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Association of oral health status with overweight and obesity in older adults aged ≥ 65 years- evidence from Chinese communities

Kan Wu¹, Wei yin², Xinhua Liang¹ and Zheng Yang^{3*}

Abstract

Objectives To evaluate the association of poor oral health conditions, such as caries, tooth loss, and tooth loss, with overweight and obesity in older adults and to complement evidence from the Chinese community to confirm this association. Additionally, we evaluated the sociodemographic characteristics, health status, and impact of health-related behavior on the BMI of older adults.

Methods This retrospective study involved health examination and follow-up data of 953 older adults from the Sichuan Province of China from 2021 to 2023. The caries status assessed by the Decayed, Missing, and Filled Teeth (DMFT) index, was used as the exposure factor, whereas body mass index (BMI) was used as the outcome indicator. The influence of confounding variables, namely the sociodemographic characteristics, health status, and oral health-related behavior, was controlled. BMI changes in older adults with different levels of oral health over 3 years were retrospectively followed up. Additionally, a Cox proportional hazard model was used to determine the association.

Results Overweight and obesity were prevalent in 29.3% and 20.4% of older adults with poor and good oral health status, respectively ($P < 0.01$). After controlling for the confounding factors, the Cox proportional hazards model demonstrated that the DMFT index was associated with overweight or obesity (BMI) (*hazards ratio* = 1.86, *95% confidence interval*: 1.52–2.28). Overweight and obesity were less prevalent in older adults with fewer chronic diseases, higher frequency of physical exercise, and better oral health-related behaviors.

Conclusions Oral health status is positively associated with overweight and obesity in older adults, particularly in older adults presenting with caries, missing teeth, and tooth loss as their primary symptoms.

Keywords BMI, DMFT, Oral disease, Oral health, Obesity, Overweight, Older adults, Survival analysis

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Introduction

Oral diseases are a public health problem globally [1]; approximately 55% of people with different levels of oral diseases, particularly older adults, experience this disease burden [2]. Older adults have poor awareness of oral health care, with caries, periodontal disease, and tooth loss as major problems. With aging, tooth loss becomes more pronounced among older adults, substantially affecting their quality of life. Multifactorial causes, including local oral diseases (such as periodontal disease and dental caries), systemic health conditions (such as diabetes and immune disorders), environmental factors (such as smoking and poor oral hygiene), external trauma, and genetic predispositions, contribute to tooth loss. Maintaining good oral hygiene, promptly treating oral diseases, managing systemic health conditions, and avoiding trauma and harmful habits can effectively prevent tooth loss. Oral diseases affect not only the mouth and chewing capacity but also physiological functions, such as pronunciation [3, 4]. Eventually, they affect the entire body, leading to heart disease, stroke, and obesity, thereby endangering the survival of older adults [5, 6]. The rapid growth of overweight and obesity rates worldwide has become one of the leading causes of mortality. Obesity has been strongly associated with various diseases and can lead to a high risk of early mortality [7]. The health and economic burden posed by obesity continues to increase. Obesity and overweight are prevalent in 59.2% of people aged ≥ 60 years in China [8].

Several studies have reported the association of oral health status with overweight and obesity [3, 5]. For example, oral inflammatory diseases have been widely associated with the pathophysiological process underlying obesity [7, 9]. Additionally, the dental status in older adults can affect food choices and nutrient intake. Missing teeth may be associated with the body mass index (BMI) [10]. This is because missing teeth can cause difficulty in chewing, thus affecting nutritional intake and body weight. Both dietary habits and lifestyle may affect body weight and oral health [11]. Additionally, some studies have demonstrated a correlation of obesity or overweight with dental caries. Sugar is the primary cause of tooth decay [12]; for example, excess sugar intake may increase the risk of dental caries [8, 12]. Moreover, a high-sugar diet can lead to overweight or obesity. These signs may contribute to altered food choices and increase the risk of overweight and obesity.

Higher BMI may be associated with poor oral health. However, the causal association is unclear [13]. Some studies have only demonstrated an association without confirming that BMI changes directly altered the Decayed, Missing, and Filled Teeth (DMFT) index [14]. However, both BMI and oral health are influenced by

multiple factors, including genetics, lifestyle, and socioeconomic status, which may complicate the causal association [15]. Despite an association between BMI and DMFT index, the causal association and underlying mechanism need to be explored. In this study, oral health status (DMFT index) was considered as the exposed factor, whereas BMI was considered as the outcome indicator [16]. The major confounding variables included chronic disease management, physical activity, and oral health-related behavior [17]. This 3-year-long retrospective study investigated BMI changes among community-dwelling older adults with different oral health levels. The Cox proportional hazards model was used to determine the association between oral health and BMI, particularly in older adults.

Materials and methods

Data sources

Data were retrospectively collected from a team of community family doctors across national basic public health services in Sichuan province, China. Data were acquired from health check-ups and follow-ups for older adults. Community health check-ups were conducted yearly, whereas follow-ups were conducted once every 3 months. The team of family doctors in the community conducted health examinations and follow-up care for older adults. The general practitioner conducted a full-body health check, including height, weight, blood pressure, and blood sugar measurements. A professional dentist at the community dental clinic conducted an oral examination to assess dental caries per the methods and standards set by the World Health Organization. Oral health follow-up was conducted by oral nurses, and data on oral health-related behavior were collected. The data primarily included sociodemographic characteristics, general health status, and chronic diseases, such as oral cavities. Of 11,093 older adults, those with inaccurate or missing data about health check-ups, follow-up management, and oral health behavior were excluded. Thus, data from 2,236 residents were retained. Additionally, residents who were lost to the follow-up or withdrew from the study for various reasons were excluded. Finally, samples with changed and missing values of oral health status between 2021 and 2023 were excluded. Older adults with normal BMI in 2021 were selected as the participants; oral health status was chosen as the exposure factor to determine BMI changes in the past 3 years. Figure 1 illustrates the sample screening process.

Inclusion and exclusion criteria

Based on the retrospective study design, the inclusion criteria for the study population were as follows: (1) age ≥ 65 years, with health records documented by the

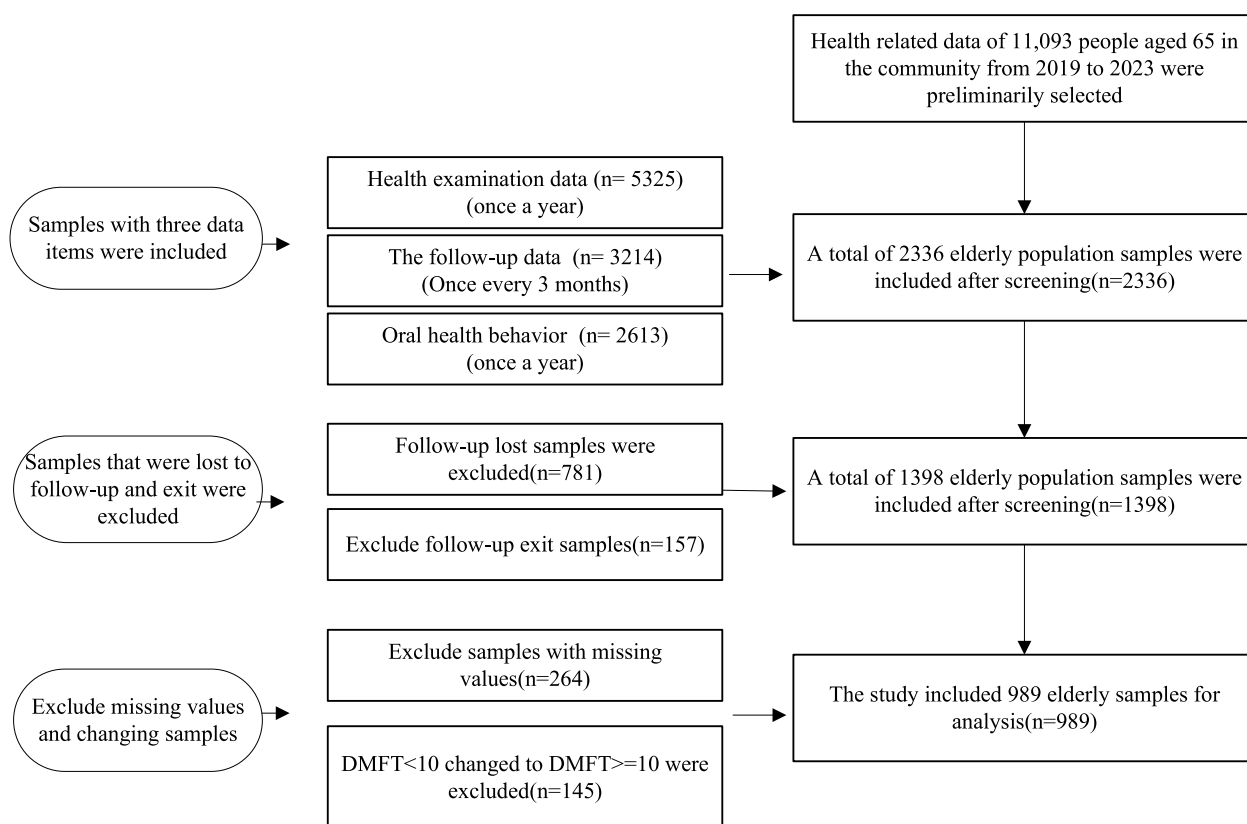


Fig.1 Sample screening process

community family doctors, and received free annual health check-ups and regular follow-up services; (2) BMI maintained from 18.5 kg/m² to 22.9 kg/m² at the beginning of the observation in 2021; (3) could understand the basic health guidelines and instructions during data collection; and (4) could cooperate with the family doctors to complete all health examinations, including oral examination, during the study and follow-up. The exclusion criteria were as follows: (1) serious systemic, endocrine, or digestive diseases and (2) apparent oral health problems. Older adults with substantial DMFT changes were excluded because of their likelihood to be affected by additional confounding factors, such as severe oral diseases, systemic conditions, trauma, and other related factors, which could interfere with the results.

Study variables

The collected data were primarily categorized as follows: (1) sociodemographic characteristics were extracted from the residents' health records; (2) whole body health status data were extracted from the annual physical examinations and follow-up records every 3 months. The health examination primarily consisted of three components as follows: (1) basic examination, including height,

weight, blood pressure, heart rate, and respiratory rate measurements, to assess the overall health condition; (2) routine blood tests to assess conditions, such as anemia or infection; and (3) specialized examinations covering areas, such as the ears, nose, throat, mouth, chest, lungs, and bones. The follow-up primarily included the following components: (1) height and weight measurements; (2) blood pressure and blood sugar measurements; (3) oral health examinations, primarily involving missing teeth, tooth loss, conditions of the oral mucosa, and periodontal health records; and (4) health-related behavior assessment. Oral health status and behavior data were extracted from the special oral examination list. According to our research design, all data were divided into independent, dependent, and control variables according to the research purpose. The specific research variables were as follows:

BMI (dependent variable)

BMI is an international standard that measures the degree of body fat and determines whether the body weight is within a healthy range. It is calculated as the ratio of body weight (kg) and square of the body height (m) (kg/ m²). Community family doctors measured the BMI using a

digital scale and tape measure to standardize the data collection. According to the World Health Organization, older adults with Asian ancestry with BMI < 18.5 kg/m², ≥ 18.5 kg/m² to < 23 kg/m², and ≥ 23 kg/m² are classified as underweight, normal weight, and overweight and obesity, respectively. To facilitate the classification, overweight and obese were regarded as a single category in this study.

DMFT (independent variable)

The DMFT index was used to assess oral health. D (Decay) refers to the number of teeth or tooth surfaces with caries. M (Miss) represents the number of teeth lost because of dental caries. F (Fill) denotes the number of teeth or surfaces that have been filled because of caries. The DMFT score is calculated as the sum of the number of teeth (or surfaces) affected by caries, lost because of caries, and filled because of caries. The DMFT index score denotes the total number of DT, MT, and FT. A DMFT index score < 10 indicated good oral health, whereas a score ≥ 10 indicated poor oral health.

Oral health behavior (control variable)

Oral health behavior was primarily investigated by collecting text records of community family doctors during health examinations. Ten variables associated with oral health behavior were included as follows: (Behavior 1) “Do you consistently brush your teeth twice daily?”; (Behavior 2) “Do you brush your teeth for at least 3 min each time?”; (Behavior 3) “Do you use fluoride toothpaste regularly?”; (Behavior 4) “Do you use toothpicks or dental floss regularly?”; (Behavior 5) “Do you follow a vertical brushing technique?”; (Behavior 6) “Do you replace your toothbrush every 2 to 3 months?”; (Behavior 7) “Do you use a soft bristle toothbrush consistently?”; (Behavior 8) “Do you clean your mouth after meals?”; (Behavior 9) “Do you avoid chewing hard objects?”; and (Behavior 10) “Do you visit your dentist regularly?”. Each affirmative answer scored 1 point, for a total score of 10 points.

Additionally, the control factors were as follows: (1) demographic and sociodemographic characteristics, such as age, sex, education level, and marital status; (2)

physical health status based on the number of chronic diseases among older adults, focusing on hypertension and diabetes. The participants were categorized into three groups, namely no chronic diseases, one chronic disease, and two or more chronic diseases; and (3) health-related behavior, including smoking, drinking, sleep, and physical activity. Smoking, drinking, and physical activity were considered categorical variables with three levels—more, moderate, and less. In contrast, sleep duration was categorized into two groups, namely 6 to 8 h and < 6 h, based on the sleep standards for older adults.

Ethical approval

This study was approved by the Research Ethics Committee of the University of West China Hospital of Stomatology, Sichuan University. All information was desensitized and absolute confidentiality was maintained. The selected residents were informed about the study by their community physicians. The research purpose was explained, and informed consent was obtained.

Statistical analysis

Descriptive statistical methods were used to define the basic characteristics and obesity level of the participants. The chi-square test was used to analyze the single factor between oral diseases and obesity symptoms in older adults. Single- and multiple-factor Cox proportional hazards models were used to analyze the correlation between oral disease symptoms and obesity. The significance level was alpha = 0.05. Additionally, forest plots and survival curves were plotted.

Results

Basic characteristics

The research examined the relationship between oral diseases and being overweight or obese among middle-aged and older adults from 2021 to 2023. In 2021, 989 older adults had obesity, including 575 (58.14%) and 414 (41.86%) with DMFT index scores < 10 and ≥ 10, respectively. By 2023, 202 older adults (48.79%) with overweight or obesity had a DMFT index score ≥ 10, whereas 212 older adults (36.87%) with obesity had a DMFT index score < 10 (*P* < 0.01) (Table 1).

Table 1 Changes in overweight and obesity in the elderly population from 2021 to 2023

BMI	2021 year		2023 year		χ ²	P value
	DMFT < 10	DMFT ≥ 10	DMFT < 10	DMFT ≥ 10		
18.5 ≤ BMI < 23	575(100%)	414(100%)	363 (63.13%)	212 (51.21%)	14.05	< 0.001
23 ≤ BMI	0(0%)	0(0%)	212 (36.87%)	202 (48.79%)		
Total	575(100%)	414(100%)	575(100%)	414(100%)		

Univariate Cox regression analysis

The oral health status was significantly associated with people with overweight and obesity ($P < 0.05$). Additionally, age, the number of chronic diseases, alcohol consumption, physical exercise, frequency and duration of brushing teeth, using toothpicks and dental floss, gargling after meals, reducing chewing of hard objects, and visiting the dentist regularly affected older adults with overweight and obesity ($P < 0.05$) (Table 2).

Multivariate Cox regression analysis

The oral health status was associated with people with overweight and obesity after controlling for age, number of chronic diseases, alcohol consumption, physical exercise, and oral health-related behaviors (hazards ratio = 1.86, $P < 0.05$; 95% confidence interval: 1.52–2.28). Older adults with poor oral health were more likely to be overweight and obese (Fig. 2).

Survival curves for each subgroup

Multivariable Cox regression analysis was conducted for the significant factors. Additionally, survival curves were analyzed for different subgroups. The rate of overweight and obesity was low in older adults. By contrast, the detection rate was high among those with chronic diseases (Fig. 3). Additionally, less physical movement and high alcohol consumption were associated with high rates of overweight and obesity. Overweight and obesity were less prevalent in older adults with good oral health behavior, such as brushing their teeth twice a day for 3 min each, using toothpicks and floss to clean the mouth, and reducing chewing of hard objects (Fig. 4).

Discussion

Considering oral health in older adults as the exposure factor, this study demonstrated the association of oral health status with overweight and obesity. After controlling for confounding factors, such as sociodemographic characteristics, health status, and health-related behaviors, older adults with poor oral health were more likely to be overweight and obese [16]. This finding may be attributed to lifestyle and dietary habits [18]. First, older adults with poor oral health may experience chewing difficulties because of severe dental caries, missing teeth, and tooth loss, which can substantially decline their chewing function [19]. Thus, older adults may become more inclined to consume soft and chewable food, such as high-sugar and high-fat foods [20]. However, they have high energy density but low nutritional value, thus leading to overweight and obesity [21]. Second, because of chewing problems, older adults may reduce their intake of fiber-rich foods, such as fruits, vegetables, and whole grains, which affects their diet quality and nutritional

balance [21, 22]. Eventually, an unbalanced diet may lead to weight gain and obesity. Finally, poor oral health may change the eating frequency; for example, chewing difficulties may increase the eating frequency, thereby surging the overall caloric intake and leading to overweight or obesity [23]. Older adults with poor oral health have poor oral hygiene and lifestyle habits, including a lack of exercise and an unreasonable diet, which may affect their body weight [24].

Body weight is affected by numerous factors, such as the number of teeth, social psychology, chronic diseases, lifestyle, and other factors. Several studies on the association between oral health status and overweight/obesity have not considered physical activity [25]. Physical activity predicts weight control, which may exclude variables and affect the result accuracy [26, 27]. This study included physical activity as a control variable [28]; the association between oral health status and overweight/obesity was significant even after controlling for this variable, affirming the reliability of the results [9, 29]. The subgroup analysis of survival curves demonstrated that higher physical activity was associated with a lower risk of overweight and obesity in older adults with poor oral health [30].

Chronic diseases, such as hypertension and diabetes, affect body weight. For example, body weight is significantly associated with hypertension; weight gain leads to increased blood pressure [31]. Additionally, diabetes is associated with body weight. In this study, after considering the number of chronic diseases, diabetes was significantly associated with body weight [27]. Furthermore, the subgroup analysis demonstrated that older adults with fewer chronic diseases were less likely to be overweight or obese, consistent with the correlation between numerous chronic diseases and body weight [32].

Additionally, this study considered oral health-related behavior as an influencing factor [33]. The subgroup analysis demonstrated that healthy behavior, such as brushing teeth twice a day for 3 min each and flossing, can reduce dental caries and gum disease and improve oral health. Moreover, improved oral health can restore normal chewing function, enabling individuals to chew better and digest numerous foods, thus promoting healthier diet choices [34]. Good oral health behavior can reduce oral pain and discomfort and prompt individuals to chew varying food items, including fiber-rich fruits and vegetables [30]. Improved dietary behavior can reduce the intake of high-energy and high-fat foods, thereby aiding weight control. Thus, oral health-related behavior is an influencing factor; significant findings were obtained even after controlling for these factors, affirming the robustness of the results [29].

Table 2 Univariate Cox regression analysis

Characteristic		DMFT < 10		DMFT ≥ 10		Pvalue
		18.5 ≤ BMI < 23	23 ≤ BMI	18.5 ≤ BMI < 23	23 ≤ BMI	
Sex/case(%)	Male	147(40.5%)	98(46.2%)	96(45.3%)	98(48.5%)	0.097
	Female	216(59.5%)	114(53.8%)	116(54.7%)	104(51.5%)	
Age/case(%)	65-70 yr	64(17.6%)	118(55.7%)	37(17.5%)	100(49.5%)	< 0.001
	70-79 yr	153(42.1%)	64(30.2%)	95(44.8%)	76(37.6%)	
	≥ 80 yr	146(40.2%)	30(14.2%)	80(37.7%)	26(12.9%)	
Education level/case(%)	Illiterate	185(51.0%)	99(46.7%)	78(36.8%)	93(46.0%)	0.757
	Primary school and below	142(39.1%)	89(42.0%)	99(46.7%)	80(39.6%)	
	Junior high school or above	36(9.9%)	24(11.3%)	35(16.5%)	29(14.4%)	
Marital status/case(%)	Have a partner	307(84.6%)	185(87.3%)	188(88.7%)	170(84.2%)	0.783
	No partner	56(15.4%)	27(12.7%)	24(11.3%)	32(15.8%)	
Chronic disease/case(%)	0	175(48.2%)	62(29.2%)	121(57.1%)	48(23.8%)	< 0.001
	1	145(39.9%)	84(39.6%)	77(36.3%)	80(39.6%)	
	≥ 2	43(11.8%)	66(31.1%)	14(6.6%)	74(36.6%)	
Smoking/case(%)	Less	125(34.4%)	54(25.5%)	65(30.7%)	64(31.7%)	0.051
	Normal	93(25.6%)	67(31.6%)	54(25.5%)	60(29.7%)	
	More	145(39.9%)	91(42.9%)	93(43.9%)	78(38.6%)	
Drinking/case(%)	Less	182(50.1%)	51(24.1%)	116(54.7%)	56(27.7%)	0.442
	Normal	138(38.0%)	43(20.3%)	74(34.9%)	44(21.8%)	
	More	43(11.8%)	118(55.7%)	22(10.4%)	102(50.5%)	
Sleeping time/case(%)	< 6 h	37(10.2%)	20(9.4%)	24(11.3%)	22(10.9%)	0.724
	6–8 h	326(89.8%)	192(90.6%)	188(88.7%)	180(89.1%)	
	Exercise/case(%)	63(17.4%)	138(65.1%)	28(13.2%)	117(57.9%)	< 0.001
	Normal	78(21.5%)	53(25.0%)	65(30.7%)	51(25.2%)	
	More	222(61.2%)	21(9.9%)	119(56.1%)	34(16.8%)	
(Behavior 1) Do you consistently brush your teeth twice daily?	Yes	280(77.1%)	72(34.0%)	146(68.9%)	110(54.5%)	< 0.001
	No	83(22.9%)	140(66.0%)	66(31.1%)	92(45.45%)	
(Behavior 2) Do you brush your teeth for at least three minutes each time?	Yes	224(61.7%)	64(30.2%)	123(58.0%)	70(34.7%)	< 0.001
	No	139(38.3%)	148(69.8%)	89(42.0%)	132(65.3%)	
(Behavior 3) Do you use fluoride toothpaste regularly?	Yes	305(84.0%)	180(84.9%)	177(83.5%)	177(87.6%)	0.439
	No	58(16.0%)	32(15.1%)	35(16.5%)	25(12.4%)	
(Behavior 4) Do you use toothpicks or dental floss regularly?	Yes	228(62.8%)	69(32.5%)	127(59.9%)	68(33.7%)	< 0.001
	No	135(37.2%)	143(67.5%)	85(40.1%)	134(66.3%)	
(Behavior 5) Do you employ a vertical brushing technique?	Yes	129(35.5%)	234(64.5%)	72(34.0%)	71(35.1%)	0.677
	No	67(31.6%)	145(68.4%)	140(66.0%)	131(64.9%)	
(Behavior 6) Do you replace your toothbrush every 2–3 months?	Yes	173(47.7%)	96(45.3%)	103(48.6%)	87(43.1%)	0.193
	No	190(52.3%)	116(54.7%)	109(51.4%)	115(56.9%)	
(Behavior 7) Do you use a soft bristle toothbrush consistently?	Yes	297(81.8%)	192(90.6%)	188(88.7%)	171(84.7%)	0.115
	No	66(18.2%)	20(9.4%)	24(11.3%)	31(15.3%)	
(Behavior 8) Do you clean your mouth after meals?	Yes	287(79.1%)	119(56.1%)	143(67.5%)	106(67.5%)	< 0.001
	No	76(20.9%)	93(43.9%)	69(32.5%)	96(47.5%)	
(Behavior 9) Do you avoid chewing hard objects?	Yes	225(62.0%)	138(38.0%)	123(58.0%)	89(44.1%)	< 0.001
	No	92(43.4%)	120(56.6%)	89(42.0%)	113(55.9%)	
(Behavior 10) Do you visit your dentist regularly?	Yes	223(61.4%)	81(38.2%)	107(50.5%)	91(45.0%)	< 0.001
	No	140(38.6%)	131(61.8%)	105(49.5%)	111(55.0%)	

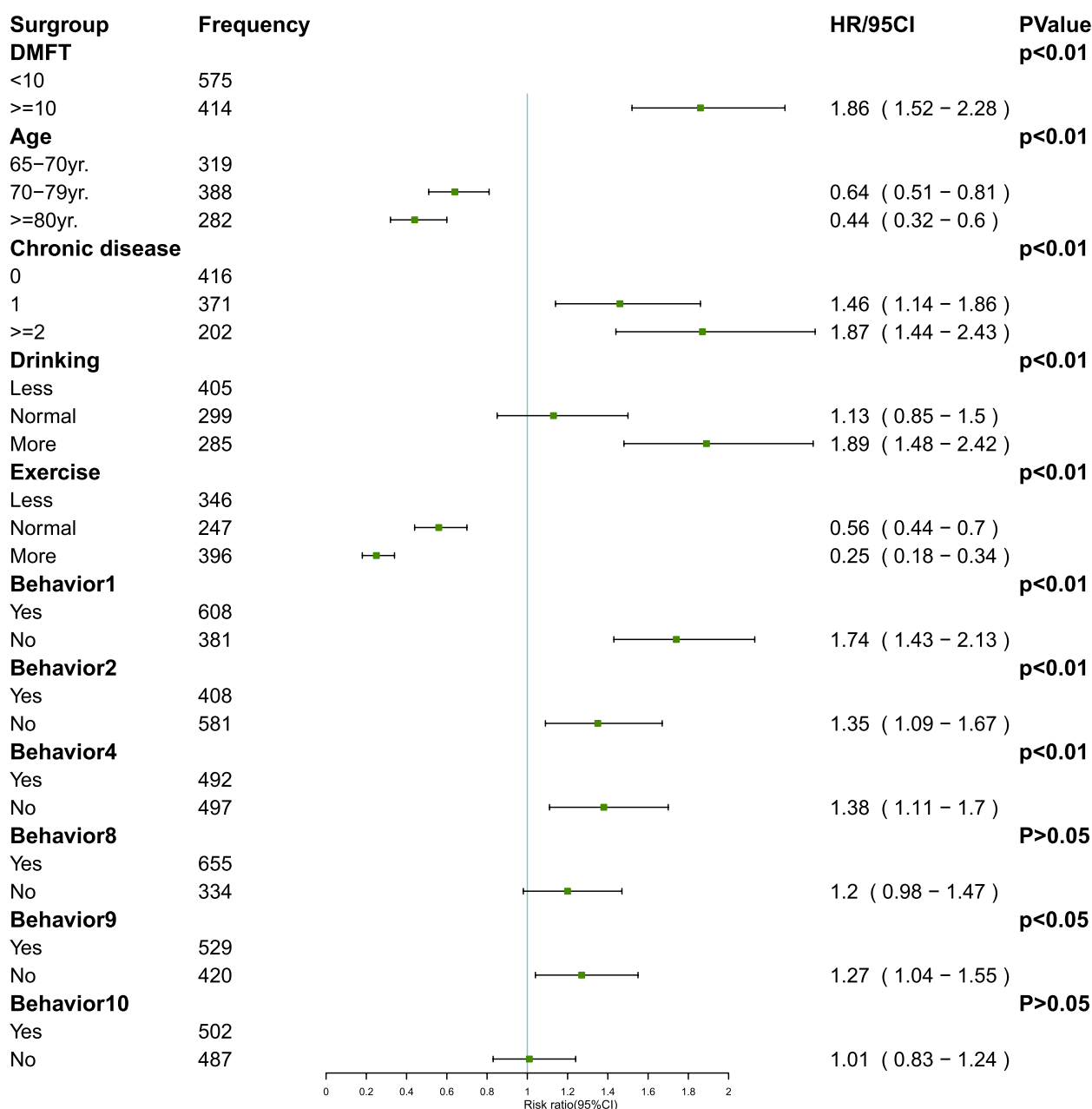


Fig.2 Multivariate Cox regression analysis and forest plot

This study has some limitations. First, this study considered the influence of multiple factors, such as chronic diseases, physical exercise, health behavior, and lifestyle [35]. However, limited data sources may have resulted in missing variables. This study did not exclude the influence of important factors, such as genetic factors, metabolic rate, and psychology [35, 36]. Second, the indicators for measuring oral health status are relatively single. Additionally, only the DMFT index was selected to represent the oral health status. However, indicators, such as periodontitis,

were excluded because of limited data, which resulted in overweight and obesity caused by oral inflammation [12]. This study has major implications because it demonstrates the causal association between oral health status and body weight based on the chronological sequence of overweight and obesity, after controlling for physical exercise, chronic diseases, oral health behavior, and other factors influencing body weight.

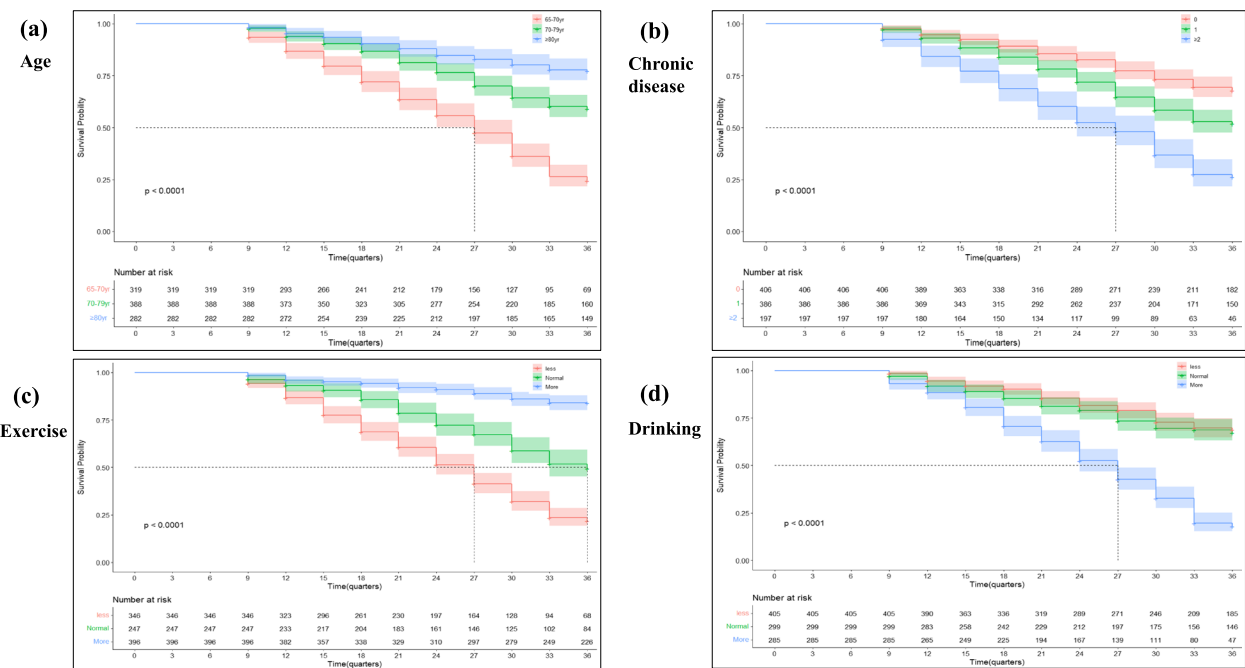


Fig.3 Survival curves for each subgroup (age, chronic disease, exercise, and drinking)

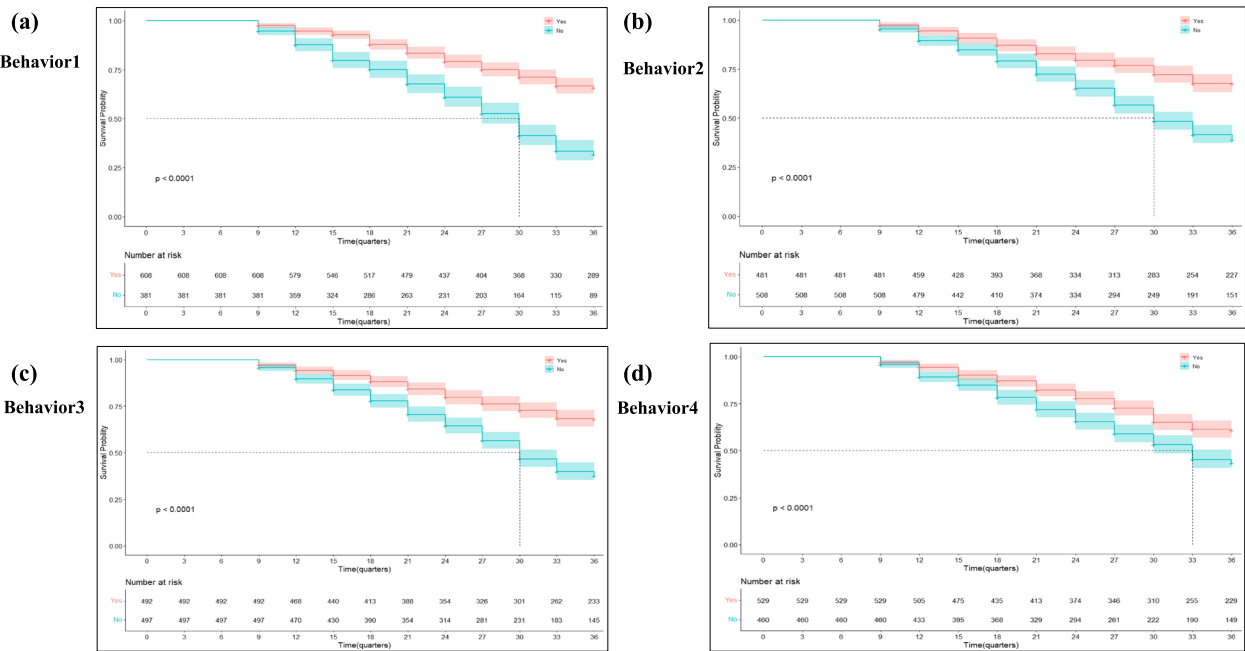


Fig.4 Survival curves for each subgroup (behavior1, behavior 2, behavior 3, and behavior 4)

Conclusions

Overweight and obesity were positively associated with oral health status in middle-aged and older adults, particularly in older adults with poor oral health

characterized by caries, missing teeth, and tooth loss. Additionally, the detection rates of overweight and obesity were lower in older adults with fewer chronic diseases, higher frequency of physical exercise, and better oral health-related behavior.

Abbreviations

BMI	Body Mass Index
DMFT	D stands for decayed. M stands for missing. F stands for “filled”
DT	Decayed teeth
MT	Missing teeth
FT	Filled teeth
COX	COX’s Proportional Hazard Model

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Not applicable.

Authors’ contributions

KW developed, in collaboration with WY, the idea of the changes of the influence of parents’ oral health literacy and behavior on oral health of preschool children aged 3–6 years. WY and X H L performed the statistical part. ZY contributed to the manuscript writing. WY provided the data of basic and oral health data for parents and children. All authors have read and approved the final manuscript.

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Data availability

Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB), West China Hospital of Stomatology, Sichuan University. In addition, consent to participate form was signed by each participant in the study. Our research fully adheres to the ethical principles outlined in the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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