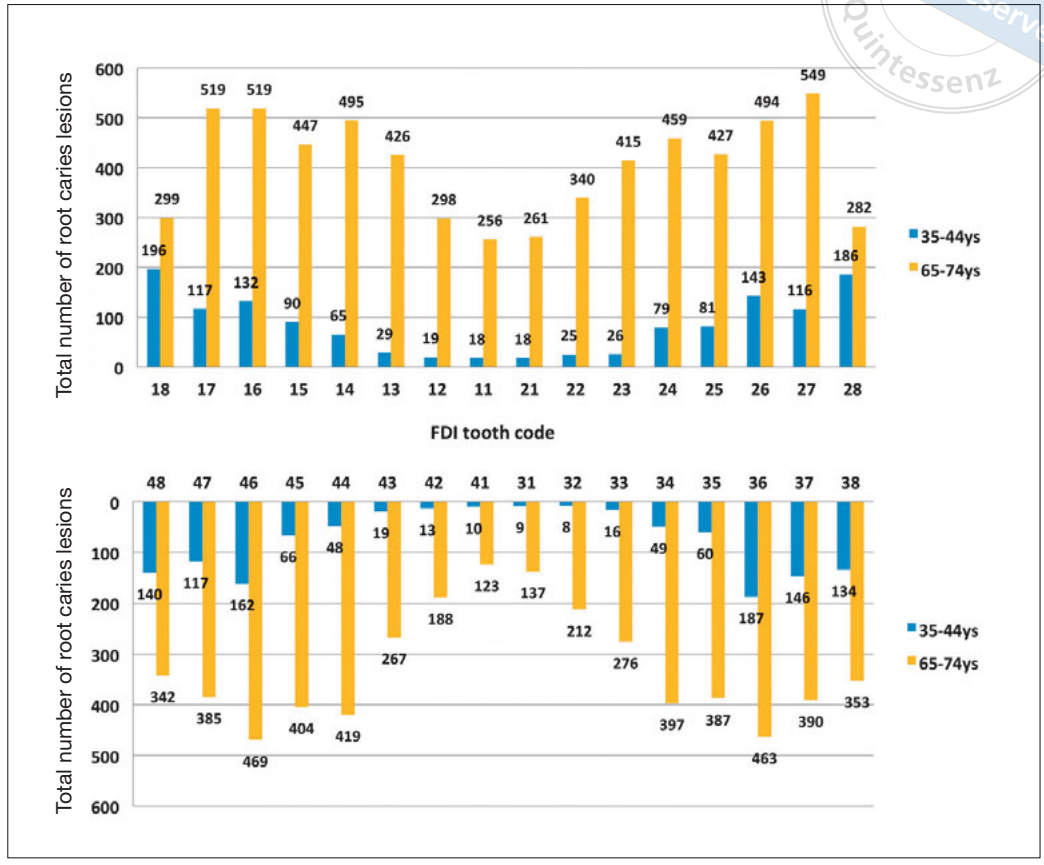

Fig 1 Relation of root caries and tooth position in adults and the elderly.

Those numbers in Figure 1, which are the sum of root caries on each position for all subjects, are strictly comparable. In the middle-aged group it was clearly shown that the root surface caries was mostly concentrated in the posterior teeth. Not only did the number of lesions per tooth increase significantly with age in the elderly group compared with the middle age group, but the ratio of anterior teeth and bicuspid teeth was no less than that of posterior teeth.

Exposed root surfaces result from gingival recession and are supposed to be at higher risk. And RCI is used to outline the activities of root caries lesions. Table 3 presents different RCI according to different variables. It showed that females, rural residents and elderly people have a higher RCI index.

In both groups there are common risk factors: being female, having sweet food or drinks more than twice a day and exposed root surfaces. There are some common protective factors: high education level and high oral health knowledge level. In the 35 to 44-year-old group, high frequency of toothbrushing is a significant protection factor (OR = 0.88, 95%CI 0.81 ~ 0.96) while using toothpicks is a risk factor (OR = 1.06, 95 CI% 1.02 ~ 1.10). In the 65 to 74 year-old-group, those people who have not had scaling during the previous 12 months were at risk (OR = 1.66, 95%CI 1.09 ~ 2.53) (Table 4).

Discussion

Root surface caries is one of the significant oral health problems in adults, especially in elderly people[18,19]. In this national cross-sectional survey in 2015, it is revealed that a great increase in root caries occurrence in Chinese adults from 35 to 44-year-olds to 65 to 74-year-olds, with the prevalence (DFR ≥ 1) from 25.4% to 61.9% and with the mean DFR score was from 0.54 to 2.63. Compared with the results in the 3rd National Oral Health Survey of China in 2005, the prevalence of root caries decreases a lot in 35 to 44-year-old subjects (from 32.7%, 0.75 to 25.4%, 0.54) and less in 65 to 74-year-olds (from 63.6%, 2.74 to 61.9%, 2.63). Considering an increase in the number of teeth retained in the mouth, the measures of oral health promotion take effects in the past 10 years. In spite of this, the filling rates were very low, only 1.8% and 3.0%, respectively.

Table 3 RCI according to different variables.

Age group	Variables	Number of residual teeth	Number of exposed root	Rate of exposed root to residual teeth	Mean DFR	RCI
35-44	Male	29.69	10.99	37.3%	0.49	10.8%
	Female	29.50	9.07	31.0%	0.66	17.3%
	Urban	29.60	9.41	32.0%	0.47	12.6%
	Rural	29.59	10.67	36.4%	0.68	15.3%
	Total	**29.60**	**10.03**	**34.2%**	**0.57**	**14.0%**
65-74	Male	23.56	15.01	68.8%	2.44	21.6%
	Female	23.54	13.65	63.1%	2.85	27.5%
	Urban	23.92	14.36	64.3%	2.37	22.6%
	Rural	23.17	14.31	67.7%	2.93	26.6%
	Total	**23.55**	**14.33**	**66.0%**	**2.64**	**24.5%**

Table 4 Multivariate binary logistic regression analysis of root caries in the middle-aged and elderly groups.

	35-44 years				65-74 years			
	P	OR	95% CI		P	OR	95% CI	
Female	0.01	1.30	1.08	1.57	0.02	1.22	1.04	1.44
Rural residents	0.56	1.05	0.90	1.22	0.77	1.02	0.89	1.17
High educational level	0.00	0.63	0.56	0.71	0.00	0.81	0.74	0.89
High sweet food or drink consumption	0.00	1.05	1.02	1.07	0.04	1.02	1.00	1.05
High frequency of toothbrushing	0.00	0.88	0.81	0.96	0.58	0.99	0.94	1.04
High frequency of toothpick use	0.00	1.06	1.02	1.10	0.21	0.98	0.95	1.01
Without scaling in past 12 months	0.17	1.23	0.92	1.65	0.02	1.66	1.09	2.53
Positive attitude to oral health	0.63	1.02	0.94	1.12	0.94	1.00	0.93	1.07
High scores in oral health knowledge	0.00	0.92	0.88	0.96	0.02	0.95	0.92	0.99
Without diagnosed choric diseases	0.56	1.05	0.89	1.25	0.30	0.93	0.82	1.06
Annual household income	0.05	0.96	0.93	1.00	0.60	1.00	1.00	1.00
Exposed root surfaces	0.00	1.03	1.03	1.04	0.00	1.05	1.05	1.06
Smoking	0.08	0.84	0.68	1.02	0.53	0.95	0.81	1.12

In this study, the root caries was measured by counting the number of roots that were decayed or filled (DF-Root). However, the diagnostic criteria of root caries are a little different from criteria recommended by the WHO and a residual root was recorded both as coronal and root caries. In fact, estimating the prevalence and incidence of root caries can be challenging as loss of teeth confounds the data and the diagnostic criteria for root caries differ between studies. There are a few published studies reporting wide ranges for the prevalence of root caries (25% to 100%). It is difficult and inappropriate to produce any definitive figures on the global prevalence and to compare with other countries. But it is believed that along with the social ageing process root disease will still put a serious burden on the population's health.

Elderly adults from urban areas had a lower mean DFR score and a higher FR score than those living in rural areas (even though some of them are not significant). But in the middle-aged group, residential area type contributes less in terms of the mean DFR score, and the mean FR score is similar between urban and rural areas. This finding shows that elderly people living in rural areas tend to receive less dental treatment compared with their counterparts living in urban areas. The middle-aged group is more likely to use dental services when they need them, regardless of where they live. This finding supports a previously reported study showing that people living in non-metropolitan areas are less likely to have used dental services in the previous 12 months.

The precondition for the occurrence of root caries is root surface exposure due to gingival recession, which reflects periodontal health. From the middle-age group to the elderly group, the number of teeth with root carious lesions increased four times, from 0.5 per person to 2.6. The prevalence of people affected increased from 25.4% to 61.9%. It was shown in Table 2, although the middle-aged group and the elderly group had 29 and 23 natural teeth respectively, the composition of root surface exposure increased from 14% to 25%. The changing trend of the above indicators is basically consistent. In multivariate analysis, the exposed root is a meaningful predictor for both the middle-aged and older group (OR 1.03, 95% CI 1.03 to 1.05; OR 1.05, 95% CI 1.05 to 1.06). Existing studies revealed that exposed root surface is mainly attachment loss due to periodontal diseases or gum atrophy formation. It is important for people to know that early prevention and control of periodontal disease are primary measures in reducing root surface caries.

In most conditions, RCI can still be used to reflect root caries activity[9,13]. According to this study, RCI in the middle-aged group was 14%, and that of the elderly group was 25%. There are similar urban-rural differences in caries, periodontal disease and missing teeth repaired among Chinese residents. This supports results reported by a previous study showing that people living in non-metropolitan areas are less likely to report that they use dental services[17].

The occurrence of root caries was shown to be related to tooth position. The lower front teeth are usually more susceptible to periodontal disease, but they are very easy to clean and get more attention, so they still have the lowest incidence of root caries.

Of the several variables that were considered in this study, the significant factors regarding root caries were gender, level of education, toothbrushing frequency, consumption of desserts, and oral health-related knowledge. Almost similar findings were reported by the previous studies conducted by Kumara-Raja and Radha et al[20] and Tan and Lo[21] which found that existing sociodemographic factors – low-income families and a low level of education – are the main factors for root caries because adults have a lack of awareness about oral health and poverty, which were responsible for the higher probability of oral diseases.

The report shows that in both the middle-aged group and the elderly group females were at a higher risk of suffering from root caries, a finding that is consistent with the 3rd National Oral Health Survey. In some studies, the results are the same, but others are not[22-25]. In both groups, men had a higher educational level than women, especially in the elderly group. Females consumed sweet food or drink more frequently than males. But women had better periodontal conditions and better oral health promoting habits. There are a lot of correlated factors, and further studies are needed to investigate the influencing factors.

Higher socio-economic status was associated with a lower severity of DR among Chinese adults. Root caries experience is socially patterned; people on a lower income and with a lower level of education suffered more with root caries. This finding was also consistent with a previous reported study[26]. Socio-economic position is associated with less healthy behaviour and more limited access to dental services, either treatment or preventative services. A combination of these factors could increase the risk of having more untreated root caries lesions.

More frequent toothbrushing is associated with lower root caries experience and presents only as decayed root surfaces, which supports a previous study[27]. As toothbrushing can mechanically remove plaque, fluoridated toothpaste used in toothbrushing could assist in altering

the balance between demineralisation and remineralisation, and brushing has a preventive effect on root caries.

Frequent use of toothpicks in the middle aged group contributes to more root caries (OR 1.06, 95% CI 1.02 ~ 1.10) while in 65 to 74 year olds the result show no significant association. There are only a few studies investigating the relationship between toothpick use and root caries. Toothpicks were originally recommended for cleaning the adjacent spaces after gingival recession and have proved to provide sufficient protection. But a lot of residents use toothpicks of improper materials, shape and methods, which lead to the possibility of periodontal trauma and gingival recession and a rise in the risk of disease.

In both groups, the attitude to oral health does not show an association to root caries, but participants with higher oral health knowledge scores had less severe root caries. This finding shows that even when people have awareness of the importance of oral health, they still need correct actions to prevent oral diseases. Thus, more public educational programmes should be carried out to help people learn the necessary skills to prevent caries.

Conclusions

The root caries experience was different for middle-aged adults and elderly adults, and this increases with age. Prevention measures should be taken as early as possible. Root exposing and gingival recession resulting from periodontitis and unhealthy oral cleaning habits were the main factors related to root caries in the population of middle-aged and elderly adults recruited for this study.

Conflicts of interest

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

Author contribution

Dr Yi Bo GAO analysed the data and drafted the manuscript; Drs Tao HU and Xue Dong ZHOU guided the analysis of the data and helped to draft the manuscript; Drs Rui SHAO and Ran CHENG provided statistical advice; Drs Guo Song WANG, Ying Ming YANG and Xue LI helped with the revision of the manuscript; Drs Bo Yuan and Ting XU inputted the data; Drs Xing WANG, Xi Ping FENG, Bao Jun TAI, De Yu HU, Huan Cai LIN, Bo WANG, Yan SI, Chun Xiao WANG, Shu Guo ZHENG, Xue Nan LIU, Wen Sheng RONG, and Wei Jian WANG trained the investigators, designed and supervised the survey; Dr Wei YIN conceived the study and designed the statistic exploration.

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