Original Article

Association between Body Mass Index and Severity of Periodontal Disease among Adult South Indian Population: A Cross-sectional Study

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Abstract

Background: Periodontal disease is one of the top six chronic noncommunicable diseases (NCDs) and is recognized as a severe global public health problem. This study aimed to assess the association between various levels of body mass index (BMI) and periodontal disease severity in Indian adults. **Material and Methods:** The study was designed as a hospital-based cross-sectional study involving 212 participants aged between 18 and 65. A questionnaire assessed by an investigator was used to assess oral health-associated risky behavior and demographical factors. Participants were also assessed using full-mouth clinical periodontal and anthropometric measurements. The mean number of sites with pocket probing depth (PPD) ≥4 mm and the presence of periodontal disease were used as outcome measures. Bivariate analysis and multiple logistic regressions were performed. **Results:** The overall proportion of participants with periodontal disease was 50%, that is, sites with PPD ≥4 mm (n = 106). Multivariate analysis showed that BMI (odds ratio (OR) = 0.77, 95% confidence interval (CI): 0.43, 1.37) was not associated with periodontal disease, but smoking (OR = 3.90, 95% CI: 1.63, 5.89), alcohol consumption (OR = 1.24, 95% CI: 0.72, 2.13), age (OR = 2.51, 95% CI: 1.08, 5.84), and diabetic mellitus (OR = 1.69, 95% CI: 0.92, 3) were positively associated with periodontal disease. **Conclusion:** A positive association was found between smoking, alcohol consumption, age, gender, history of diabetic mellitus, and periodontal disease. No significant association exists between obesity and periodontal disease in South Indian adults.

Keywords: Body mass index, obesity, oral health, periodontal disease, periodontitis, waist circumference

Introduction

Periodontitis is a chronic noncommunicable disease (NCD) that shares social determinants and risk factors with the major NCDs that cause around two-thirds of deaths, such as heart disease, diabetes, cancer, and chronic respiratory disease.[1] Obesity, poor nutrition, and physical inactivity were related to an increased risk of periodontitis.[2]

According to the Global Burden of Disease Study, periodontal diseases are the leading cause of 3.5 million years of life with disabilities.[3] It is also recognized as one of the top six chronic NCDs.[4] It has been considered a severe global public health problem due to its prevalence and economic impact on the healthcare system and its consequences for health. It is a chronic inflammatory disease caused by dental plaque and biofilm and perpetuated by a deregulated immune response within the gingival tissue.[5] Periodontitis is also a common cause of dental loss and is often associated with systemic diseases, such as stroke, heart disease, and endocrine disorders.[6]

The literature suggests that an increased body mass index (BMI) may be a potential risk factor for periodontitis. The association between BMI and periodontitis has been attributed to unhealthy dietary patterns, insufficient micronutrients, and excess sugar and fat content. Those with a BMI of 30 kg/m^2 (obese) were identified as having a significantly increased risk of developing periodontitis compared with a BMI of 18.5 to 24.9 kg/m.[7,8] Recently, the importance of obesity has also been identified in

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the new classification of periodontal diseases and conditions. Obesity is recognized as one of the systemic conditions or metabolic disorders that affect the periodontal attachment apparatus by influencing periodontal inflammation.[9-11]

Obesity is defined as the abnormal or excessive accumulation of fat that may affect health. The World Health Organization (WHO) defines overweight as a BMI of ≥25 kg/m2 and overweight as a BMI of ≥30 kg/m2. BMI is an indicator of total adipose tissue actively involved in controlling inflammation and immunity associated with dysregulated or altered release of various pro-inflammatory and anti-inflammatory factors (e.g., leptin, adiponectin, cytokines, and chemokines).[12] Adipose tissue secretes various cytokines and hormones actively engaged in the inflammatory cascade, indicating that similar pathways are linked in the pathophysiology of obesity and chronic periodontal disease. It has been suggested that obesity is second only to smoking as the most potent risk factor for chronic periodontal tissue destruction.[13,14]

In addition, an analysis of the Third National Health and Nutrition Examination Survey (NHANES III) showed that BMI was significantly associated with periodontal disease. This has suggested that abnormal fat metabolism may be essential in periodontal disease pathogenesis. Current evidence indicates that obesity and periodontitis are interlinked. Although clinical attachment loss (CAL) was not associated with obesity, pocket probing depth (PPD) was significantly correlated with obese determinants. However, it is still not understood how obesity modifies the pathogenesis of periodontal disease. This finding would further strengthen the link between oral and systemic diseases. This study was therefore hypothesized to find a comparative evaluation of the association between the varying decrease in BMI and the severity of periodontitis in adults by adjusting for a comprehensive list of covariate variables and potential confounders.

Methods and Materials

The study was designed as a hospital-based cross-sectional study to evaluate the relationship between various levels of BMI and the severity of periodontal disease in adults, as shown in Figure 1. The study was conducted from March 2019 to November 2019 in two healthcare centers, an urban center (Cochin) and a tribal center (Kalpetta) in Kerala, India. Patients visiting the outpatient departments of Amrita Kripa Charitable Hospital and Amrita Urban Health Centre were approached for participation in the study. After satisfying the inclusion criteria, the patients aged between 18 and 65 years attending either of these hospitals were enrolled as the study population. The research was approved by the Board of Institutional Ethics Committee (Ref/IRB-XXX-2019-155). Permission was sought from a medical officer at Armita Kripa Hospital in Kalpetta. A written informed consent form explaining the details of the study was provided to the participants requesting their consent, as well as an oral and anthropometric examination by all the volunteering participants. This research was conducted in full compliance with the Helsinki Declaration of the World Medical Association.

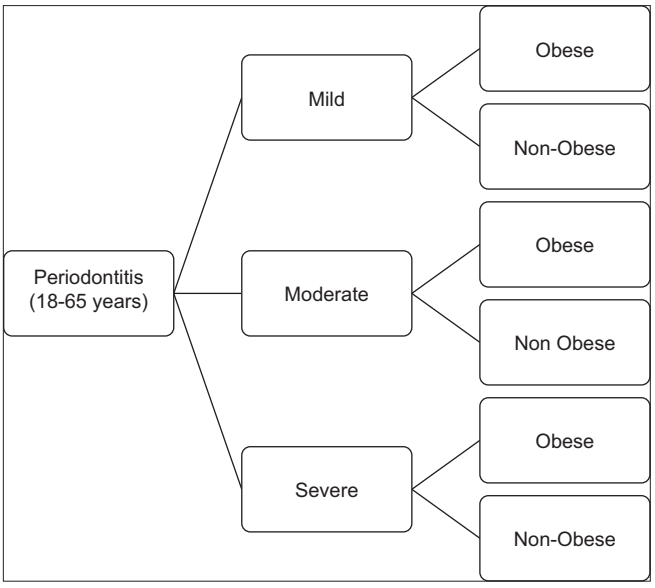

Figure 1: Showing the study design

Based on the mean values of CAL score, that is, BMI category normal (2.27 ± 0.77) and obese (3.03 ± 1.14) observed in an earlier publication,[11] and with 95% confidence and 80% power size, the minimum sample size comes to 26 in each group. To cover for additional comorbid covariates and loss of consent, the final sample size was increased to 60 per group. The final sample size was rounded to 180 (70 in each group) to cover attrition and other covariates. The inclusion criteria included participants with mild, moderate, and severe periodontitis, participants between the age groups of 18–65 years, and patients irrespective of systemic or comorbid conditions who will also be included in the study. The exclusion criteria include participants who had received periodontal treatment at least 3 months before the study and chronic usage of anti-inflammatory drugs and premedication within 3 months.

A calibrated dentist evaluated sociodemographic, lifestyle, and medical history variables through structured interviews and questionnaires. Sociodemographic characteristics comprising age, gender, community, income, marital status, years of education, and family type have been collected. Education was categorized into three categories: school completed, college or university completed, and no formal education. The status of the community was categorized as urban or tribal according to the participants' statements. The occupation was categorized as unemployed or employed.

Lifestyle variables, such as smoking, alcohol consumption, fluoridated products, frequency of dental visits, salt intake, and physical inactivity, were also collected. Smokers were divided into never smokers, current smokers, and past smokers. Participants were assessed as physically active (yes or no) if they did any moderate walking or leisure activities that would cause a slight increase in breathing or heart rate for at least

10 minutes each day. Participants also stated the time of the last dental visit (within 6 months or over 1 year). The history of chronic diseases, including cholesterol, hypertension, and diabetes, was collected. During data collection, participants were asked whether they had been diagnosed with regular medication for the abovementioned diseases.

The clinical oral examinations included an assessment of dental status (DMF) and a detailed periodontal status assessment (Oral Hygiene Index-Simplified (OHI-S), gingival index (GI), CAL, and PPD). All clinical oral procedures were evaluated by a calibrated dentist on a dental chair by means of a headlamp, a mouth mirror, an explorer, and a WHO periodontal probe (Michigan O). The oral hygiene of six selected teeth, excluding third molars, was measured using the OHI-S by John C Greene and Jack R Vermillion in 1964. The Loe and Silness (1963) GI was evaluated for six selected teeth, excluding the third molar. PPD and CAL were calculated at six locations (mesio-facial, midfacial, disto-facial, mesiolingual, mid-lingual, and disto-lingual) per tooth, excluding third molars.

The DMF index of Henry Klein, Carrole E Palmer, and JW Knutson (1938) was assessed for 28 teeth, with the number of decayed teeth (DT), number of filled teeth (FT), and number of missing teeth (MT) recorded for each participant. Periodontal participants with PPD <4 mm and CAL <5 mm were considered as moderate periodontitis and PPD ≥5 mm and CAL ≥6 mm were considered as severe periodontitis. Periodontal pocket depths were calculated from the gingival margin to the base of the clinical pocket with the probe tip parallel to the tooth's long axis. The CAL was recorded as the distance from the cement–enamel junction to the base of the clinical pocket.

All participants, after a clinical oral examination, underwent an anthropometric examination, including an assessment of the status of detailed evaluation of general body fat and central body fat. Anthropometric measurements, including height, weight, waist circumference (WC), hip circumference (HC), and blood pressure (BP), were measured by a trained nurse. Height was measured using a wall-mounted height-measuring stature meter, and body weight was measured using a flat electronic weighing scale. WC and HC were measured using a circumference measuring tape. The Omron digital body fat composition monitor measured the body fat percentage (BFP).

The WC was calculated at the midpoint between the lower margin of the last rib and the top of the iliac crest. HC was calculated in the broadest part of the body below the waist. The waist-to-hip (WHR) ratio was calculated as the ratio of WC to HC. The BMI was calculated as the weight ratio (kilograms) to the height square (meters). The BP was measured using a mercury sphygmomanometer and a stethoscope with the participant's arms supported at the heart level.

The data collected were analyzed using the Statistic Package for Social Sciences (SPSS) version 20 (IBM SPSS for Windows, SPSS Inc., Chicago, IL, USA). Characteristics of subject variables have been described using frequency distribution for categorical variables and mean and standard deviation for continuous variables. The Chi-square test was used to test the statistical significance of the association between the BMI (underweight, normal weight, and overweight) and periodontal disease severity (PPD site ≥3 and PPD site ≥4) and the association of other common risk factors with periodontal disease severity. Multivariate logistic regression models have been used to estimate ORs and associated 95% confidence intervals (CIs). A *P*-value of <0.05 was statistically significant.

Results

A total of 212 participants (80 males and 132 females) aged 18–65 years were assessed in this study, representing a response rate of 65.7%. Table 1 shows their demographic, behavioral habits, oral health-related risk factors or commodities, oral and periodontal status, anthropometric measurements, and relevant characteristics. More than half of the participants were between 35 and 64 (n = 147, 69.3%). About 38.2% (n = 81) of the participants were tobacco smoking. Periodontal status was assessed by probing pocket depth (PPD). Nearly 50% showed normal (BMI) (18.5–24.9 kg/m^2) obesity levels. Similarly, 40.6% were having high WHR (n = 78). The participants with high BFP are nearly 49.9% (n = 129).

Table 2 shows the association between periodontal disease and other explanatory variables. The periodontal disease is associated with smoking status (odds ratio (OR) =2.42; 95% CI = 1.58; 3.62), alcohol consumption (OR = 2.52; 95% CI = 1.39; 4.57), history of diabetic mellitus (OR = 2.42; 95% CI = 1.01, 4.56), and increase in age (OR = 2.57; 95% CI = 1.15, 5.75) [Table 2]. Figure 2 shows the distribution of smoking habits among obese and nonobese participants. Therefore, the odds of 3.44 times the risk of periodontal disease were increased for nonobese participants with the habit of smoking compared with obese participants without smoking habit, which is 1.38.

The factors that appeared to be associated with periodontal disease among the urban and tribal populations were carried forward to a multivariate model. The stepwise method was used for regression. Periodontal disease was the dependent variable, and other variables compared were the independent variables. In the multivariate analysis model [Table 3], the association of

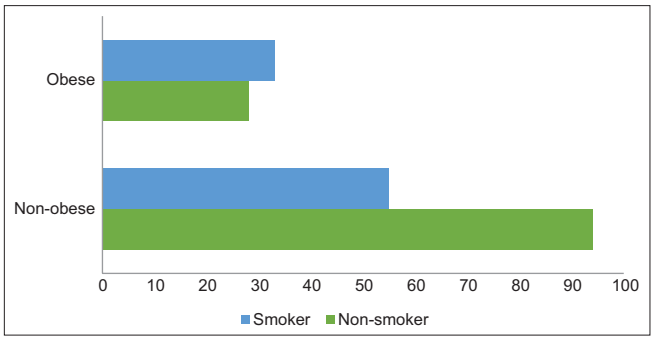

Figure 2: Distribution of the study population according to smoking status

Table 1: Characteristics of the study population

Variables	*n* (%)
Age	
18–34 years	34 (16.0)
35–64 years	147 (69.3)
≥65 years	31 (14.6)
Gender	
Male	80 (37.7)
Female	132 (62.3)
Community type	
Non-tribal	116 (54.7)
Tribal	96 (45.3)
Family type	
Nuclear family[a]	110 (51.9)
Joint family[b]	102 (48.1)
Education	
School completed	55 (25.9)
College or university completed	25 (11.8)
No formal schooling	132 (62.2)
Occupation	
Employed	152 (71.7)
Unemployed	60 (28.3)
Smoking status	
Never smoker	84 (39.6)
Past smoker	47 (22.2)
Current smoker	81 (38.2)
Alcohol consumption	
Yes	69 (32.5)
No	143 (67.5)
Fluoridated products	
Yes	150 (70.8)
No	62 (29.3)
Frequency of dental visit	
Yes	98 (46.2)
No	114 (53.8)
Salt consumption	
Yes	101 (47.6)
No	111 (52.4)
Physical activity	
Yes	70 (33.0)
No	142 (67.0)
History of diabetic mellitus	
Yes	135 (63.7)
No	77 (36.3)
Under nutritional supplement	
Yes	101 (47.6)
No	111 (52.4)
Hypertension	
Mean SBP[c]	130.08±16.9 mm/Hg
Mean DBP[d]	85.24±11.6 mm/Hg
PPD	
Sites with PPD ≥3 mm	106 (50.0)
Sites with PPD ≤4 mm	106 (50.0)
CAL	
Sites with CAL ≥3 mm	98 (46.2)
Sites with CAL ≤4 mm	114 (53.8)
OHI index	
Mean (SD)	3.12±1.0
Gingival index	
Mean (SD)	1.49±0.6
DMF index	
Number of decayed teeth	4.49±4.7
Number of missing teeth	0.52±1.3
Number of filled teeth	2.08±1.5
BMI	
Underweight	44 (20.7)
Normal	107 (50.5)
Overweight	61 (28.8)
WHR	
Low	104 (40.6)
Moderate	30 (12.0)
High	78 (47.4)
BFP	
Lean	22 (14.1)
Moderate	61 (44.9)
High	129 (41.0)

[a]Nuclear family=parents with one child or four members, [b]Joint family=three generation or more than five members, [c]SBP=systolic blood pressure, [d]DBP=diastolic blood pressure, PPD=probing pocket depth, CAL=clinical attachment loss, OHI=oral hygiene index, DMF=decay, missing, and filled teeth, BMI=body mass index, WHR=waist-to-hip ratio, BFP=body fat percentage

smoking status (OR = 3.09; 95% CI = 1.63, 5.89) persisted even after the adjustment of potential confounders. The unadjusted OR of 2.42 increased to 3.98 (95% CI 1.63–5.89). Periodontal disease, that is, sites with PPD ≥3 mm (OR: 0.77; 95% CI: 0.43, 1.37), was not associated with overweight or obesity.

Discussion

In this research, 106 (50%) participants had periodontitis (37.7% among males and 62.3% among females). The overall prevalence of periodontal disease was 50%, similar to other studies in India (Goel *et al*. 2021, Nisha *et al*. 2020 and Varma *et al.* 2023).[15,16] The prevalence of periodontal disease varies from 9.4% to 71.7% in the age group of 18–65 years. This was in accordance with earlier studies conducted in different parts of the Indian population.[17-19] However, there was no statistically significant association found between periodontal disease and obesity, which seems to indicate that the main reason for periodontal disease in this population was due to tobacco smoking. This can possibly be a consequence of the complexity of the relationship between obesity, periodontitis, and potential confounding factors, including smoking, diabetes, aging, and alcohol consumption behavior. This finding is strengthened by other studies,[20-24] suggesting no association between obesity and periodontitis in adults after adjusting for potential confounders. This result is contrary to other epidemiological studies[25-28] that reported a substantial relationship between obesity and periodontitis.

Table 2: Bivariate analysis

Variables	Periodontal disease		Total	Odds ratio	*P*-value
	No	Yes			
Age					
18–34 years	24 (22.6)	10 (9.4)	34 (16.0)	---1---	0.014*
35–64 years	71 (67.0)	76 (71.7)	147 (69.3)	2.57 (1.14–5.7)	
≥65 years	11 (10.4)	20 (18.9)	31 (14.6)	4.36 (1.53–12.36)	
Community type					
Non-tribal	60 (56.6)	56 (52.8)	116 (54.7)	---1---	
Tribal	46 (43.4)	50 (47.2)	96 (45.3)	1.16 (0.67–2.00)	0.581
Gender					
Male	35 (33.0)	45 (42.5)	80 (37.7)	0.66 (0.38–1.16)	0.157
Female	71 (67.0)	61 (57.5)	132 (62.3)	---1---	
Family type					
Nuclear	57 (53.8)	53 (50.0)	110 (51.9)	---1---	
Joint	49 (46.2)	53 (50.0)	102 (48.1)	1.16 (0.67–1.99)	0.58
Education					
No formal schooling	61 (57.6)	71 (67.0)	126 (62.2)	---1---	
Schooling	33 (31.1)	22 (20.8)	55 (25.9)	0.57 (0.30–1.08)	
Graduated	12 (11.3)	13 (12.3)	25 (11.8)	0.93 (0.39–2.19)	0.388
Occupation					
Employed	72 (67.9)	80 (75.5)	152 (71.7)	---1---	
Unemployed	34 (32.1)	26 (24.5)	60 (28.3)	0.69 (0.37–1.25)	
Smoking status					
Never smoker	53 (50.0)	31 (29.2)	84 (39.6)	---1---	
Past smoker	25 (23.6)	22 (20.8)	47 (22.2)	1.50 (0.72–3.10)	0.001*
Current smoker	28 (26.4)	53 (50.0)	81 (38.2)	3.23 (1.71–6.12)	
Alcohol consumption					
Yes	24 (22.7)	45 (42.4)	69 (32.5)	0.39 (0.21–0.72)	0.002
No	82 (77.4)	61 (57.5)	143 (67.5)	---1---	
Salt consumption					
Yes	51 (48.1)	50 (47.2)	101 (47.6)	1.03 (0.60–1.78)	0.891
No	55 (51.9)	56 (52.8)	111 (52.4)	---1---	
Physical activity					
Yes	30 (28.3)	40 (37.7)	70 (33.0)	0.65 (0.36–1.15)	0.144
No	76 (71.7)	66 (62.3)	142 (67.0)	---1---	
History of diabetic mellitus					
Yes	76 (71.7)	59 (59.7)	135 (63.7)	2.01 (1.14–3.5)	0.015
No	30 (28.3)	47 (44.3)	77 (36.3)	---1---	
Under nutritional supplement					
Yes	51 (48.1)	50 (47.2)	101 (47.6)	1.03 (0.60–1.78)	0.891
No	55 (51.9)	56 (52.8)	111 (52.4)	---1---	
History of cardiac diseases					
Yes	9 (8.5)	12 (11.3)	21 (9.9)	0.72 (0.29–1.80)	0.490
No	97 (91.5)	94 (88.7)	191 (90.1)	---1---	
Body mass index					
Underweight	20 (18.8)	24 (22.6)	44 (20.7)	---1---	
Normal	56 (52.8)	51 (48.1)	107 (50.5)	0.75 (0.37–1.53)	0.189
Overweight	30 (28.3)	31 (29.2)	61 (28.8)	0.86 (0.39–1.87)	
Waist-to-hip ratio					
Low	54 (48.5)	50 (47.2)	104 (48.5)	---1---	
Moderate	14 (6.6)	18 (9.5)	32 (17.5)	1.39 (0.62–3.08)	0.157
High	31 (14.6)	45 (29.2)	76 (34.0)	1.57 (0.86–2.85)	

As periodontitis and obesity coexist concurrently, and the relationship is reversible, we found the cross-sectional methodology, incorporating all the possible co-variables, which are at risk of both obesity and periodontal disease. This strengthens our study findings. Our assessment was not related to the temporal causation of periodontal disease with

Table 3: Multivariate analysis

Variables	Crude odds ratio	Reference	Adjusted odds ratio	*P*	95% confidence interval	
					Lower	Upper
Age						
35–64 years	2.57	18–34 years	2.51	0.031	1.08	5.84
≥65 years						
Smoking status						
Smoker	3.23	Nonsmoker	3.09	0.001	1.63	5.89
BMI						
Obese	0.79	Nonobese	0.77	0.383	0.43	1.37
Alcohol intake						
Yes	1.52	No	1.24	0.423	0.72	2.13
History of DM						
Yes	0.5	No	1.69	0.001	0.92	3.10

obesity, but rather to the ascertainment of various risk factors associated with these chronic diseases in the adult population.

The participant's recruitment was performed exclusively based on the periodontal disease diagnosis regardless of the presence or absence of obesity in the potential participants. This sort of proper case definition mainly helped eliminate the study population's selection bias. Also, the information bias was controlled by validating the risk factors obtained from the patient interviewed by cross-checking with the participant's medical records. As the source of participants for the study was hospital-based outpatient departments, it may have Berksonian bias. However, the study participants were selected from two incomparable geographical areas covering urban and tribal socioeconomic conditions, strengthening the study's external validity.

It is essential to highlight that many studies[29-31] showed that smoking status is a risk indicator for periodontal disease. It was observed in the present study that the prevalence of periodontal disease among smokers was 50.0% (n = 53), and multivariate analysis, after adjusting for the confounders, showed that smokers had a 3.24 increased risk compared with nonsmokers. These observations highlight the destruction of periodontal tissue by smoking and the unfavorable clinical outcomes of periodontal disease. The present study further confirms the consistent association between periodontal disease and smoking. Other influencing factors, such as alcohol consumption, diabetic mellitus, and aging, were also very significant with periodontal disease. Our findings is similar to other earlier studies,[32,33] that the functional abnormalities of T and B lymphocytes, natural killer cells, and monocytes or macrophages results in an altered immune response and along with alcohol has increased periodontal disease in older population. Furthermore, diabetic mellitus and periodontitis have a bidirectional relationship that is well documented in many reviews and epidemiological studies.[34-36] While this study does not identify a strong association of periodontal disease with obesity, it cannot establish a causal relationship, nor can it detect the timing of the relationship as it has two-way causal relationships and a complex interaction with other covariates. Hence, prospective studies under the molecular inflammatory pathway level should be considered in further research to identify the linking mechanism between obesity and periodontal disease, which can be accounted for as a limitation of this study.

Conclusion

The overall prevalence of periodontal disease was 50.0% among the urban and tribal populations of South India. Within the limitations of this study, obesity is not statistically associated with periodontal disease parameters in the urban and tribal regions, but other covariates, such as smoking, alcohol consumption, age, and history of diabetic mellitus, are strongly associated with periodontal disease.

Public health implications

Periodontitis and obesity are the significant common health problems in India; the common attributing risk factors include socioeconomic, diet, chronic comorbidities, and behavioral habits. The risk factors for periodontal disease are of a wide range. It is more of a social problem than a biomedical problem. For dentists, patients presenting with early stages of periodontitis should be considered at risk of tooth mortality and other chronic NCDs that may affect long-term health and well-being. A multipronged approach, such as the common risk factor approach, will be beneficial to combat the burden of oral and chronic diseases. The common risk or health factor approach (CRHFA) is an integrated common risk approach that promotes general health by controlling a small number of risk factors that may have a significant impact on a large number of diseases at a lower cost, efficiency, and effectiveness than disease-specific approaches (Sheiham *et al.*).[37]

Evidence from the present study indicated that oral diseases, such as periodontal disease, should be prioritized for a common risk factor approach to reduce the burden of NCDs among the Indian population. Effective early prevention measures will reduce the burden of economic expenditures for oral diseases and systemic conditions by adopting a multipronged strategy. Thus, coordinated, collaborative strategic action must be strengthened to address the high burden of NCD and oral disease.

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Conflicts of interest
There are no conflicts of interest.

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