



## OPEN Association between multimorbidity and having less than 20 natural teeth among Chinese older adults: a cross-sectional study

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Understanding the impact of multimorbidity on having less than 20 natural teeth is crucial for safeguarding the oral health of older adults with multimorbidity. This study aimed to analyze the association between multimorbidity and having less than 20 natural teeth in older Chinese adults. The data for this analysis were obtained from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), which covers 23 provinces, municipalities, and autonomous regions throughout China. The survey includes information on dental health (such as dentition status), a variety of chronic conditions, and other sociological characteristics of older adults in China. Having less than 20 natural teeth was used as the dependent variable, with multimorbidity as the independent variable. A multivariable logistic regression model was applied to estimate the association between multimorbidity and having less than 20 natural teeth. A total of 3,640 older adults were included in the study, of whom 58.27% (2121) were identified as having less than 20 natural teeth. The results indicated that factors such as age, education level, exercise, ability to perform daily activities, frequency of brushing teeth, and BMI are associated with having less than 20 natural teeth. Additionally, compared with those without chronic disease, the odds ratio (OR) of having less than 20 natural teeth was 1.32 (95% CI: 1.10, 1.57) for older adults with only one chronic disease, and the OR for those with two or more chronic diseases was 1.418 (95% CI: 1.06, 1.89). This study highlights the importance of monitoring the oral health of older adults with multimorbidity and identifies an association between multimorbidity and having less than 20 natural teeth. Oral health care institutions should implement measures to support the development of more comprehensive public health policies.

**Keywords** Multimorbidity, Having less than 20 natural teeth, Older adults, Oral health

### Abbreviations

CLHLS Chinese Longitudinal Healthy Longevity Survey

Tooth loss is a significant public health issue influenced by various biological, behavioral, and socioeconomic factors. Among American older adults who underwent dental examinations between 2011 and 2016, 59.9% were found to have fewer than 20 natural teeth<sup>1</sup>. A survey in Japan revealed that only 28.5% of the older adults

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retained 20 or more natural teeth<sup>2</sup>. In Mexico, a study reported that 62.4% of the 2,098 participants had lost at least one tooth<sup>3</sup>, while another study found that 27% of the sample had no natural teeth remaining<sup>4</sup>.

The evidence indicates that missing or severely impaired dentition is a common condition. It reduces chewing capacity and hinders nutritional intake<sup>5</sup>, and impacts facial appearance, communication, social interaction, and mental health<sup>6</sup>. In 2019, the National Health Commission launched the ‘Healthy Oral Action Plan 2019–2025’, emphasizing the importance of oral health for older adults, particularly those with chronic illnesses, to improve their overall well-being.

Dental caries and periodontal disease are the primary causes of tooth loss. Caries often result from poor oral hygiene and high sugar intake, while periodontal disease involves gum inflammation that weakens the teeth’s supporting structures<sup>7–9</sup>. Tooth loss is also linked to risk factors such as smoking, inadequate oral hygiene, low socioeconomic status, and limited access to preventive dental care<sup>3,10–14</sup>. Socioeconomic and cultural factors further contribute to this issue, as older adults—particularly those with low income, low education, minority backgrounds, or living in rural areas—face higher risks of tooth loss<sup>11,12,14,15</sup>.

To better study such issues, ‘having less than 20 natural teeth’ has been established as a key standard for assessing oral health. This measure refers to individuals with fewer than 20 natural teeth remaining, based on the World Health Organization’s ‘8020 Plan’, which highlights the importance of retaining at least 20 teeth for maintaining proper chewing function and overall well-being<sup>16</sup>. The threshold of 20 natural teeth is useful for evaluating oral health and its impact on daily functioning<sup>17,18</sup>.

Recent clinical studies have increasingly highlighted a significant link between chronic diseases and having less than 20 natural teeth<sup>19</sup>. Chronic diseases can disrupt the oral microbiome and elevate systemic inflammatory factors, both of which contribute to periodontal disease—a key predictor of having less than 20 natural teeth<sup>20–22</sup>. Additionally, chronic diseases and having less than 20 natural teeth often share common risk factors, including smoking, excessive alcohol consumption, and poor dietary habits such as rich in sugary and processed foods<sup>16,23</sup>. For instance, smoking significantly impairs gum health and immune function, increasing the risk of having less than 20 natural teeth by more than four times<sup>24,25</sup>.

Chronic diseases often cluster, a phenomenon known as multimorbidity, which the World Health Organization defines as the presence of two or more chronic diseases that require medical management or impacting daily activities<sup>26–29</sup>. While existing research largely focuses on the relationship between high-prevalence conditions like hypertension, heart disease, and diabetes with having less than 20 natural teeth<sup>30–33</sup>, limited attention has been given to other chronic conditions such as lung disease, cataracts, Parkinson’s disease, and rheumatoid arthritis<sup>34–42</sup>. Furthermore, most studies focus on single diseases rather than the cumulative impact of multimorbidity on dysfunctional dentition. Therefore, from the perspective of multimorbidity, this study expands the scope of chronic disease and assesses the association between multimorbidity and having fewer than 20 natural teeth in a nationally representative sample of Chinese elderly people.

## Objectives

This research aims to examine the relationship between multimorbidity and having less than 20 natural teeth among older adults aged 60 and above in China. We hypothesize that among Chinese older adults, there will be an association between multimorbidity and having less than 20 natural teeth. The study seeks to provide insights into the associations between multimorbidity and oral health, particularly highlighting the prevalence of dental issues among older individuals with multiple chronic conditions, and to underscore the importance of oral health prevention and protection in this population.

## Method

All the data of the elderly in this study are derived from the CLHLS database. The Chinese Longitudinal Healthy Longevity Survey (CLHLS), organized by the Center for Healthy Aging and Development Studies, is a comprehensive longitudinal study spanning 23 provinces, municipalities, and autonomous regions across China. The sampling design of the CLHLS employs a multi-stage proportionate and targeted random sampling method<sup>43,44</sup>. To avoid deviation caused by age imbalance, we weighted the data by age. The CLHLS investigators conducted face-to-face interviews with older and middle-aged individuals to collect data. Data for the analysis were retrieved from the Chinese Longitudinal Healthy Longevity Survey (CLHLS, 2017–2018), which included 15,874 individuals (≥ 50 years). In this study, all methods were performed in accordance with Declaration of Helsinki and Strengthening the Reporting of Observational studies in Epidemiology.

The inclusion criteria for the study sample were as follows: (1) older adults aged between 60 and 90 years; (2) no missing responses pertaining to the number of missing teeth; and (3) complete responses on the presence or absence of chronic diseases. The exclusion criteria are the presence of missing or incorrectly filled data for any of other related variables. Ultimately, a total of 3,640 valid participants were included in the study.

## Assessment of having less than 20 natural teeth

The assessment of having less than 20 natural teeth was carried out by asking the question: “How many natural teeth do you currently have, excluding any dentures or artificial replacements?” As stipulated in the “8020 Plan” introduced by the World Health Organization in 2001, the possession of at least 20 natural teeth is deemed the minimum threshold for an individual to engage fully in social activities and maintain adequate chewing capability<sup>17</sup>. Furthermore, previous studies have consistently demonstrated that this metric possesses good reliability and validity<sup>16,19</sup>.

## Assessment of multimorbidity

Multimorbidity was assessed through the inquiry, “Do you currently suffer from any of the following chronic diseases?” The diseases considered included chronic lung disease, tuberculosis, cataracts, glaucoma,

gastrointestinal ulcers, Parkinson's disease, rheumatism or rheumatoid arthritis, and chronic nephritis. Subsequently, the participants' chronic disease status was categorized into three groups: (1) absence of any chronic disease, (2) presence of a single chronic disease, and (3) multimorbidity, defined as the coexistence of two or more chronic diseases. Notably, previous research has consistently demonstrated the reliability and validity of this assessment method<sup>45</sup>.

### Covariates

Covariates were selected from the questionnaire that might be associated with having less than 20 natural teeth and multimorbidity, which were divided into sociodemographic characteristics and health behavior habits. Table 1 shows the specific variables.

### Statistical analysis

The data were analyzed using the version of SPSS by IBM 25.0. Descriptive statistics were computed for demographic data using percentages and frequencies (n). In this study, having less than 20 natural teeth was taken as the dependent variable and multimorbidity as the independent variable. The chi-square test was employed to compare differences in the prevalence of having less than 20 natural teeth across demographic variables and multimorbidity status. Variables found to be significant in the chi-square test were subsequently included in the binary logistic regression model to identify influencing factors of having less than 20 natural teeth, which was coded as functional = 0 (reference group for univariate and multivariate analyses) and non-functional = 1. Adjusted odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) derived from the logistic regression analysis were utilized to quantify the association between multimorbidity and having less than 20 natural teeth. Additionally, interaction terms between covariates were incorporated into the logistic regression model to test for potential interactions, with statistical significance for interactions set at  $p$  for interaction  $< 0.05$ . All interaction terms were included simultaneously in the original model to evaluate their combined effects comprehensively. The significance of each interaction term was determined using  $p$ -values obtained from the Wald test. The Hosmer-Lemeshow test was conducted to assess the fitness of the logistic regression model. Throughout the analysis, statistical significance was considered at  $p < 0.05$ , and  $p$  values were interpreted in a two-sided manner.

## Results

### Demographic characteristics of respondents

Figure 1 provides a detailed information of the inclusion and exclusion criteria that were used to screen 3,640 older persons who were eventually included in the research. 50.36% of participants were female, with an average age of 75 years. Most of the older adults (85.80%) had sufficient sources of income, and 80.47% of the adults regularly participated in annual physical examinations. Another 56.24% of the older adults have received nine-year compulsory education. In the present study, 58.27% of older adults experienced having less than 20 natural teeth.

### Analysis of differences in having less than 20 natural teeth rates among older adults

The findings presented in Table 2 show that instead of ventilation condition, staple food, main taste preference, smoking, medical expenses in the past year, and annual physical examinations, other covariates may be associated with having less than 20 natural teeth in older adults.

After controlling for sociodemographic variables and health behaviors, Table 3 shows the association between multimorbidity and having less than 20 natural teeth. Compared with those without chronic disease, the odds ratio (OR) of having less than 20 natural teeth was 1.32 (95% CI: 1.10, 1.57) for older adults with only one chronic disease, and the OR for those with two or more chronic diseases was 1.418 (95% CI: 1.06, 1.89). Additionally, we identified several other factors linked to having less than 20 natural teeth, such as age, education level, ability to perform daily activities, frequency of vegetable intake, frequency of brushing teeth, toothache in the past six months, and BMI.

The Hosmer-Lemeshow test was conducted to assess the fitness of the logistic regression model. Since the significance level ( $p = 0.777$ ) is greater than the commonly used significance level of 0.05, it indicates that there is no significant difference between the observed and predicted values.

The results in Fig. 2 showed that among the numerous factors included, only the interaction between frequency of brushing teeth and multimorbidity demonstrated a significant association ( $p$  for interaction  $< 0.05$ ). This indicates that, at different frequency of brushing teeth, the impact of multimorbidity on tooth loss varies.

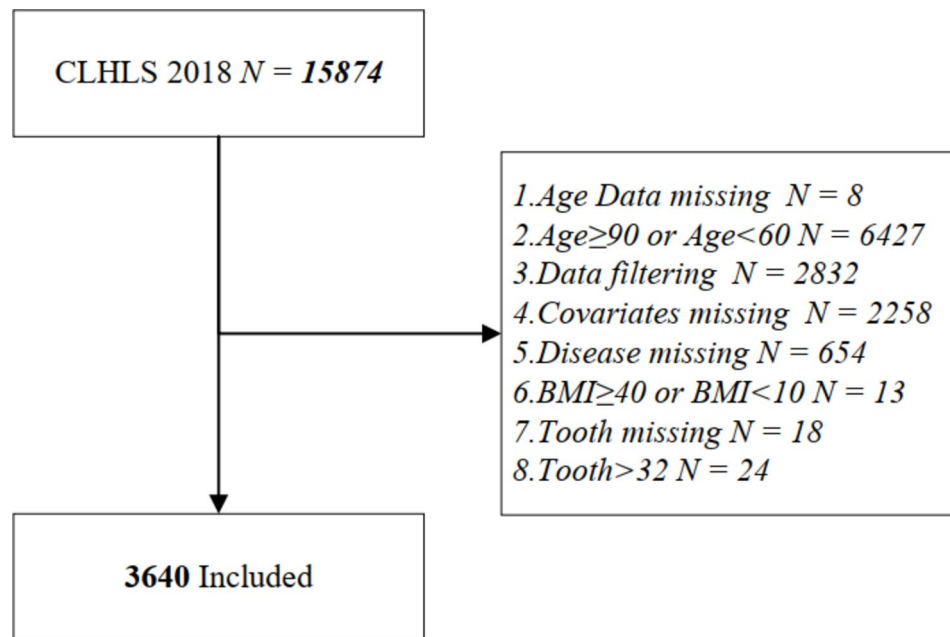
## Discussion

The results indicated that there was an association between multimorbidity and having less than 20 natural teeth among the older adults. Older adults with multimorbidity were found to have a higher prevalence of having less than 20 natural teeth compared to those without chronic diseases.

Having less than 20 natural teeth is a major public health issue influenced by biological, behavioral, and socioeconomic factors<sup>7</sup>, in addition to the two main causes of dental caries and periodontitis, we also found that common demographic characteristics and health behavior habits, such as gender, age, education level, and marital status, influence the rate of having less than 20 natural teeth among the older adults in this study. This is consistent with previous research findings<sup>46,47</sup>. Specifically, age is positively correlated with having less than 20 natural teeth, and this phenomenon increases steeply when the age reaches 70 years old<sup>48</sup>. Additionally, education level may have a significant impact on having less than 20 natural teeth in this study. We observed that older adults with no education are more likely to suffer from having less than 20 natural teeth compared to

Variable		Classification
Independent variable	Number of chronic diseases <sup>16,24</sup>	No chronic disease
		Only one chronic disease
		Multimorbidity
Dependent variable	Natural teeth count <sup>45</sup>	having less than 20 natural teeth
		having at least 20 natural teeth
Covariates	Sociodemographic characteristics	Gender <sup>16</sup>
		Male
		Female
		Age <sup>16</sup>
		60 ≤ Age < 75
		75 ≤ Age < 90
		Education level <sup>16</sup>
		No education
		Primary to junior high school
		High school and above
	Marital status <sup>57</sup>	Married and living with spouse
		Married but not living with spouse
		Divorced or widowed or never married
	Source of income <sup>19</sup>	Sufficient
		Insufficient
	Health behavior habits	Room condition <sup>58</sup>
		Musty
		Not musty
		Ventilation condition <sup>58</sup>
		Not ventilated
		Ventilated
		Main taste preference <sup>59</sup>
		Light
		Salty
		Others
		Frequency of fruit intake <sup>60</sup>
		Daily
		Often
		Sometimes or rarely
		Frequency of vegetable intake <sup>60</sup>
		Daily
		Often
		Sometimes or rarely
		Smoking <sup>16</sup>
		Yes
		No
		Alcohol consumption <sup>60</sup>
		Yes
		No
		Exercise <sup>60</sup>
		Yes
		No
		Ability to perform daily activities <sup>45</sup>
		Severely limited
		Somewhat limited
		Not limited
		Medical expenses in the past year <sup>61</sup>
		Less than 1000 yuan
		1000 yuan and above
		Annual physical examinations <sup>62</sup>
		Yes
		No
		Frequency of brushing teeth <sup>63</sup>
		Never
		Occasionally
		Often(at last once per day)
		Toothache in the past six months <sup>64</sup>
		Yes
		No
		BMI <sup>19</sup>
		18.5 ≤ BMI < 24
		BMI < 18.5
		BMI ≥ 24

**Table 1.** Study's variables.



**Fig. 1.** Data Screening Flowchart.

those with education. From a social perspective, higher education levels provide better access to resources and higher health awareness, influencing lifestyle and behavior<sup>49</sup>, meanwhile, older adults without education often lack knowledge about oral health and dental care, leading to poorer oral health and higher rates of having less than 20 natural teeth<sup>50</sup>. The findings demonstrate that older adults who engage in regular tooth brushing and physical exercise exhibit a significantly reduced risk of having less than 20 natural teeth. Notably, the frequency of brushing teeth serves as a significant moderating factor in the association between multimorbidity and having less than 20 natural teeth, suggesting that oral hygiene behaviors may play a buffering role in mitigating the adverse effects of systemic chronic diseases on oral health. Furthermore, the observed relationship implies that having less than 20 natural teeth is closely linked to individual activity levels. Collectively, these findings emphasizing that enhancing awareness of daily physical activities, structured exercise among older adults and improving their self-care capacity could reduce the risk of severe tooth loss in this population.

This study focuses on the association between multimorbidity and having less than 20 natural teeth among older adults. The results indicate that there is an association between multimorbidity and having less than 20 natural teeth in the older adult population. This result is consistent with the findings of Mohamed<sup>45</sup>. Older adults with two or more chronic diseases tend to have a higher prevalence of having less than 20 natural teeth compared to those without chronic diseases. Existing research shows that patients with multimorbidity often experience multi-organ involvement and greater systemic inflammatory responses, leading to the overexpression of inflammatory factors, which exacerbates periodontal infections and causes the condition of having less than 20 natural teeth<sup>51</sup>. Furthermore, scholars like Hayata et al. have found that pathogenic bacteria in the mouths of individuals with having less than 20 natural teeth can colonize the respiratory or digestive tract, contributing to the development of lung diseases such as chronic obstructive pulmonary disease, which indicates that there may be a potential bidirectional relationship between multimorbidity and having less than 20 natural teeth<sup>52</sup>. On the other hand, older adults with multimorbidity often require polypharmacy for treatment, and many medications, especially anticholinergics, antidepressants, and some bronchodilators, can induce dry mouth<sup>53</sup>. Dry mouth not only causes chewing and swallowing problems but also affects taste, speech, denture tolerance, and increases the risk of oral mucosal diseases and caries (tooth decay), leading to a higher risk of having less than 20 natural teeth<sup>54,55</sup>.

It is crucial to recognize the association between multimorbidity and having less than 20 natural teeth among older adults and consider the oral condition of patients when treating those with multiple chronic diseases. Currently, several states in the United States have successfully piloted integrated treatment programs for chronic diseases and oral health, promoting collaboration between various departments to deal with chronic diseases and oral health<sup>55</sup>. This association has not yet received much attention in China. However, with the progression of healthcare in China, oral health has been incorporated into the "China Health Action 2030" blueprint<sup>56</sup>, indicating a promising future where China will pay increasing attention to the oral health. Medical staff should offer oral health education specifically tailored for older adults with multimorbidity. Develop relevant public health prevention plans that address the relationship between multimorbidity and having less than 20 natural teeth, and provide optimal dental service conditions for older people living in economically disadvantaged and poorly educated areas, which can help reduce the risk of having less than 20 natural teeth<sup>14</sup>.

Variable			n(%) (N = 3640)	Proportion of having less than 20 natural teeth (%)	$\chi^2$	p
Sociodemographic characteristics	Gender	Male	1807(49.64)	56.50	4.60	0.03
		Female	1833(50.36)	60.01		
	Age	60 ≤ Age < 75	2126(58.41)	47.32	252.06	<0.001
		75 ≤ Age < 90	1514(41.59)	73.65		
	Education level	No education	1116(30.66)	68.46	100.24	<0.001
		Primary to junior high school	2047(56.24)	56.42		
		High school and above	477(13.10)	42.35		
	Source of income	Sufficient	3123(85.80)	57.41	6.63	0.01
		Insufficient	517(14.20)	63.44		
	Marital status	Married and living with spouse	2396(65.82)	53.80	62.06	<0.001
		Married but not living with spouse	71(1.95)	54.93		
		Divorced or widowed or never married	1173(32.23)	67.60		
Health behavior habits	Room condition	Musty	507(13.93)	63.12	5.69	0.02
		Not musty	3133(86.07)	57.48		
	Ventilation condition	Not ventilated	301(8.27)	62.13	2.01	0.16
		Ventilated	3339(91.73)	57.92		
	Staple food	Rice	2206(60.60)	57.75	3.48	0.18
		Flour	627(17.23)	61.56		
		Other	807(22.17)	57.13		
	Frequency of fruit intake	Daily	870(23.90)	51.38	36.08	<0.001
		Often	2012(55.27)	58.30		
		Sometimes or rarely	758(20.82)	66.09		
	Frequency of vegetable intake	Daily	2635(72.39)	55.83	31.61	<0.001
		Often	951(26.13)	63.62		
		Sometimes or rarely	54(1.48)	83.33		
	Main taste preference	Light	2589(71.13)	57.78	0.94	0.63
		Salty	789(21.68)	59.70		
		Others	262(7.20)	58.78		
	Smoking	Yes	707(19.42)	58.27	0.00	1.00
		No	2933(80.58)	58.27		
	Alcohol consumption	Yes	666(18.30)	53.60	7.30	0.01
		No	2974(81.70)	59.31		
	Exercise	Yes	1497(41.13)	53.44	24.39	<0.001
		No	2143(58.87)	61.64		
	Ability to perform daily activities	Severely limited	155(4.26)	62.58	31.20	<0.001
		Somewhat limited	599(16.46)	68.11		
		Not limited	2886(79.29)	55.99		
	Medical expenses in the past year	Less than 1000 yuan	2095(57.55)	57.71	0.64	0.43
		1000 yuan and above	1545(42.45)	59.03		
	Annual physical examinations	Yes	2929(80.47)	57.66	2.25	0.13
		No	711(19.53)	60.76		
	Frequency of brushing teeth	Never	333(9.15)	86.79	132.05	<0.001
		Occasionally	2114(58.08)	57.38		
		Often	1193(32.77)	51.89		
	Toothache in the past six months	Yes	841(23.10)	53.51	10.20	0.00
		No	2799(76.90)	59.70		
	BMI	18.5 ≤ BMI < 24	1834(50.38)	61.23	40.82	<0.001
		BMI < 18.5	327(8.98)	71.25		
		BMI ≥ 24	1479(40.63)	52.40		
Multimorbidity	Number of chronic diseases	No chronic disease	2608(71.65)	55.90	21.20	<0.001
		Only one chronic disease	779(21.40)	64.44		
		Multimorbidity	253(6.95)	63.64		

**Table 2.** Differential analysis of having less than 20 natural teeth rates among Chinese older adults with different sociodemographic characteristics, health behavior habits and Multimorbidity.



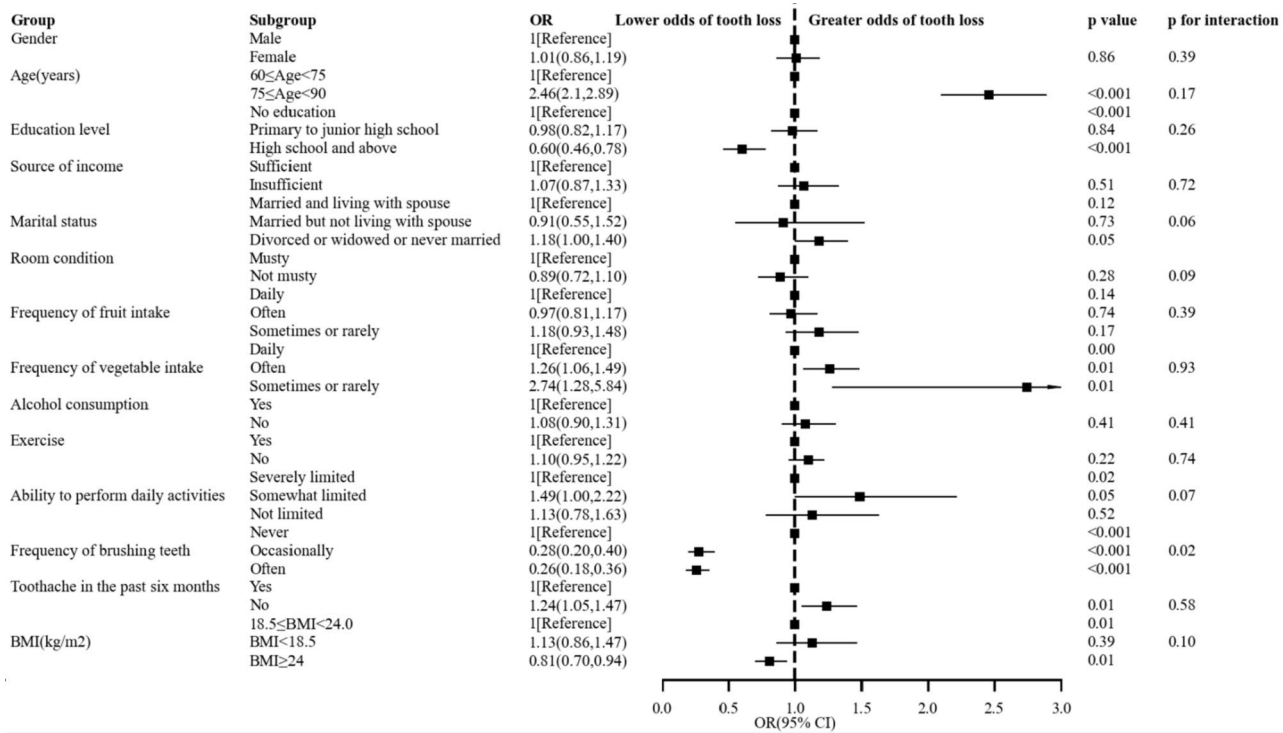
Variable			B	S.E.	Wald $\chi^2$	p	OR	95%CI	
								Lower limit	Upper limit
	Gender	Male					reference		
		Female	0.01	0.08	0.03	0.86	1.01	0.86	1.19
	Age	60 ≤ Age < 75					reference		
		75 ≤ Age < 90	0.90	0.08	121.47	< 0.001	2.46	2.10	2.89
	Education level	No education			19.41	< 0.001	reference		
		Primary to junior high school	-0.02	0.09	0.04	0.84	0.98	0.82	1.17
		High school and above	-0.51	0.14	14.16	< 0.001	0.60	0.46	0.78
	Source of income	Sufficient					reference		
		Insufficient	0.07	0.11	0.43	0.51	1.07	0.87	1.33
	Marital status	Married and living with spouse			4.21	0.12	reference		
Married but not living with spouse		-0.09	0.26	0.12	0.73	0.91	0.55	1.52	
Divorced or widowed or never married		0.17	0.09	3.93	0.05	1.18	1.00	1.40	
Health behavior habits	Room condition	Musty					reference		
		Not musty	-0.12	0.11	1.16	0.28	0.89	0.72	1.10
	Frequency of fruit intake	Daily			3.99	0.14	reference		
		Often	-0.03	0.10	0.11	0.74	0.97	0.81	1.17
		Sometimes or rarely	0.16	0.12	1.90	0.17	1.18	0.93	1.48
	Frequency of vegetable intake	Daily			12.78	0.00	reference		
		Often	0.23	0.09	6.81	0.01	1.26	1.06	1.49
		Sometimes or rarely	1.01	0.39	6.76	0.01	2.74	1.28	5.84
	Alcohol consumption	Yes					reference		
		No	0.08	0.10	0.67	0.41	1.08	0.90	1.31
	Exercise	Yes					reference		
		No	0.10	0.08	1.53	0.22	1.10	0.95	1.28
	Ability to perform daily activities	Severely limited			8.20	0.02	reference		
		Somewhat limited	0.40	0.20	3.87	0.05	1.49	1.00	2.22
		Not limited	0.12	0.19	0.42	0.52	1.13	0.78	1.63
	Frequency of brushing teeth	Never			57.62	< 0.001	reference		
		Occasionally	-1.27	0.17	52.97	< 0.001	0.28	0.20	0.40
		Often	-1.37	0.18	55.95	< 0.001	0.26	0.18	0.36
	Toothache in the past six months	Yes					reference		
		No	0.21	0.09	6.25	0.01	1.24	1.05	1.47
BMI	18.5 ≤ BMI < 24			9.84	0.01	reference			
	BMI < 18.5	0.12	0.14	0.75	0.39	1.13	0.86	1.47	
	BMI ≥ 24	-0.21	0.08	7.39	0.01	0.81	0.70	0.94	
Number of chronic diseases	Number of chronic diseases	No chronic disease			12.89	0.00	reference		
		Only one chronic disease	0.28	0.09	9.18	0.00	1.32	1.10	1.57
		Multimorbidity	0.35	0.15	5.66	0.02	1.42	1.06	1.89
		Constant	0.78	0.31	6.38	0.01	2.18		

**Table 3.** Adjusted odds ratios and 95% confidence intervals of sociodemographic characteristics, health behavior habits and Multimorbidity of having less than 20 natural teeth in the Chinese older adults. Note: The model corrects the sociodemographic characteristics and health behavior habits.

### Strengths and limitations of the study

The advantage of this study lies in its focus on the relationship between multimorbidity and having less than 20 natural teeth among the older adults in China, while also expanding the scope of chronic diseases studied. Currently, most research concentrates on a few common chronic diseases such as hypertension and diabetes, with less attention given to other chronic conditions like cataracts and tuberculosis in relation to tooth loss. By broadening the range of chronic diseases under investigation, this study can more comprehensively explore the relationships between these diseases and having less than 20 natural teeth in the older adults, thereby providing a more complete scientific basis for future prevention and intervention measures.

However, this study also has certain limitations. First, it employs a cross-sectional design. Although our findings clearly indicate a relationship between the presence of multimorbidity and having less than 20 natural teeth, the study does not provide longitudinal observations on having less than 20 natural teeth, thus preventing the establishment of a temporal relationship and exploration of a definitive causal relationship between the two. In addition, since the study participants are older adults aged 60 and above, recalling past exposure history or



**Fig. 2.** The Odds Ratios (95% Confidence Interval) of having less than 20 natural teeth among different demographic characteristics and multimorbidity groups of older adults in China. The horizontal line (X-axis) represents the 95% confidence interval of the OR value; The center vertical line (OR = 1) serves as a reference line perpendicular to the X-axis, indicating no effect; The small square is positioned at the OR value of the confidence interval.

medical history may lead to memory distortion or incomplete recollection due to the long passage of time, and there may be bias in self-perception when answering questionnaires in self-examination of disease. Furthermore, disease status was determined using a self-reported strategy, which poses a limitation regarding the accuracy of the data. Participant may have recall bias during the process of recall, resulting in self-reported underestimation or overestimation due to inaccurate or incomplete memory. This bias is particularly common in studies that rely on self-reported data, affecting the reach and generalizability of the study's results.

In this study, we incorporated all interaction terms simultaneously into the logistic regression model to comprehensively assess potential interaction effects. While this approach allowed for straightforward evaluation of multiple interactions, it also increased the risk of multicollinearity, potentially leading to unstable coefficients and reduced interpretability. Moreover, the complexity of the model might have masked subtle interactions that could be better identified individually. Future research could adopt a stepwise approach to introduce interaction terms sequentially, minimizing multicollinearity and providing clearer insights into each interaction's contribution.

In addition, the database used in this study employed an oversampling method, which may have introduced age distribution bias. Interaction analysis revealed a significant influence of age on the relationship between multimorbidity and having less than 20 natural teeth. However, this study did not further explore its specific mechanism, and we look forward to future research providing deeper insights into this aspect.

Conclusions

There is an association between multimorbidity and having less than 20 natural teeth in the older adults. Healthcare professionals should pay attention to the oral health of patients with multimorbidity while treating their chronic conditions and guide patients to use oral care resources appropriately in the early stages of their disease. This will help raise awareness of oral health care and enhance the prediction of risks related to having less than 20 natural teeth and chronic systemic diseases. The findings emphasize the relationship between the oral health of older adults and multimorbidity. Oral health institutions should implement measures to prevent older adults with multimorbidity from having less than 20 natural teeth and develop more comprehensive public health policies to ensure their oral health.

Data availability

This study is based on the dataset of the Longitudinal Healthy Longevity Survey (CLHLS) in China Longevity Region. The data utilized in this study is freely accessible on the Peking University Open Research Data Platform, accessible via the following <https://doi.org/10.18170/DVN/WBO7LK>.



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## Author contributions

Yang Fu, Mei Yin, and Lei Shi conducted research; Wu Yi, Hui Liu Yue Qin, HaoRan Chen and Junling Ma wrote papers; Wu Yi, Hui Liu, Yue Qin, HaoRan Chen, Mei Yin, Lei Shi, and Yang Fu provided administrative, technical or material support and critically revised the important intellectual content of the manuscript; All the authors revised the final version of the manuscript, and Yang Fu, Mei Yin, and Lei Shi gave the final approval.

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## Declarations

## Competing interests

The authors declare no competing interests.

### Ethics approval and consent to participate

The study was approved by the ethics committees from both the Duke University Institutional Review Board (Protocol No. Pro00062871) and the Peking University Biomedical Ethics Committee (Approval No. IRB00001052-13074). The CLHLS database has not been clinically registered. All methods were performed in accordance with Declaration of Helsinki and Strengthening the Reporting of Observational studies in Epidemiology. Written informed consent was obtained from all participating individuals prior to their enrollment in the study.

### Consent for publication

Not Applicable.

### Additional information

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