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Oral Health Status of Residents in Jiangsu Province, China: An Epidemiologic Survey

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ABSTRACT

Introduction: This study was conducted to characterise the oral health conditions of residents in Jiangsu Province, China.

Methods: In this descriptive study, 5 groups of participants were selected by a multistage stratified equal capacity random sampling, including 3- to 5-year-olds, 12- to 15-year-olds, 35- to 44-year-olds, 55- to 64-year-olds, and 65- to 74-year-olds. The data were collected by using the fifth edition of Oral Health Surveys-Basic Methods recommended by the World Health Organization (WHO).

Results: In these 5 groups, the mean DMFT/dmft of coronal caries were 3.07, 0.69, 4.03, 7.15, and 11.97, respectively, resulting in prevalence rates of 59.69%, 34.98%, 52.05%, 56.86%, and 72.19%, respectively. However, the filling rates were low in all age groups (1.88%, 17.53%, 29.88%, 16.13%, and 19.36%, respectively). Only 3.58% of the 12-year-old participants had good pit and fissure sealants. The adults include three groups, 35- to 44-year-olds, 55- to 64-year-olds, and 65- to 74-year-olds, and the prevalence rates of clinical attachment loss (CAL ≥4 mm) were 32.19%, 76.47%, and 85.43%, respectively. The proportions of adult groups with implant dentures, fixed dentures, removable partial dentures, complete dentures, and substandard dentures were 0%, 26.44%, 11.11%, 0.67%, and 4.89%, respectively. Additionally, 49.64% of adults had missing teeth that were not replaced.

Conclusions: Dental caries and periodontal disease were frequent and common in Jiangsu, China. But only a few of the residents sought treatment. Oral diseases continued to be a major problem for local residents.

Introduction

Oral disease is a major global health burden and is one of the most common public health issues worldwide, and yet it has frequently been neglected in public health policy.[1] To monitor the trend of oral health and to assist in formulating appropriate public health policies, an oral health epidemiologic survey was carried out to obtain relevant information.[2] Since 1983, China has carried out 4 oral health surveys using the Oral Health Surveys-Basic Methods, which has been continuously revised, as recommended by the World Health Organization (WHO).[3] The data are uploaded to the WHO database, which is convenient for international comparison and monitoring. This study was part of the 4th Oral Health Survey, which investigated the oral health status of residents in Jiangsu Province from 2015 to 2016 based on the methods and standards described in the fifth edition of the Oral Health Surveys-Basic Methods.[4]

Jiangsu Province, located on the eastern coast of mainland China, covers an area of 107,000 square km[5] and has a population of approximately 80 million.[6] It has the second highest gross domestic product (GDP) with the fifth largest population and the highest population density of all provinces and autonomous regions of China.[7] The 3rd Oral Health Survey in Jiangsu conducted in 2005 showed that the mean decayed, missing, filled teeth (DMFT) in children aged 5 (3.49) and

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adolescents aged 12 (0.47) were close to the national data, whereas that in 65- to 74-year-old adults (3.81) was much lower than the national average level. However, the filling (restoration) rate of dental caries in deciduous teeth (2.24%) and permanent teeth (10.16%) was very low, especially in children with deciduous teeth, which means that residents lacked awareness of oral health care at that time.[8] Periodontal disease is a common and frequently occurring disease amongst residents in Jiangsu Province, and dental calculus is an important oral health problem faced by these individuals. These findings reveal that they did not pay enough attention to oral hygiene. If sufficient oral health education is not in place, the burden on dental clinics will be greater in the future.

There is a lack of data on the epidemiology of oral disease in Jiangsu Province. Findings from this study provide an overview on the caries and filling rate, periodontal status, and dentition status and restoration of residents in Jiangsu Province, including their distribution in age, urban and rural areas, and sex. The objectives of this study are to describe the current status of oral health of residents in Jiangsu Province and to analyse the prevalence of common oral diseases, the current situation of prevention and treatment as related to age, urban and rural areas, and sex.

Methods

Participants

The participants included 5 age groups, namely, the permanent residents of urban and rural areas aged 3 to 5, 12 to 15, 35 to 44, 55 to 64, and 65 to 74 in Jiangsu Province. Participants must have lived in Jiangsu Province for more than 6 months. This study was approved by the Ethics Committee of the Chinese Stomatological Association (NO.2014–003), and written informed consent was acquired from the participants or from parents or guardians for minors to participate in this study.

Sampling design and sample size

The participants were selected with multistage stratified equal capacity random sampling. First, survey districts and counties need to be selected as the primary sampling unit. According to population data from the 2010 census published by the National Bureau of Statistics of China, the Jingkou and Tinghu districts were randomly selected from all districts (defined as urban districts) in Jiangsu Province, and Changshu and Tongshan counties were randomly selected from all counties or county-level cities (defined as rural districts) by probability-proportionate-to-size sampling (Figure). Second, 3 village (neighborhood) committees, 3 middle schools, and 3 kindergarten schools were selected from each county (district). Finally, the individual sampling process of the survey was conducted by quota sampling, which was completed by the staff in the county (district).

The following formula was used to estimate the sample size:

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

where n is the sample size; $deff$ is the design effect (4.5)[9]; p of 3- to 5-year-old and 12- to 15-year-old groups are the

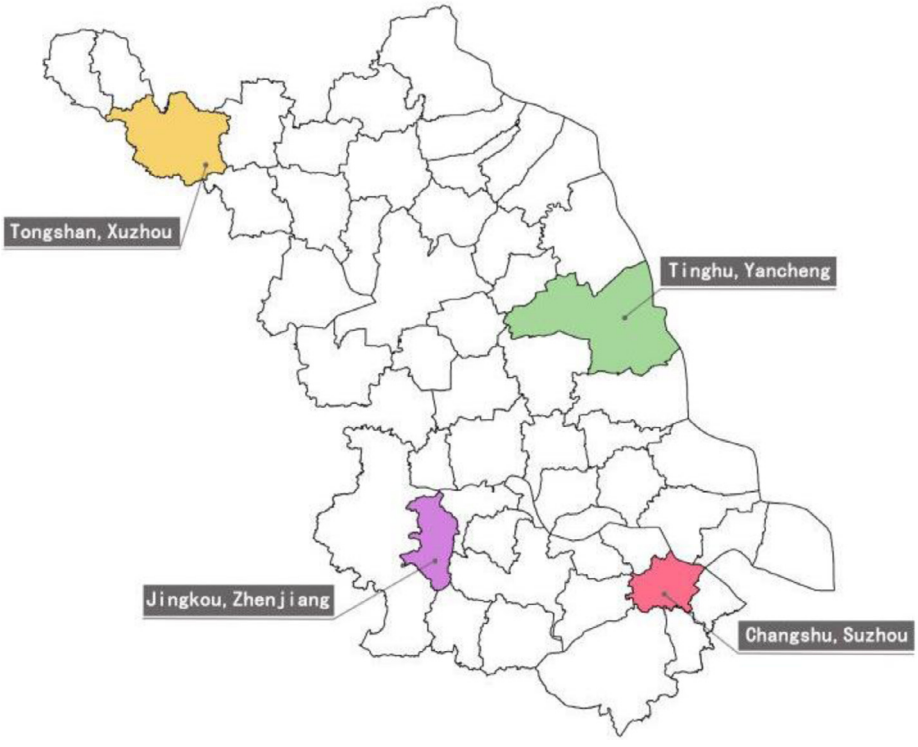

Fig – Four locations sampled in this survey in Jiangsu Province, China.

prevalence rates of dental caries in 5-year-olds and 12-year-olds, respectively; and p of 35- to 44-year-old, 55- to 64-year-old, and 65- to 74-year-old groups are the detection rates of periodontal disease in 65- to 74-year-olds in the 3rd National Oral Health Survey, which were 66.0%, 28.9%, and 86.0% in 5-year-olds, 12-year-olds, and 65- to 74-year-olds, respectively.[10] The allowable relative error of the overall rate p is controlled at 10% (15% for the 12-year-old group). Taking into account the stratification factor (12 layers) and the nonresponse rate (calculated to be 20%), the theoretical national sample size is available. Then, equal capacity allocation was implemented in each province. Finally, it was concluded that the minimum sample size that should be examined in Jiangsu Province was 5568, including 432 participants aged 3 to 5 years old, 960 participants aged 12 to 15 years old, and 144 participants in the 35-to-44, 55-to-64, and 65-to-74 age groups.

Clinical examination

In accordance with the basic methods and standards published in the WHO Oral Health Survey, each participant agreed to the clinical examination. The contents included dental status, periodontal status, and denture status.[4] Children aged 3 to 5 years were assessed only for dental status; adolescents aged 12 to 15 years were assessed for dental status, gingival bleeding, and dental calculi. Adults were assessed for all the items. Moreover, amongst children and adolescents, only the condition of the crown was examined, but not the root. Pit and fissure sealants were examined amongst the 12- to 15-year-old group. Portable dental chairs, including recliner, treatment lamp, operating table, and spittoon, were carried to the survey sites, and the participants were examined in a supine position. The examination was performed by visual diagnosis combined with probing under an artificial light source. The examination instruments included a disposable odontoscope and a Community Periodontal Index (CPI) probe, and the soft debris could be removed with cotton swabs if necessary. Throughout the examination process, the examiners were provided with personal protective equipment, including disposable medical masks, hats, and rubber gloves.

Dental measures

We performed statistics according to decayed teeth (DT/dt), missing teeth (MT/mt), filled teeth (FT/ft), and decayed, missing, filled teeth (DMFT/dmft). The mean DMFT (the mean number of decayed, missing, filled teeth)/dmft (DMFT of deciduous teeth)/DFR (decayed teeth with root caries and filled root without any primary or secondary caries), the prevalence of dental caries (the percentage of people with dental caries in total participants), and the filling rate of dental caries (the percentage of FT/(DT+FT)) were used to indicate the dental caries status. In addition, individuals were sorted according to their DMFT/dmft values and, then, the one-third of the population with the highest caries scores was selected to calculate the mean DMFT/dmft for this subgroup. This value is the Significant Caries Index (SiC).[4] The pit and fissure sealant rate (the percentage of participants with pit and fissure sealants in the total population in the corresponding group) was also recorded for the 12-year-old group.

We used the modified CPI recommended by the WHO (collecting data on gingival bleeding, dental calculus, periodontal pocket depth, and clinical attachment loss) for the periodontal examination[4] and counted the average number of teeth for every clinical condition,and determined the prevalence (the percentage of participants with the clinical condition to the total subjects in the corresponding group), respectively. For 12- to 15-year-old children, only gingival bleeding and dental calculus were recorded. For the adult group, all periodontal parameters were examined. All teeth (including third molars) were part of the periodontal examination.

In the adult group, we investigated the average number of missing teeth, the percentage of people with missing teeth, and the proportion of edentulous (no remaining teeth) people in the corresponding group. Similarly, we recorded the existence of dentures, including implant dentures, fixed dentures, removable partial dentures, complete dentures, and substandard dentures and counted the percentage of each denture to all participants in the corresponding group.

Quality control

The 3 examiners were qualified as dental practitioners and engaged in oral clinical care. They received theoretical and clinical training before the survey and all took part in an intra-examiner consistency test of clinical examination, with Kappa values higher than 0.80 for the DMFT index and 0.60 for periodontal pocket depths. In the course of the survey, 5% of the participants were randomly samples for duplicate examinations, and the average Kappa values of the DMFT index and periodontal pocket depth were 0.91 and 0.78, respectively.

Statistical analysis

The database was created in EpiData3.1 (EpiData Association), and the data were input twice. After the data were verified, the statistical analyses were performed by IBM SPSS Statistics v. 22.0 (IBM). The Chi-square test was used to compare the differences in rates amongst different groups. Student's t test and analysis of variance (normal distribution, uniform variance) or nonparametric tests (skewed distribution, uneven variance) were used to evaluate the mean differences amongst different groups. Statistical tests were performed at the .05 level of significance.

Results

Participants

A total of 5701 people in Jiangsu Province participated in this oral health survey. The population distribution is shown in Table 1. There was no significant difference in age, sex, or regional distribution. The nonresponse rate was 4.50%, 2.15%, 8.75%, 4.38%, and 5.63% for participants aged 3 to 5, 12 to 15, 35 to 44, 55 to 64, and 65 to 74 years, respectively.

Table 1 – Distribution of participants in the 4th Oral Health Survey in Jiangsu Province, N (%).

Age		3-5	12-15	35-44	55-64	65-74	Total
Residence location							
	Urban	693 (51.83)	1939 (49.54)	74 (50.68)	78 (50.98)	77 (50.99)	2861 (50.18)
	Rural	644 (48.16)	1975 (50.46)	72 (49.32)	75 (49.02)	74 (49.01)	2840 (49.82)
Gender							
	Male	668 (49.96)	1955 (49.95)	71 (48.63)	74 (48.37)	77 (50.99)	2845 (49.90)
	Female	669 (50.04)	1959 (50.05)	75 (51.37)	79 (51.63)	74 (49.01)	2856 (50.10)
Total		1337	3914	146	153	151	5701

Oral health status

Dental caries

Table 2 presents the prevalence of dental caries, the mean DMFT/dmft, the SiC index, and the filling rates for the juvenile groups. In 3- to 5-year-olds, the prevalence of dental caries in deciduous teeth was 59.69%, and the value in urban areas was lower than that in rural areas ($P = .004$). The mean dmft was 3.07, but the SiC index was 7.66 in this group. The filling rate of deciduous teeth was only 1.88%, which is slightly lower in rural areas than in urban areas ($P = .010$). In the 12- to 15-year-old group, the prevalence of dental caries and the mean DMFT of permanent teeth were 34.98% and 0.69%, respectively; these 2 values were significantly higher amongst girls than amongst boys ($P < .001$). The SiC index of this group was 2.03, and the filling rate was 17.53%.

Table 3 shows the status of dental caries in the adult groups in Jiangsu Province, including coronal caries and root caries. It can be observed that 60.44% of adults experienced coronal caries, and the mean DMFT was 7.75, whilst 19.11% of adults experienced root caries, and the mean DFR was 0.45. There was no difference in gender or residential location, but there was a significant difference amongst participants of the 3 age groups ($P < .001$), and these indices showed an increasing trend with age. The overall filling rates of coronal caries and root caries were 20.82% and 24.51%, respectively. The filling rate of root caries in rural areas was significantly lower (35.43% and 6.49% in urban and rural areas, respectively).

In this study, the 12-year-old participants were also evaluated for pit and fissure sealants and dental fluorosis (Table 4). The prevalence of dental caries and the mean DMFT were 33.84% and 0.61, respectively, and the filling rate was 15.23%. Girls experienced more dental caries than boys ($P = .02$, $P = .009$). We found that only 3.58% of the participants had pit and fissure sealants, and the rate in rural areas was much higher than that in urban areas (0.21% and 6.87% in urban and rural areas, respectively; $P < .001$).

Periodontal status

In 12- to 15-year-olds, periodontal status was indicated only by gum (gingival) bleeding and dental calculus (Table 5). The prevalence of gum bleeding on probing was 89.16%, and the mean tooth number was 7.82, whilst 79.75% of teenagers had dental calculus, and the mean tooth number was 6.85. The indices above were all higher in urban areas than in rural areas ($P < .001$), and the prevalence of calculus and the mean teeth number in boys were higher than in girls ($P < .001$).

The prevalence of gum bleeding and the prevalence of dental calculus in the 3 adult groups were high at 92.62% and 99.11%, respectively. People with periodontal pocket depth between 4 and 5 mm accounted for 52.13%, whilst people with periodontal pocket depth (≥6 mm) accounted for only 8.50%. In 35- to 44-year-olds, 55- to 64-year-olds, and 65- to 74-year-olds, the mean number of teeth with clinical attachment loss (CAL ≥4 mm) was 1.18, 6.04, and 6.30, respectively, and the prevalence was 32.19%, 76.47%, and 85.43%. There are significant differences in these 2 values amongst different age groups, and they both showed a tendency to increase with age ($P < .001$). In addition, the mean number of teeth in adult males with CAL ≥4 mm was much higher than that in females ($P < .001$). Detailed periodontal data are presented in Table 6.

Denture status

The tooth loss and denture restoration status of the 35- to 44-year-old group, 55- to 64-year-old group, and 65- to 74-year-old group were examined. Table 7 shows that the mean numbers of missing teeth in the 3 groups were 0.51, 2.90, and 5.99, respectively, showing an increasing tendency with age ($P < .001$). The prevalence of tooth loss presented a similar tendency. Only 1.99% of 65- to 74-year-old patients had edentulous jaws. Table 7 also presents various forms of denture restorations in these groups. Amongst them, the proportions of participants with fixed dentures, removable partial dentures, and complete dentures were 26.44%, 11.11%, and 0.67%, respectively. Some of the participants (4.89%) used informal dentures. There were no dental implants in the oral cavity of the adult participants. Additionally, 49.64% of the participants had missing teeth that were not replaced. In these data, the prevalence of fixed dentures in urban areas was higher than that in rural areas ($P = .049$), and the prevalence of missing teeth without replacment in urban areas was lower than that in rural areas ($P = .003$). Additionally, the prevalence of fixed dentures, removable partial dentures, and substandard dentures showed an increasing trend with age, respectively ($P < .001$, $P < .001$, $P = .006$).

Discussion

This study examined dental status, periodontal conditions, dentures, of 3- to 5-year-olds, 12- to 15-year-olds, 35- to 44-year-olds, 55- to 64-year-olds, and 65- to 74-year-olds to characterise the oral health conditions of residents in Jiangsu. We found that dental caries was still prevalent, young children

Table 2 – Dental caries status amongst people aged 3 to 5 and 12 to 15 in Jiangsu Province.

		3-5 years (deciduous teeth)				12-15 years (permanent teeth)			
		Prevalence of dental caries/%	Mean dmft	SiC	Filling rate/%	Prevalence of dental caries/%	Mean DMFT	SiC	Filling rate/%
Residence location									
	Urban	55.99*	2.99	7.65	2.42**	34.30	0.70	2.07	18.41
	Rural	63.66*	3.16	7.67	1.33**	35.65	0.69	2.00	16.64
Gender									
	Male	57.93	3.03	7.62	2.08	30.54***	0.55****	1.65	15.77
	Female	61.43	3.11	7.70	1.68	39.41***	0.84****	2.34	18.67
Total		59.69	3.07	7.66	1.88	34.98	0.69	2.03	17.53

* $P = .004$,
** $P = .010$,
*** $P < .001$,
**** $P < .001$.
dmft, decayed, missing, filled deciduous teeth; DMFT, decayed, missing, filled teeth; SiC, The Significant Caries Index，Individuals are sorted according to their DMFT values. One third of the population with the highest caries scores is selected. The mean DMFT for this subgroup is calculated. This value is the SiC Index.

Table 3 – Dental caries status in adults in Jiangsu Province.

		Coronal caries			Root caries		
		Prevalence of dental caries/%	Mean DMFT	Filling rate/%	Prevalence of dental caries/%	Mean DFR	Filling rate/%
Age							
	35-44	52.05*	4.03**	29.88	2.05***	0.03****	20.00
	55-64	56.86*	7.15**	16.13	20.92***	0.48****	2.74
	65-74	72.19*	11.97**	19.36	33.77***	0.83****	37.30
Residence location							
	Urban	58.52	8.03	20.68	20.52	0.56	35.43
	Rural	62.44	7.47	20.95	17.65	0.35	6.49
Gender							
	Male	59.91	7.90	18.53	19.37	0.48	26.17
	Female	61.96	7.61	22.62	18.86	0.43	22.68
Total		60.44	7.75	20.82	19.11	0.45	24.51

** $P < .001$,
*** $P < .001$,
**** $P < .001$.
DFR, decayed teeth with root caries and filled root without any primary or secondary caries; dmft, decayed, missing, filled deciduous teeth.

Table 4 – Dental status and pit and fissure sealing in 12-year-old adolescents.

			Dental status			
		Number of participants	Prevalence of dental caries/%	Mean DMFT	Filling rate/%	Pit and fissure sealing rate/%
Residence location						
	Urban	483	34.37	0.62	15.67	0.21***
	Rural	495	33.33	0.59	14.78	6.87***
Gender						
	Male	491	30.35*	0.50**	11.79	3.26
	Female	487	37.37*	0.71**	17.68	3.90
Total		978	33.84	0.61	15.23	3.58

* $P = .02$,
** $P = .009$,
*** $P < .001$.
DMFT, decayed, missing, filled teeth.

Table 5 – Periodontal status in 12- to 15-year-old adolescents in Jiangsu Province.

		Gum bleeding on probing		Calculus	
		Teeth number	Prevalence/%	Teeth number	Prevalence/%
Residence location					
	Urban	8.52*	92.75**	7.68***	86.13****
	Rural	7.13*	85.66**	6.03***	73.54****
Gender					
	Male	7.80	89.21	7.31△	82.28△△
	Female	7.84	89.12	6.39△	77.21△△
Total		7.82	89.16	6.85	79.75

* $P < .001$,
** $P < .001$,
*** $P < .001$,
**** $P < .001$;
△ $P < .001$,
△△ $P < .001$.

had more severe caries and most adult residents experienced various periodontal problems. The findings can provide baseline data for oral prevention and health care and oral health promotion programmes, adjusted to local conditions. In addition, this study can also provide effective guidance for decision makers to set oral health goals for the next stage and carry out the subsequent oral epidemiologic survey.

Compared with Zhejiang Province (eastern China, bordering Jiangsu), Hunan Province (central China), and Sichuan Province (western China), the prevalence of deciduous caries and the mean dmft in 3- to 5-year-olds in Jiangsu Province were significantly lower.[11-13] However, compared with first-tier cities such as Beijing and Shanghai, these 2 values were on the high end.[14,15] Moreover, the prevalence level was still higher than that in the Oral Health Goals for the year 2000 established by the WHO (the prevalence of dental caries in children aged 5 <50%)[2]; in particular, the SiC index (7.66) was significantly high. Notably, the prevalence of caries was significantly higher than that in Europe.[16] Children from low socioeconomic status have a higher risk of dental caries, and it is difficult for them to obtain dental services because China is still a developing country.[17] For a long time, Chinese parents had the incorrect opinion that deciduous teeth would eventually fall out and permanent teeth would replace them, so oral prevention and treatment in children were not important. These results demonstrate that the dental caries status in young children in the region is still serious, and further intervention is necessary.

In adolescents, dental caries status in Jiangsu is less prevalent than that in Zhejiang, Sichuan, and Shanghai.[13,18,19] It is worth noting that Jiangsu Province is one of the areas where the National Oral Health Comprehensive Intervention Program for Children has been implemented in China. In this survey, the prevalence of dental caries and the mean DMFT in children aged 12 in Jiangsu were lower than the average value in those areas covered by the programme.[20] Moreover, an oral health survey in Jakarta, which is also located in Asia, the capital city of Indonesia in 2016, and the 2013 United Kingdom's Children's Dental Health Survey showed that more 12-year-old children had permanent dental caries, and the mean DMFT was higher than that in Jiangsu.[21,22] Comparing the data of oral epidemiologic surveys in 2005 and 2015, it was found that the prevalence of dental caries (27.02% in 2005 and 33.84% in 2015) and the mean DMFT (0.47 in 2005 and 0.61 in 2015) of children aged 12 years increased. This may be related to the rapid economic development of Jiangsu Province between 2005 and 2015 and thus the increasing intake of sugar. On the whole, the caries status of 12- to 15-year-olds in Jiangsu Province was at a lower level compared with other areas, but it still did not meet the goal of reducing

Table 6 – Periodontal status in adults in Jiangsu Province.

		Gum bleeding on probing		Calculus		PD (4 mm-5 mm)		PD (≥6 mm)		CAL		Prevalence of periodontal health/%
		Teeth number	Prevalence/%	Teeth number	Prevalence/%	Teeth number	Prevalence/%	Teeth number	Prevalence/%	Teeth number	Prevalence/%	
Age												
	35-44	11.27	95.21	21.30	100.00	1.60	38.36	0.04	2.05	1.18*	32.19**	2.05
	55-64	11.33	95.42	21.52	99.35	3.03	64.05	0.29	13.07	6.04*	76.47**	0.65
	65-74	8.05	85.43	17.64	96.03	2.27	52.32	0.23	9.93	6.30*	85.43**	5.96
Residence location												
	Urban	10.20	93.15	19.95	99.19	2.59	55.24	0.21	10.48	4.66	65.73	1.61
	Rural	10.38	91.96	20.69	98.99	2.00	48.24	0.17	6.03	4.48	65.33	3.02
Gender												
	Male	9.18	90.50	21.14	98.64	2.54	58.37	0.25	10.86	5.52***	70.59	3.17
	Female	11.35	94.69	19.44	99.56	2.12	46.02	0.13	6.19	3.66***	60.62	1.33
Total		10.28	92.62	20.28	99.11	2.33	52.13	0.19	8.50	4.58	65.55	2.24

* $P < .001$,
** $P < .001$,
*** $P < .001$.
CAL, clinical attachment loss; PD, periodontal pocket depth.

Table 7 – Missing teeth status and denture restorations in adults (not including third molars).

		Number of missing teeth	Missing tooth rate/%	Prevalence of endontulism/%	Prevalence of implant dentures/%	Prevalence of fixed dentures/%	Prevalence of removable partial dentures/%	Prevalence of complete dentures/%	Prevalence of substandard dentures/%	Prevalence of missing teeth without repair/%
Age										
	35-44	0.51#	31.51##	0.00	0.00	15.75△	0.68△△	0.00	0.68△△△	54.35
	55-64	2.90#	64.71##	0.00	0.00	26.80△	12.42△△	0.00	5.23△△△	48.48
	65-74	5.99#	88.08##	1.99	0.00	36.42△	19.87△△	1.99	8.61△△△	48.87
Residence location										
	Urban	3.13	60.24	0.40	0.00	30.12*	12.45	0.40	3.21	41.33**
	Rural	3.19	63.68	1.00	0.00	21.89*	9.45	1.00	6.97	59.38**
Gender										
	Male	3.59	63.96	0.45	0.00	23.87	12.16	0.45	5.86	52.82
	Female	2.75	59.65	0.88	0.00	28.95	10.09	0.88	3.95	46.32
Total		3.16	61.78	0.67	0.00	26.44	11.11	0.67	4.89	49.64

\# $P < .001$,
\#\# $P < .001$,
* $P = .049$,
** $P = .003$,
△ $P < .001$,
△△ $P < .001$,
△△△ $P = .006$.

the prevalence of dental caries to less than 30% by 2025, as proposed in the China Chronic Disease Prevention and Control Program (2017-2025).[23] Meanwhile, periodontal disease was quite prevalent. The proportions of 12- to 15-year-olds with gum bleeding on probing and dental calculus were high, and it may be due to mixed dentition that is difficult to clean.[24] Adolescence is the transitional and critical period from the mixed dentition to the permanent dentition, which will establish the basis of oral health in adulthood. Therefore, the resulting goals are to further reduce the number of decayed teeth in children prone to caries and to lower the rate of early periodontal problems by promoting oral hygiene knowledge, attitudes, and behaviours.

Based on the analyses of the data of 3 adult groups, we found that for both crown caries and root caries, the prevalence and the mean DMFT/DFR of the middle-aged and elderly residents of Jiangsu Province were significantly lower than the national averages.[25,26] For periodontal health status, the prevalence of gum bleeding and dental calculus in 35- to 44-year-olds was higher than the national average, but the prevalence of periodontal pocket depth and CAL (≥4 mm) was lower.[27] However, we found that our results regarding CAL (≥4 mm) were in accordance with those reported in the United States (2009-2010).[28] Therefore, similar to most areas, periodontal disease is still a common oral problem plaguing the middle-aged and elderly in Jiangsu Province. The edentulous rate is generally regarded as the most important indicator of the dental-related quality of life amongst elderly people. In this survey, the edentulous rate of the residents aged 65 to 74 was lower than the national value (4.5%)[29] According to a 2016 survey in the United States, the edentulous rate amongst 65- to 74-year-old adults in rural Colorado was as high as 15%.[30] We speculate that the low edentulous rate in Jiangsu Province might be due to the failure to remove many residual roots and crowns.

The filling rates of crown caries in all age groups were less than one-third, especially in young children. Only 1.88% of deciduous dental caries were addressed. Some studies have demonstrated that pit and fissure sealing can effectively prevent posterior pit and fissure caries in children and adolescents.[31] Nevertheless, of 978 children aged 12 surveyed, only 3.58% had sound pit and fissure sealants. On the one hand, these findings reflected a common phenomenon of parents' neglect of children's oral health problems. On the other hand, the relevant health departments still did not provide adequate public services for oral health. The ratio of stomatologists/dentists to the population in Jiangsu Province is 1:19,980, which is far lower than the WHO's standard of 1:5000.[32] For adults with tooth loss, approximately half of them did not replace their missing teeth or chose substandard dentures, which suggested that the understanding of damage caused by tooth loss needs to be strengthened. Meanwhile, the low caries filling rate and denture restoration rate also reflected the heavy oral disease burden in the local areas, and the primary health care in the communities needed to be further developed.[29]

We can notice that the gap between urban and rural areas still existed in the filling rates and the prevalence of missing teeth without replacement. It might be related to the uneven distribution of oral health resources in different areas. Depending on the survey, more than 90% of China's dental hospitals and preventive institutions are established at the provincial and municipal levels.[33] There was an exception that the pit and fissure sealing rate in urban areas was lower than that in rural areas. This might be due to the coverage of free pit and fissure sealant programmes in the rural areas. There are also gender differences. Dental caries status in girls in the 12- to 15-year-old group was significantly worse than that in boys, which may be related to the earlier eruption of permanent teeth in girls and the longer exposure to dental caries in the oral environment[34] In addition, the age difference in the dental caries status in the adult groups may be because the occurrence of dental caries indicates the persistent and cumulative effects of dental caries over the lifetime of a particular dentition, so it showed an increasing trend with age. Similarly, periodontal disease is a chronic progressive disease, and dental caries and periodontitis are the major causes of tooth loss.[35]

One of the global goals for oral health in 2020 set by the WHO is to minimise the impact of dental caries on individuals and society and to develop strategies for the early diagnosis, prevention, and effective management of dental caries.[36] Therefore, it is urgent to establish a sound dental disease prevention system to strengthen the primary prevention of oral diseases. For deciduous dental caries, oral health records can now begin to be established after birth or during the mothers' pregnancy to facilitate the monitoring of their oral health from infancy. In addition to pit and fissure sealants, fluoride has also been confirmed to be an effective way to prevent caries,[37] including fluoride toothpaste, fluoride mouthwash, and topical fluoride agents.[38] Public health departments should further popularise and expand the coverage of these 2 elementary oral prevention measures. According to the WHO's recommendation to adopt a comprehensive public health prevention strategy based on common risk factors related to periodontal disease and other systemic chronic diseases, such as smoking, stress, and low socioeconomic status, oral disease prevention strategies should be incorporated into the prevention of chronic systemic diseases.[39] To narrow the differences between cities and villages, Jiangsu Province needs to strengthen the construction of grassroots dental staff and direct oral health resources to rural areas. Schools provide a good environment in which to promote oral health because they benefit nearly the whole community in the area, including the students, school staff, and families in the community[40] Thus, oral health education centred on schools should be strengthened to impact society. The community situation is quite complicated. It is necessary to further explore the community oral primary care model in combination with the above methods to achieve early prevention, early diagnosis, and early treatment.

In recent years, there have been few studies on oral epidemiology in Jiangsu Province, China, so there is a lack of comparison of results from the same region. However, compared with similar research, this study has a large age span and wide coverage. The research content covers dental caries, periodontal conditions, tooth loss and restoration, and prevention. At the same time, it takes into consideration the contrast between urban and rural areas and gender. Therefore, it is possible to have a more comprehensive understanding of the current oral health status of residents in the province, so

as to make overall plans for oral public health. The strengths of this study also include good intra-examiner reliability of clinical examination, acceptable participation rates, and sufficient sample size.

We acknowledge that there are limitations in this study. There is the absence of data collection on socioeconomic status, which results in the absence of that variable in the analysis. A cross-sectional study can only reflect the correlation between these factors and oral diseases, and thus a longitudinal study needs to be performed to confirm the current findings. While this research covers a wide range of ages and variables, such variables as the specific teeth affected by caries and periodontal disease have not been included.

Conclusions

The residents in Jiangsu Province had a high prevalence of dental caries, especially young children. Most adolescents and adults experienced gingival bleeding and dental calculus, and more than half of adults had clinical attachment loss. The low filling rate and denture restoration rate indicated that Jiangsu Province has a heavy oral disease burden. Accordingly, strategies and policies on oral public health should be adjusted over time. Further, analysis of risk factors associated with oral diseases will be carried out next and could contribute to refining future policy.

Conflict of interest

None disclosed.

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Author contributions

Tingting Fu and Yiran Liu contributed equally to this work. Tingting Fu and Yiran Liu contributed to the analysis and interpretation of the data and drafted the manuscript. Hong Shen contributed to the conception and design and critically revised the manuscript. Jiaping Shen carried out the surveys and experiments and critically revised the manuscript. All authors gave final approval of the version to be published.

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REFERENCES

1. Marcenes W, Kassebaum NJ, Bernabe E, et al. Global burden of oral conditions in 1990-2010: a systematic analysis. J Dent Res 2013;92(7):592–7.
2. Petersen PE. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century—the approach of the WHO Global Oral Health Programme. Community Dent Oral Epidemiol 2003;31(Suppl 1)):3–23.
3. Wang HY, Petersen PE, Bian JY, Zhang BX. The second national survey of oral health status of children and adults in China. Int Dent J 2002;52(4):283–90.
4. World Health Organization. Oral health surveys: basic methods. 5th ed. Switzerland: World Health Organization; 2013. p. 1–125.
5. Zhang X, Jin X, Fan Y, Liu J, Shan W, Zhou Y. Spatial-temporal characteristics and coordination status of the land use function transition in Jiangsu Province from 1995 to 2015. Journal of Natural Resources 2019;34(4):689–706.
6. Lu S, Reavley N, Zhou J, et al. Depression among the general adult population in Jiangsu Province of China: prevalence, associated factors and impacts. Soc Psychiatry Psychiatr Epidemiol 2018;53(10):1051–61.
7. Zhou L, Xu X, Antwi HA, Wang L. Towards an equitable healthcare in China: evaluating the productive efficiency of community health centers in Jiangsu Province. Int J Equity Health 2017;16(1):89.
8. Jiaping S, Lin W, Ning C, Hongbing S, Yijun W, Hongyan Z. Cross-sectional study on dental caries among population aged 5 to 74 in Jiangsu Province. J Biomed Res 2006;26 (12):1283–7.
9. Lu HX, Tao DY, Lo ECM, Li R, Wang X, Tai BJ, et al. The 4th National Oral Health Survey in the mainland of China: background and methodology. Chin J Dent Res 2018;21(3): 161–5.
10. Cao CF. Prevalences of periodontal diseases and dental caries in China: re-analysis of the data from the Third National Epidemiological Survey on Oral Health. Chin J Stomatol 2013;48 (5):257–9.
11. Zhou N, Zhu H, Chen Y, et al. Dental caries and associated factors in 3 to 5-year-old children in Zhejiang Province, China: an epidemiological survey. BMC Oral Health 2019;19(1):9.
12. Wang Z, Rong W, Zhang Y, Zeng X, Li Z, Liu Z. Prevalence and contributing factors of dental caries of 6-year-old children in four regions of China. PeerJ 2019;7:e6997.
13. Yin W, Yang YM, Chen H, et al. Oral health status in Sichuan Province: findings from the oral health survey of Sichuan, 2015-2016. Int J Oral Sci 2017;9(1):10–5.
14. Xu M, Yuan C, Sun X, Cheng M, Xie Y, Si Y. Oral health service utilization patterns among preschool children in Beijing, China. BMC Oral Health 2018;18(1):31.
15. Su H, Yang R, Deng Q, Qian W, Yu J. Deciduous dental caries status and associated risk factors among preschool children in Xuhui District of Shanghai, China. BMC Oral Health 2018;18 (1):111.
16. Mantonanaki M, Koletsi-Kounari H, Mamai-Homata E, Papaioannou W. Prevalence of dental caries in 5-year-old Greek children and the use of dental services: evaluation of socioeconomic, behavioural factors and living conditions. Int Dent J 2013;63(2):72–9.
17. 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(5):650–8.
18. Hu J, Jiang W, Lin X, et al. Dental caries status and caries risk factors in students ages 12-14 years in Zhejiang, China. Med Sci Monit 2018;24:3670–8.

19. Zhang H, Zeng X, Jiang Y, et al. The disparity in caries and sealants between migrant and native children in Shanghai: A cross-sectional study. Int J Dent Hyg 2020;18(1):84–91.
20. Yuan C, Wang XZ, Sun XY, et al. Oral health status of 12-year-olds from regions with and without coverage of the national oral health comprehensive intervention program for children in China. Chin J Dent Res 2018;21(4):299–306.
21. Maharani DA, Zhang S, Gao SS, Chu CH, Rahardjo A. Dental caries and the erosive tooth wear status of 12-year-old children in Jakarta, Indonesia. Int J Environ Res Public Health 2019;16(16):2994.
22. Hong J, Whelton H, Douglas G, Kang J. Consumption frequency of added sugars and UK children's dental caries. Community Dent Oral Epidemiol 2018;46(5):457–64.
23. Zhou X, Xu X, Li J, et al. Oral health in China: from vision to action. Int J Oral Sci 2018;10(1):1.
24. Chen X, Ye W, Zhan JY, et al. Periodontal status of Chinese adolescents: findings from the 4th National Oral Health Survey. Chin J Dent Res 2018;21(3):195–203.
25. Gao YB, Hu T, Zhou XD, et al. Dental caries in Chinese elderly people: findings from the 4th National Oral Health Survey. Chin J Dent Res 2018;21(3):213–20.
26. Gao YB, Hu T, Zhou XD, et al. How root caries differs between middle-aged people and the elderly: findings from the 4th National Oral Health Survey of China. Chin J Dent Res 2018;21(3):221–9.
27. Sun HY, Jiang H, Du MQ, et al. 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):241–7.
28. Eke PI, Dye BA, Wei L, Thornton-Evans GO, Genco RJ. Prevalence of periodontitis in adults in the United States: 2009 and 2010. J Dent Res 2012;91(10):914–20.
29. Guo J, Ban JH, Li G, et al. 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):249–57.
30. Tiwari T, Scarbro S, Bryant LL, Puma J. Factors associated with tooth loss in older adults in rural Colorado. J Community Health 2016;41(3):476–81.
31. Ahovuo-Saloranta A, Forss H, Walsh T, Nordblad A, Mäkelä M, Worthington HV. Pit and fissure sealants for preventing dental decay in permanent teeth. Cochrane Database Syst Rev 2017;7(7):CD001830.
32. Sun XY, Yuan C, Wang XZ, et al. Report of the National Investigation of Resources for Oral Health in China. Chin J Dent Res 2018;21(4):285–97.
33. Liu J, Zhang SS, Zheng SG, Xu T, Si Y. Oral health status and oral health care model in China. Chin J Dent Res 2016;19(4):207–15.
34. Lukacs JR, Largaespada LL. Explaining sex differences in dental caries prevalence: saliva, hormones, and "life-history" etiologies. Am J Hum Biol 2006;18(4):540–55.
35. Nilsson H, Sanmartin Berglund J, Renvert S. Longitudinal evaluation of periodontitis and tooth loss among older adults. J Clin Periodontol 2019;46(10):1041–9.
36. Hobdell M, Petersen PE, Clarkson J, Johnson N. Global goals for oral health 2020. Int Dent J 2003;53(5):285–8.
37. Hiiri A, Ahovuo-Saloranta A, Nordblad A, Mäkelä M. Pit and fissure sealants versus fluoride varnishes for preventing dental decay in children and adolescents. Cochrane Database Syst Rev 2006(4):CD003067.
38. Zhang J, Sardana D, Li KY, Leung KCM, Lo ECM. Topical fluoride to prevent root caries: systematic review with network meta-analysis. J Dent Res 2020;99(5):506–13.
39. Petersen PE, Ogawa H. Strengthening the prevention of periodontal disease: the WHO approach. J Periodontol 2005;76(12):2187–93.
40. Kwan SY, Petersen PE, Pine CM, Borutta A. Health-promoting schools: an opportunity for oral health promotion. Bull World Health Organ 2005;83(9):677–85.