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Linear and non-linear associations of depressive symptoms with oral health knowledge, attitudes, and practices among rural older adults in China: a cross-sectional study

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Abstract

Background Depression affects the oral health of older adults; however, little is known about its impact on oral health among rural older adults in developing countries, which warrants further research. Taking China as an example, there is a large population base of rural older adults suffering from depression, and many rural older people also have long-term oral health problems, which have seriously affected their quality of life in later life. Therefore, this study aimed to explore linear and non-linear associations of depressive symptoms with oral health knowledge, attitudes, and practices among rural older adults in China.

Methods From November 2020 to December 2020, 1,902 rural community-dwelling older people aged 60 years and older were investigated, via a cross-sectional survey. The general information, depressive status, oral health knowledge, attitudes, and practices of the participants were obtained through face-to-face structured questionnaires. Among them, the Zung Depression Self-Rating Scale was used to investigate the depressive symptoms of the participants in this survey. The generalized linear model and classification and regression tree model were used, separately.

Results Based on linear analysis results, we found that minimal to mild depressive symptoms [regression coefficient (β) = -0.345; 95% confidence interval (CI): -0.582 to -0.109, $P = 0.004$] and depressive symptoms (β = -1.064; 95% CI: -1.982 to -0.146, $P = 0.023$) were significantly correlated with oral health knowledge. A negative correlation was observed between minimal to mild depressive symptoms (β = -0.385; 95% CI: -0.600 to -0.170, $P < 0.001$) and oral health attitudes. In addition, while both minimal to mild depressive symptoms ($\beta = 0.018$; 95% CI: -0.312 to 0.347, $P = 0.916$) and depressive symptoms ($\beta = 0.604$; 95% CI: -0.675 to 1.883, $P = 0.355$) were associated with oral health practices. Furthermore, the non-linear analysis showed a combined effect of depressive symptoms on oral health attitudes, indicating that older people of a younger age, not living alone, and not suffering from depressive symptoms are more likely to report better oral health attitudes.

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Conclusion Both the linear and non-linear analyses in our study showed that depressive symptoms are significantly correlated with the poor oral health attitudes of older adults in rural communities. Furthermore, depressive symptoms were associated with oral health knowledge in the linear analysis. However, no statistically significant difference was found between depressive symptoms and oral health practices in either analysis. This research deepens our knowledge and understanding of relevant evidence in the mental and oral health of people in later life. In addition, analyzing the factors that affect the oral health of older people from the perspective of their depressive status provides new thinking directions and scientific references for improving the oral health of older adults in practical life.

Keywords Oral health, Depressive symptoms, Older people, Rural, China

Background

Nowadays, with an aging population worldwide, the health of older people has become a great concern [1]. Oral health is of great significance to the general health and quality of life of older adults [2]. For example, a survey from China showed a positive correlation between oral health and cognitive function among rural older adults in China, with lower levels of oral health leading to poorer cognitive function [3]. Another study suggests that maintaining good oral health in older people can effectively reduce the probability of frailty [4]. As a result, much attention has been paid to oral health, especially to oral health knowledge, attitudes, and practices [5]. The purpose of maintaining oral health and the conception of how to maintain oral health practice are all part of oral health knowledge, which is the basic premise of health-related behaviors [6]. Oral health attitudes refer to people's attitudes towards oral health [7], while oral health practices represent the basic behaviors or actions people take to maintain oral health [8]. Previous studies have shown that oral health knowledge, attitudes, and practices negatively correlate with oral conditions including dental caries, periodontitis, and tooth loss [9, 10]. Currently, World Health Organization defines oral health literacy as the motivation and ability to access, understand, and use information in ways that promote and maintain good health depending on their cognitive and social skills [11]. Previous studies have suggested that a lower oral health literacy could lead to poorer oral health outcomes [12, 13]. Therefore, maintaining good oral health literacy and improving it in terms of related knowledge, attitudes, and practices remains an urgent social issue.

Depression is a common health issue in later life [14]. A previous study has shown that approximately 28.4% of older adults worldwide suffer from depressive symptoms [15]. Similarly, the prevalence of depression among older people in China is exceedingly high, especially in rural areas where the prevalence of older people is about 24.0% [16]. Depression is recognized as a significant risk factor for many adverse outcomes, particularly in older adults [17]. For example, depressive symptoms can compromise cognitive performance [18], increase the probability of suffering from anxiety [19], and may even lead to suicide [20]. At present, the relationship between depressive symptoms and oral health knowledge, attitudes, and practices is understudied. In previous studies, the relationship between depressive status and poor oral health outcomes has been demonstrated [21, 22], indicating that older people with depressive symptoms tend to ignore oral hygiene procedures and avoid the need for dental care, eventually leading to an increased risk of oral disease [23]. However, according to current findings, the association between depressive symptoms and oral health in older adults is bi-directional [24, 25]. For example, some studies proved that people with poor oral health are more likely to suffer from depressive status [24, 26], while others concluded that depressive symptoms can harm the oral health of the respondents [27, 28]. Furthermore, in studies investigating the relationship between depressive symptoms and oral health in older adults, the methods used have mainly focused on linear models, showing that depressive status is harmful to oral health [23, 28].

In practice, the oral health outcomes of older adults are influenced by many factors, such as advanced age, being male, lower educational attainment, and living alone [28–30]. Although these factors have been fully explored in many studies, whether they interact with depressive symptoms to affect oral health in older adults remains unclear. Exploring multiple interactions is conducive to obtaining effective interventions to reduce the occurrence of oral health diseases, and these findings may be valuable in finding effective ways to improve oral health. Therefore, in order to explore the interactions between variables and their combined relationships, we adopted the classification and regression tree (CART) model, which is an original and complex non-parametric approach [31].

In addition, in the past decades, studies that examined the impact of depressive symptoms on oral health were mainly conducted in developed countries, such as Australia and the United States [28]. Findings on this topic focusing on developing countries are limited. Furthermore, the participants recruited for analyses

were from urban communities, whereas rural residents were less frequently discussed. Given the lack of medical and health resources in rural areas as well as the fact that older people are relatively poorly educated, more attention should be paid to these challenged communities [7, 32].

Therefore, linear and non-linear models were used in this study to explore the impact of depressive symptoms on oral health knowledge, attitudes, and practices of older people in rural China. The relationship between depressive status and oral health among rural older adults in developing countries can be better illustrated by the results of this study, which provides a foundation for promoting the oral health of older adults, thus improving their oral health care.

Methods

Data and study sample

In accordance with the study design requirements, a cross-sectional study was conducted from November to December 2020. A multi-stage stratified random sampling method was applied to recruit subjects. The sampling process of this study can be divided into the following three steps: Firstly, according to the research design and geographical location, we selected four regions from the east of China: Jinshan of Shanghai, Huzhou of Zhejiang Province, Changzhou of Jiangsu Province, and Huainan of Anhui Province. Secondly, two county-level regions were randomly selected from the abovementioned four regions, yielding a total of eight county-level regions. Finally, 2 to 4 communities, including urban communities (streets) and rural communities (townships), were randomly selected from the abovementioned eight county-level regions, resulting in 24 communities as the sampling areas for this study.

Criteria for inclusion of subjects included those with clear verbal expression and consciousness, aged ≥ 60 years, resided ≥ 3 years in the local community, and agreed to be investigated. Meanwhile, we excluded those who were not able to carry out proper verbal communication (e.g., being deaf or mute and dementia or cognitive impairments, and bedridden patients). At the same time, the participants received a verbal description of the purposes and procedures of the study, and informed consent was needed before the interview. The study involved 4,257 participants who met the study design requirements. After excluding invalid questionnaires, 4,218 participants were included in the final analysis, of which 1,902 lived in rural areas. To reduce overlaps, the data collection and study design details had been described previously [33, 34].

Measures

Independent variable

In this study, depressive status was taken as the independent variable, which was assessed using the Zung Self-Rating Depression Scale, with a score from 1 to 4 for each item on the scale. There are 20 items on the scale, with an overall depressive symptoms score ranging from 20 to 80, with higher scores indicating more severe depressive symptoms. For data analysis, we categorized this score into three groups: no depressive symptoms (<50), minimal to mild depressive symptoms (50 – 59), and depressive symptoms (>60), which was similar to previous research [35]. The samples had good internal consistency, as Cronbach's α of the scale was 0.666.

Outcome variables

Based on the Oral Health Surveys: Basic Methods from the World Health Organization and the Fourth National Oral Health Epidemiology Survey in China [36, 37], we measured oral health knowledge, attitudes, and practices as follows.

Oral health knowledge

There were eight questions in the oral health knowledge questionnaire, with 2 points for correct answers, 1 point for unknown answers, and 0 points for wrong answers, totalling 16 points. The sum of the scores for each question is the total score for each participant; the higher the respondents' scores, the better their knowledge of oral health. Cronbach's α was 0.653, which showed a good consistency.

Oral health attitudes

The questionnaire on oral health attitudes included six questions, in which negative attitudes were scored with 0 points and gradually positive attitudes with 1 to 2 points. The score for each question was added to obtain the total score for each respondent's oral health attitudes, a total score of 12 points. The higher the respondent's score, the more positive their oral health attitude. Cronbach's α was 0.681 in this population.

Oral health practices

The oral health practices questionnaire consisted of 12 questions, each with a maximum and a minimum score of 3 and 0 points, respectively. If the frequency of eating sweets, smoking, drinking, and other harmful practices is lower, the score of oral health practices is higher; similarly, the higher the frequency of oral health practices, such as brushing teeth, using fluoride toothpaste, flossing, and dental cleaning, the higher the score of oral health practices. The score range was 0 to 36 points; the higher the score of the interviewees, the more correct

their oral health practices. Cronbach's α for this measurement was 0.676.

Assessment of demographic data

In addition, we also collected the characteristic information of interviewees during the survey. These data consisted of age (years), body mass index (BMI, kg/m^2), gender (male or female), marital status (married or single), living status (living alone and not living alone), and educational attainment (primary school or below, junior school, high school, and college or above). Moreover, health practice information regarding smoking and drinking status and socioeconomic status regarding the source of income was also collected.

Data analysis

Initially, we used mean ± standard deviations to express continuous variables. Next, we aimed better to display the characteristics and current situation of the participants. A general linear model (GLM) was used to explore the relationship between depressive symptoms and oral health knowledge, attitudes, and practices. The GLM can be specified as follows:

$$Y \approx \alpha + \beta_1 depression + \beta_2 Confounders_1 + \cdots + \beta_n Confounders_n$$

In this model, oral health knowledge score is the dependent variable, represented by Y; α is the intercept; $\beta 1$ is the corresponding coefficient; $\beta 2$ Confounders1 + … + βn Confoundersn indicate potential confounders, with $\beta 2 \ldots \beta n$ as their corresponding coefficients. Based on previous studies [28, 38], we included age, gender, marital status, living status, and education as potential variables in the analysis. Due to the low number of cases, we combined the high school and college numbers above. In the data analysis process, according to the variance inflation factor (VIF), there was no collinearity between any of the independent variables (VIF > 10 indicated collinearity).

Subsequently, to identify the interactions among the risk factors for oral health, a Classification And Regression Tree (CART) was employed. This non-parametric model has been used to explore the interactions between different variables in public health studies [39].

Lastly, completed data were processed using SPSS version 23.0 for statistical analysis, and the significance level was set at 5%.

Results

Descriptive analysis results

As shown in Table 1, the women's scores were 9.96 ± 2.48, 7.53 ± 2.30, and 18.67 ± 3.33, respectively, while those of the elder adults living alone were 9.53 ± 2.33, 7.06 ± 2.29, and 17.44 ± 3.78, respectively. The scores in oral health knowledge, attitudes, and practices of single respondents were 9.70 ± 2.40, 7.35 ± 2.18, and 17.49 ± 3.62, respectively.

In addition, respondents with educational attainment of college or above scored 11.67 ± 1.53 and 9.67 ± 2.08 for their oral health knowledge and attitudes, respectively, and had mean scores of 15.00 ± 5.29 for their oral health practices.

GLM results

The generalized linear model results are presented in Table 2. It shows that after controlling the variables, minimal to mild depressive symptoms (β = -0.345; 95% CI: -0.582 to -0.109) and depressive symptoms (β = -1.064; 95% CI: -1.982 to -0.146) had a statistically significant negative correlation with the oral health knowledge of the respondents. Specifically, among all the participants, for each unit increase in minimal to mild depressive symptoms or depressive symptoms, oral health knowledge decreased by 1.064 and 0.345, respectively. Table 2 also displays that among participants, minimal to mild depressive symptoms (β = -0.385; 95% CI: -0.600 to -0.170) had a negative effect on oral health attitudes. In addition, no statistically significant correlation between depressive symptoms and oral health practices was observed in this study ($P > 0.05$).

Results of the CART model

Figures 1, 2, and 3 are used to show the analysis results of the CART model. Figure 1 shows that oral health knowledge was associated with the living status, gender, and age of the subjects, among which the living status was the first classifying factor.

In Fig. 2, age, living status, and depressive symptoms were related to the oral health attitudes of the respondents, with age as the primary factor. Based on these factors, the samples were divided into multiple subsets. Participants aged 60 – 69 years (Node 1), living with others (Node 6), and with no depressive symptoms (Node 8) were most likely to have a high oral health attitude score. Conversely, respondents aged 70 years or older (Node 1) and those living alone (Node 3) were most likely to have low scores in oral health attitudes.

In addition, the results of the analysis in Fig. 3 indicate that the factors related to oral health practices were mainly gender, age, and education. Among these, gender was the most important, while depressive status was not significant.

Discussion

Before this study, there had been no investigation of the impact of depressive symptoms on oral health knowledge, attitudes, and practices of rural older adults in developing countries. Overall, in this paper, the linear

Table 1 Sociodemographic characteristics of the studied subjects ($N = 1902$)

Variables	Variable Categories	Numbers of subjects	Oral health knowledge	Oral health attitudes	Oral health practices
Age (years)			10.06 ± 2.48	7.59 ± 2.27	17.85 ± 3.69
Gender	Male	623	10.27 ± 2.48	7.71 ± 2.20	16.17 ± 3.83
	Female	1279	9.96 ± 2.48	7.53 ± 2.30	18.67 ± 3.33
BMI (kg/m^2)			10.06 ± 2.48	7.59 ± 2.27	17.85 ± 3.69
Living status	Living alone	1667	9.53 ± 2.33	7.06 ± 2.29	17.44 ± 3.78
	Living with others	235	10.14 ± 2.50	7.66 ± 2.26	17.90 ± 3.68
Marital status	Married	1498	10.16 ± 2.50	7.65 ± 2.29	17.94 ± 3.71
	Single	404	9.70 ± 2.40	7.35 ± 2.18	17.49 ± 3.62
Education	Primary school and below	1591	10.01 ± 2.49	7.50 ± 2.31	17.81 ± 3.67
	Junior school	229	10.26 ± 2.43	8.00 ± 1.97	18.21 ± 3.86
	High school	79	10.39 ± 2.41	8.13 ± 2.03	17.68 ± 3.65
	College and above	3	11.67 ± 1.53	9.67 ± 2.08	15.00 ± 5.29
Smoking status	Smoking-quitter	108	10.53 ± 2.30	7.40 ± 2.43	17.42 ± 3.90
	Smoker	267	10.21 ± 2.51	7.78 ± 2.24	14.38 ± 3.63
	Non-smoker	1527	10.00 ± 2.49	7.57 ± 2.26	18.48 ± 3.33
Drinking status	Drinking-quitter	74	10.24 ± 2.39	7.53 ± 2.39	17.12 ± 4.24
	Drinker	281	10.48 ± 2.68	8.04 ± 2.10	15.42 ± 3.81
	Non-drinker	1547	9.98 ± 2.45	7.51 ± 2.28	18.32 ± 3.46
Income	Pension	296	10.20 ± 2.42	8.31 ± 2.00	18.03 ± 3.99
	Salary	323	10.45 ± 2.40	7.78 ± 2.36	17.58 ± 3.70
	Family providing	778	9.66 ± 2.42	7.42 ± 2.08	17.97 ± 3.59
	Subsidy	352	10.38 ± 2.76	7.27 ± 2.71	17.57 ± 3.64
	Others	153	10.30 ± 2.13	7.36 ± 2.04	18.07 ± 3.72
Depression			10.06 ± 2.48	7.59 ± 2.27	17.85 ± 3.69

Continuous variables are presented as range and mean ± standard deviation

Table 2 The relationship between depressive symptoms and oral health using GLM

Variables	Oral health knowledge (Adjusted)			Oral health attitudes (Adjusted)			Oral health practices (Adjusted)		
	B(S.E.)	95% CI	*P* value	*B*(S.E.)	95% CI	*P* value	*B*(S.E.)	95% CI	*P* value
Depression (minimal to mild depressive symptoms)	-0.345(0.121)	-0.582 to -0.109	**0.004**	-0.385(0.110)	-0.600 to -0.170	**< 0.001**	0.018(0.168)	-0.312 to 0.347	0.916
Depression (depressive symptoms)	-1.064(0.468)	-1.982 to -0.146	**0.023**	-0.726(0.426)	-1.561 to 0.108	0.088	0.604(0.653)	-0.675 to 1.883	0.355
Age (70–79)	-0.194(0.125)	-0.438 to 0.050	0.120	-0.375(0.113)	-0.597 to -0.153	**0.001**	-0.936(0.174)	-1.276 to -0.596	**< 0.001**
Age (≥ 80)	-0.603(0.185)	-0.965 to -0.241	**0.001**	-0.626(0.168)	-0.955 to -0.297	**< 0.001**	-1.821(0.257)	-2.325 to -1.317	**< 0.001**
Gender (Female)	-0.316(0.125)	-0.560 to -0.072	**0.011**	-0.194(0.113)	-0.417 to 0.028	0.086	2.393(0.174)	2.052 to 2.733	**< 0.001**
Living status (Living alone)	-0.412(0.208)	-0.819 to 0.005	**0.047**	-0.558(0.189)	-0.928 to -0.188	**0.003**	-0.135(0.289)	-0.702 to 0.432	0.641
Education (Primary school and below)	-1.559(1.424)	-4.350 to 1.231	0.273	-2.234(1.294)	-4.770 to 0.303	0.084	0.932(1.984)	-2.956 to 4.821	0.638
Education (Junior school)	-1.454(1.430)	-4.257 to 1.350	0.310	-1.844(1.301)	-4.393 to 0.705	0.156	1.613(1.993)	-2.294 to 5.520	0.418
Marriage (Single)	-0.124(0.173)	-0.462 to 0.215	0.474	0.119(0.157)	-0.189 to 0.427	0.448	-0.291(0.241)	-0.763 to 0.181	0.226

B Regression coefficient, *S.E.* Standard error, *95% CI* Confidence interval of 95%

No depressive symptoms, age (60–69), male, living with others, high school and above and married/cohabited were set as reference groups

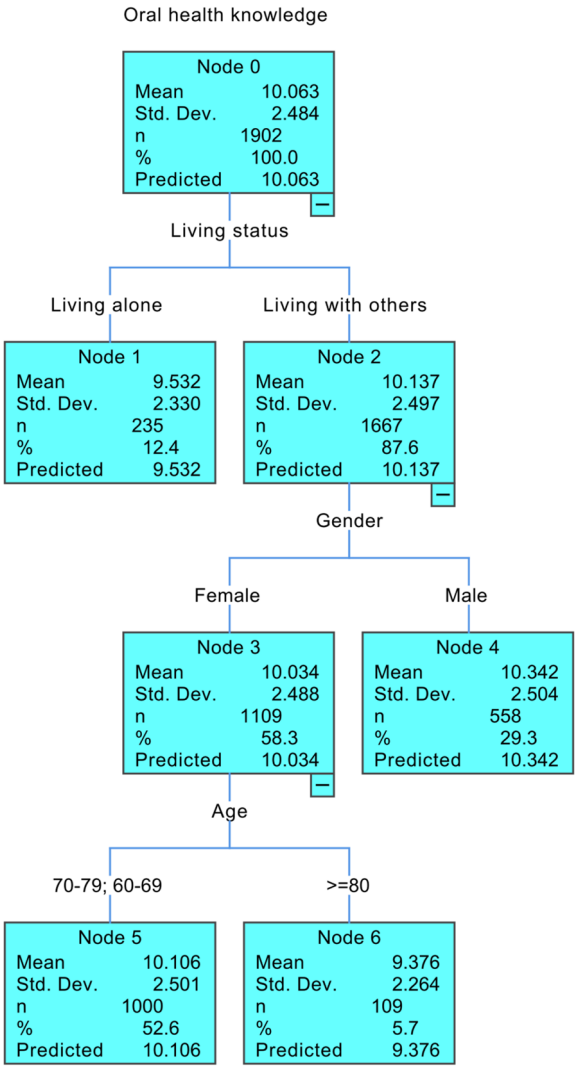

Fig. 1 The main factors affecting oral health knowledge were obtained by using CART model

analysis results showed that depressive status leads to poorer oral health knowledge and attitudes. Furthermore, depressive symptoms were positively correlated with oral health practice scores. In addition, in the non-linear analysis, depressive status was one of the joint factors affecting the oral health attitudes of older adults.

Most recent studies on the oral health effects of depressive status have focused on older adults in urban areas and have shown that depressive symptoms can determine poor oral health outcomes [28, 40]. Our research also indicates that depressive symptoms could lead to poor oral health knowledge in older adults and that the degree of depressive status in rural older adults is negatively related to their oral health knowledge. Previous studies have demonstrated that depressive symptoms can result in cognitive ability and subjective memory decline in older adults and that depressive symptom deterioration is significantly associated with faster cognitive and subjective memory decline [41, 42]. This may explain why older adults with depressive status had lower levels of oral health knowledge.

The linear analysis in our research uncovered that both minimal to mild depressive symptoms and depressive symptoms were harmful to the oral health attitudes of older adults, with a statistically significant relationship between minimal to mild depressive status and oral health attitudes. Older people with depressive symptoms tend to have a negative attitude towards life, which may have contributed to the results, and thus pay less attention to their physical health, eventually affecting their health choices [43].

In contrast to oral health knowledge and attitudes, depressive status was found to improve the oral health practices of participants in our linear analysis, although it was not statistically significant. This result is different from that in previous research on the relationship between depressive status and oral health [44]. This may be because of the other dependent variables, with various oral diseases or outcomes used as the dependent variables in previous studies. Furthermore, prior studies have shown that poor oral health knowledge, attitudes, and practices can increase the incidence of oral diseases, such as cavities, caries, and periodontitis [9, 45]. Therefore, further studies are needed to explore the effects of depressive symptoms on oral health practices in older adults.

In addition, the non-linear results of our study show that the main factors influencing the oral health knowledge of older people are living status, gender, and age. Previous research has confirmed this finding [38]. Through linear analysis, we found that older women living alone were more likely to have poor oral health knowledge. However, depressive status was not a significant factor affecting oral health in our non-linear analysis, unlike previous results [24]. This difference may be due to the different analytical methods used in previous studies. Therefore, more studies involving non-linear analytical methods are needed to confirm our findings in order to better understand the role of depressive symptoms in respondents' oral health knowledge.

Furthermore, gender, age, and educational achievement were found to be factors affecting the oral health practices of older adults in the CART model, whereas depressive status was not a main factor. The results of the non-linear analysis were consistent not only with the linear analysis in this study but also with previous studies showing that advanced older men have the worst oral

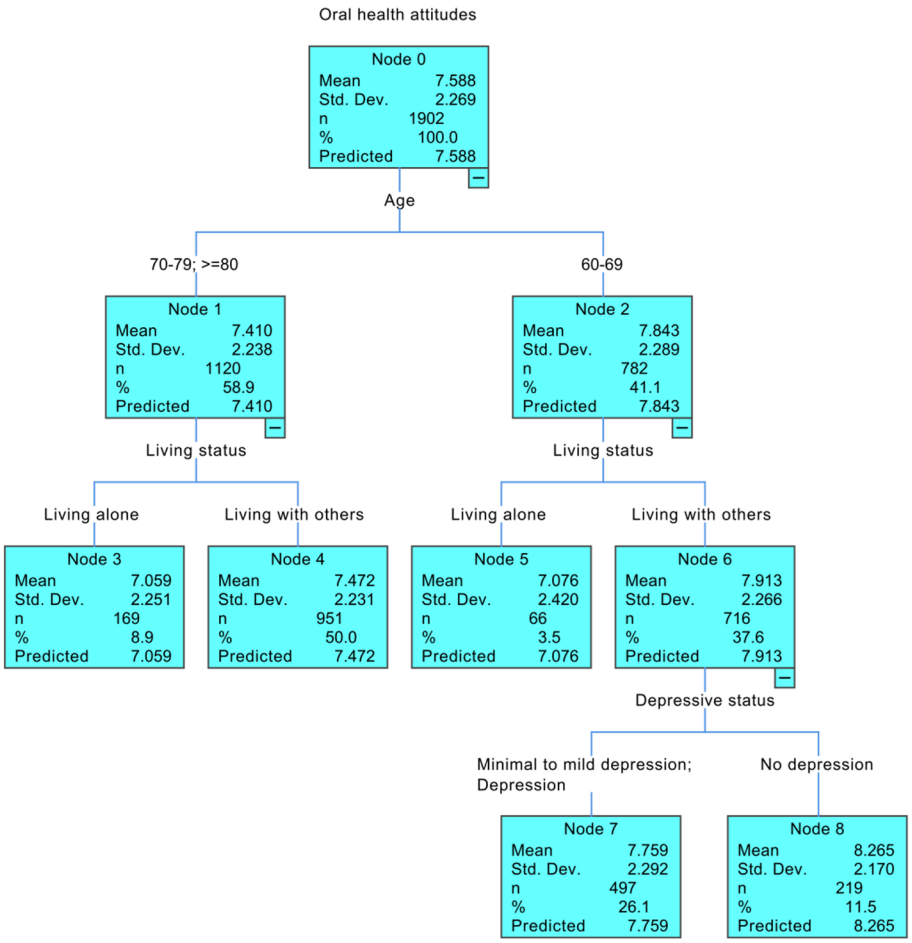

Fig. 2 The main factors affecting oral health attitudes were obtained by using CART model

health practices [28, 29]. This outcome can be explained by the fact that men are less likely to visit a doctor and engage in oral preventive care than women [46]. Smoking is also a poor oral health practice, and the probability of men smoking is greater than that of women [47].

Interestingly, the non-linear analysis of the effect of depressive symptoms on oral health attitudes differed from the above. Depressive symptoms, age, and oral health attitudes were negatively correlated. Additionally, in the present study, an interactive relationship between depressive symptoms, age, and living status was observed. In other words, older people aged 60 – 69 years who lived with others and did not suffer from depressive symptoms had better oral health attitudes. Depressive status was one of the factors that influenced the oral health attitudes of the respondents, and minimal to mild depressive symptoms and depressive symptoms could have different degrees of influence on the oral health attitudes of older adults. Furthermore, this study suggests that older adults' age and living status are related to oral health improvement. This further confirms the results of previous studies and the linear analysis performed in ours [38, 48].

In current studies on depressive symptoms and oral health, the latter is mainly represented by various oral diseases or symptoms of oral discomfort. However, there has been little research into the links between depressive symptoms and oral health knowledge, attitudes, and practices. Although these factors differ from those associated with various oral diseases and discomfort, they also play an essential role in the oral health of older adults. For example, previous studies have displayed that oral health knowledge, attitudes, and practices affect older adults' quality of life and well-being [49, 50]. Therefore, the findings of our study may help enhance the oral health knowledge, attitudes, and practices of older adults and alleviate the harmful effects of depressive symptoms on oral health. For instance, older adults with depressive

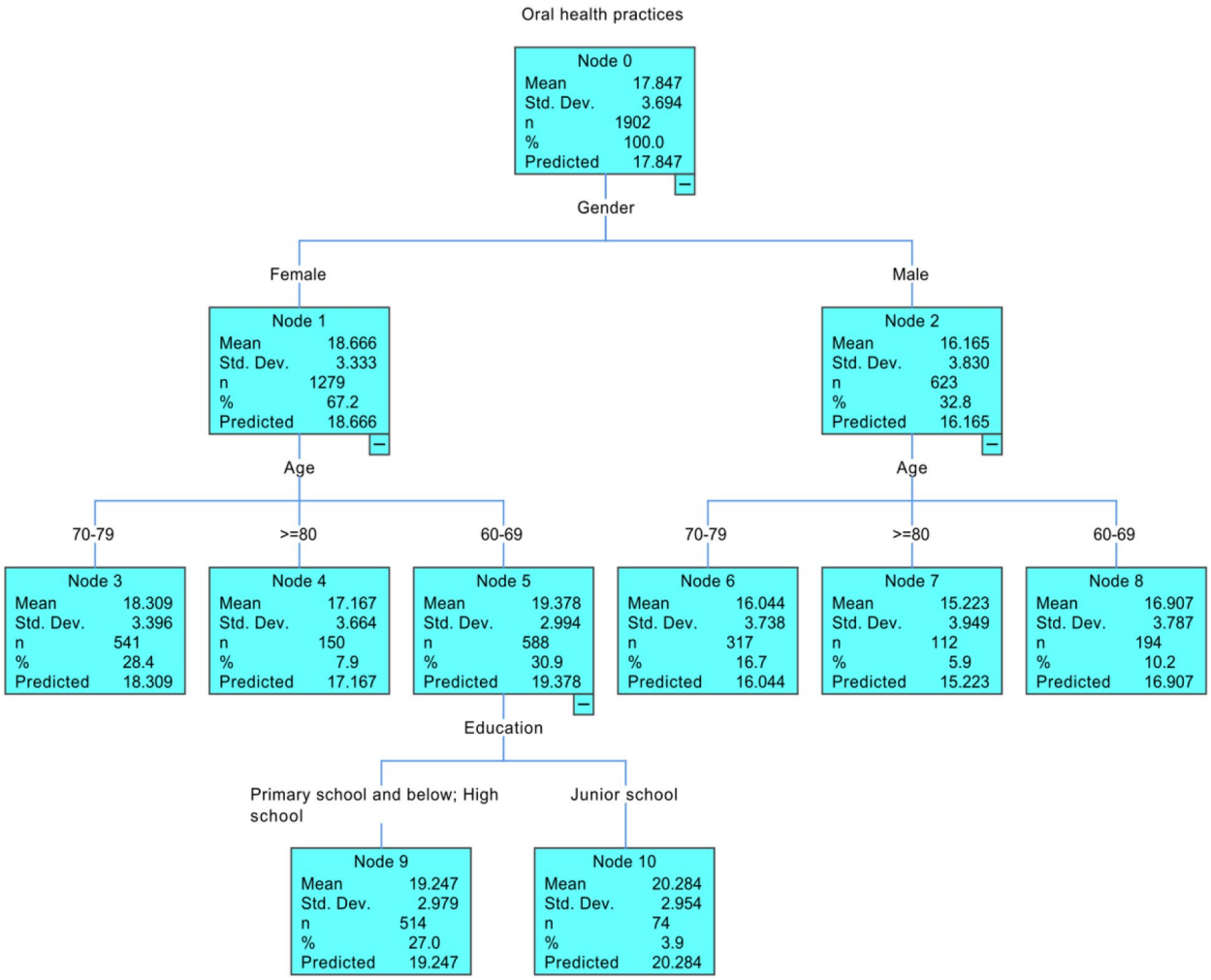

Fig. 3 The main factors affecting oral health practices were obtained by using CART model

status and poor oral health attitudes may choose to live with others because it is easier for them to protect their oral health. Meanwhile, families and governments should teach older adults how to improve their oral health by flossing, toothpicking, and brushing on time.

However, the study still has limitations. For example, this study cannot provide enough evidence to establish causality because it is cross-sectional. Future longitudinal studies are needed to verify these results. Second, the participants in this study were only from four provinces in China, thus, the results may not be generalizable to all older adults living in rural areas. In addition, this study only investigated the subjective attitudes or cognitions of older adults towards oral health, which does not accurately reflect their actual oral health level in life.

Conclusions

The linear analysis showed that depressive status was significantly associated with poor oral health knowledge and attitudes among older adults living in rural areas. Interestingly, in the non-linear analysis, depressive symptoms were related to oral health attitudes, but it was not a co-acting factor of oral health knowledge or practices. According to the results of our study, measures and programs should be designed to optimize oral health care and management among rural older adults.

Abbreviations

GLM	General linear model
BMI	Body mass index
VIF	Variance inflation factor
CART	Classification and regression tree

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-19892-x.

Supplementary Material 1.

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Authors' contributions
ZB and RC conceived and designed the study. WC, CC, YG, ZH and XZ performed statistical analyses, and drafted the manuscript. ZB undertook data collection. ZB, BR, and ZH revised the manuscript. All authors checked, interpreted results, and approved the final version.

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Availability of data and materials
The datasets analysed during the current study are not publicly available due to data management regulations but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Informed consent was obtained from all subjects involved in the study. The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Anhui Medical University (No. 20150927).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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