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Social determinants of health for moderate and severe periodontal disease in rural and urban populations

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Objective: We assessed the prevalence of moderate and severe periodontitis and its association with social determinants of health in rural and urban population from the State of Chiapas, in Southern Mexico. ***Material and methods***: A cross-sectional population-based study was conducted in 2013 comprising people 20 years and older. The determinants were categorized as proximal (age, sex, indigenous origin, diabetes, smoking, diet), intermediate (level of schooling, occupation, medical and dental care), and structural (type of institution of health care provision, residence area). Periodontal status was assessed using the Periodontal Screening and Recording (PSR) Index. ***Results***: In total, 467 persons (72.4% women; mean age 43.0 years [s.d 14.7]) participated. Of them, 76.5% lived in rural areas and 56.7% were of indigenous origin. Participants with moderate and severe periodontitis had a significantly lower toothbrushing frequency (44.1% and 44.8%, respectively), and poorer oral hygiene (90% and 90.3%, respectively) compared with people without periodontitis (29.4% for toothbrushing frequency and 74.5% for oral hygiene). Moderate periodontitis was associated with poor oral hygiene (OR=2.63) and no schooling (OR=1.86). Severe periodontitis was associated with age (OR=1.05), poor oral hygiene (OR=3.99), no schooling (OR=2.08), and the interaction term of rural area and indigenous origin (RM=5.23). ***Conclusions***: Social determinants of health play an important role in the development of periodontitis. Preventive oral health programs should thus focus on the specific social, economic, and geographical context of the population.

Keywords*: Oral health, periodontal disease, social determinants of health, indigenous population*

Introduction

Periodontal disease is a concern for public health systems worldwide, given its prevalence and impact on quality of life. In the 2017 Global Burden of Disease (GBD) study, around 796 million people had severe periodontitis, with a prevalence of 9.8%. This represents an increase of 5.8% from 1990 to 2017, the greatest impact being in middle- and low-income countries. The prevalence of severe periodontitis varies from 6.5% in high-income to 11.7% in low-income countries, explained in part by inequity in access to health services, lower schooling level, less education in oral health, lower purchasing power, and ethnicity in poorer countries (Peres *et al.*, 2019). Furthermore, in 2017 an estimated 3.5 million people lacked periodontal treatment (Bernabe *et al.*, 2020).

The study of periodontitis has focused on factors such as sex, inadequate oral hygiene, smoking, diet, and diabetes (Geyer *et al.*, 2010). Social factors such as socioeconomic status and level of education have become more relevant in disadvantaged populations (Mejia *et al.*, 2018). Studies in Brazil, Australia, India, Canada, the United States, and New Zealand have concluded that people in rural or indigenous areas have a higher prevalence and greater severity of periodontal disease (Mejia *et al.*, 2018; Gardiner *et al.*, 2020; Arantes *et al.*, 2021). These differences are linked to general health, level of schooling, and access to health services (Marmot, 2005). Mexican disadvantaged populations, such as those living in rural areas, have a higher likelihood of poor oral health. This is known as the "social gradient in health" (Peres *et al.*, 2019; Singh *et al.*, 2019).

To help determine the association between periodontal disease and social disadvantage, we aimed to assess the prevalence of moderate and severe periodontitis and its association with social determinants of health in adult population living in rural and urban areas of the Municipality of Comitan, Chiapas, in Southern Mexico.

Method

The Comitan population-based study was conducted in the Municipality of Comitan de Dominguez, in Chiapas, between 2010 and 2012, to determine the prevalence of type 2 diabetes in adults ≥20 years. A detailed description of the study was published by (Jimenez-Corona *et al.*, 2019). Briefly, a census was carried out in 3 urban neighborhoods and 5 rural settlements. In rural areas, all eligible people were invited to participate; in urban areas, people were chosen at random. For this analysis, a subsample of 467 persons in 3 rural and 2 urban areas was chosen and assessed from July to October 2013. The Research, Ethics, and Biosafety Committees of the National Institute of Public Health approved the study

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protocol. The protocol followed the tenets of the Helsinki Declaration. All participants signed informed consent.

The assessment included questionnaires on sociodemographic data and medical and oral health history. An oral clinical examination was performed. Peripheral blood samples were taken after 8-hour fasting and at 2 hours after loading 75 gr of anhydrous glucose; laboratory tests were done at the Central Laboratory of the Salvador Zubiran National Institute of Medical Sciences and Nutrition, in Mexico City, Mexico.

The determinants of health were defined according to Marmot (2005) as proximal (characteristics of the individual), intermediate (characteristics of the individual's immediate environment), and structural (socioeconomic and political context). The proximal category consisted of age, sex, self-reported indigenous origin, and the speaking of any indigenous language. Diabetes was defined as a fasting serum glucose concentration ≥126 mg/dL or 2-hour glucose >200 mg/dL after a load of 75 grams of glucose, or according to previous medical diagnosis. Tobacco use was determined by self-report and classified as non-smokers (smoked less than 100 cigarettes in their lifetime), former smokers (smoke-free for one month before participation), and current smokers (smoked at least 100 cigarettes in their lifetime and currently smokes cigarettes). Dietary information was obtained (semi-quantitative food frequency questionnaire (FFQ, Willett *et al*., 1998) and intake of carbohydrates, proteins, and fat was calculated.

The intermediate social determinants comprised level of schooling (defined as none, if participants never attended school, and greater than or equal to elementary school, if they completed at least one year), occupation (classified as housewife, farmer, trader or other [domestic workers, musicians, masons, among others]), and medical and dental care (defined as care received in the past 6 and 12 months, respectively).

The structural social determinants comprised the institutions where participants received regular medical care (Mexican Institute of Social Security (IMSS) / Health Secretariat (SS) / private health care services), affiliation to Social Protection Insurance in Health (SPSS) (yes / no). Rural areas were defined according to Mexico's National Institute of Statistics and Geography (INEGI) criteria as those with settlements of less than 2,499 inhabitants.

Oral health variables included self-reported perceived gum health (excellent/good, fair/bad), satisfaction with chewing ability (very satisfied/ satisfied/unsatisfied/very unsatisfied), bleeding gums (no/yes), bad breath (no/yes), tooth pain (no/yes), and toothbrushing daily frequency (none or once/twice/thrice, or more a day). The number of teeth present was defined as the number of natural teeth in the participant's mouth excluding the third molars. The oral clinical assessment was performed by two dentists previously standardized for inter- and intra-rater agreement (kappa coefficient ≥0.85) for the measurement of plaque, dental calculus and depth of periodontal pockets on permanent and completely erupted teeth. Artificial light and a dental mirror #5 were used. Plaque and calculus were recorded at the mesial, distal, vestibular, and lingual sites of all teeth present using the Green and Vermillion criteria. Oral hygiene was classified as good (<10% of teeth sites with at least 2/3 of surface covered by plaque) and poor (>10% of teeth sites with at least 2/3 of surface covered by plaque). Likewise, dental calculus was classified as good (<10% of teeth sites with at least 1/3 of surface covered by calculus) or poor (>10% of teeth sites with at least 1/3 of surface covered by calculus). An Oral Hygiene Index (OHI) was constructed as the sum of tooth sites with >2/3 of surface covered by plaque or >1/3 of surface covered by calculus divided by the total number of surfaces and scored as good (<10% of teeth surfaces covered by plaque/dental calculus) or poor (≥10% of teeth surfaces covered).

Periodontal status was recorded using a WHO periodontal probe (Hu-Friedy®) according to the Periodontal Screening and Recording (PSR) Index, whose scale ranges from 0 to 4. Probing depth was measured at six sites per tooth (mesial-buccal, mid-buccal, distal-buccal, mesial-lingual, mid-lingual, and distal-lingual) and the highest score recorded for each tooth. Moderate periodontitis was thus defined as having at least one tooth scored 3 (3.5-5.5 mm depth at probing) and severe periodontitis as having at least one tooth scored 4 (≥ 5.5 mm depth at probing), in addition to involvement of furcation or gingival recession ≥3.5 mm (Dye and Selwitz, 2005).

Proximal, intermediate, and distal determinants by periodontal status were compared using Pearson's χ^2 tests, and Student's t-tests (means and standard deviation (s.d.)) or Wilcoxon rank-sum tests (median and 25th-75th percentiles) as appropriate. Age- and sex-adjusted prevalence, and prevalence ratios and their 95% confidence interval (95% CI) for moderate and severe periodontitis were estimated in logistic regression. The associations between periodontal disease and age, sex, indigenous origin, diabetes, smoking, toothbrushing frequency, OHI, schooling level, and area of residence was assessed in multiple logistic regression. Biologically relevant variables and p-values less than 0.25 obtained in bivariate analysis were added to the models using a backward stepwise technique. The interaction between area of residence and indigenous origin was determined; the significance of the components of this interaction individually and jointly was calculated through likelihood ratio χ^2 test. To obtain the OR of interaction, the values were substituted in the equation: $OR=\exp^{(\beta \text{area of residence} + \beta \text{interaction})}$. Goodness of fit of the models was tested in Hosmer-Lemeshow tests; the presence of extreme values was assessed through residue analysis and influence statistics. All analyses were performed using Stata/SE 14 (Stata Corp, College Station, TX, USA).

Results

In total, 467 individuals participated (mean age 43.0 years, s.d. 14.7). Those with severe and moderate periodontitis were older, more likely to have received no schooling, and more likely to live in a rural area than those without (Table 1). They were less likely to be satisfied with their chewing ability and had poorer oral hygiene than people without periodontitis (Table 2).

Age- and sex-adjusted prevalence showed that moderate periodontitis was more common in people who brushed their teeth once a day or less, with poor oral hygiene and no schooling. Severe periodontitis was more common in people with poor oral hygiene, no schooling, and who lived in rural areas (Table 3).

Table 1. Proximal, intermediate, and structural determinants of health by periodontal status among 467 adults.

	No periodontitis n=102 %	*Moderate periodontitis n =231 %*	*Severe periodontitis n =134 %*	*p**
Proximal determinants				
Age, median	35	39	48	<0.001
Sex				
Women	80.4	69.7	70.9	0.119
Men	19.6	30.3	29.1	
Self-report of indigenous origin				
Yes	42.2	45.5	40.3	0.612
No	57.8	54.5	59.7	
Speaking any indigenous language†				
No	62.7	61.9	53.7	0.438
Yes	37.3	38.1	46.3	
Civil status				
Single	12.8	9.1	9.0	0.030
Married/Cohabiting	85.3	88.7	82.8	
Widowed	1.9	2.2	8.2	
Diabetes				
No	91.2	94.8	97.0	0.141
Yes	8.8	5.2	3.0	
Smoking				
Never	79.4	79.7	76.9	0.512
Past	12.8	8.2	9.7	
Current	7.8	12.1	13.4	
Carbohydrates intake %, (median, 25th-75th)	57.0 (52.6-59.7)	57.7 (53.8-60.6)	57.2 (53.9-60.3)	0.384
Proteins intake %, (median, 25th-75th)	17.5 (16.0-18.9)	17.5 (16.2-18.7)	17.8 (16.2-19.2)	0.440
Lipids intake %, (median, 25th-75th)	26.8 (22.8-30.0)	24.8 (22.2-29.8)	25.8 (22.7-28.7)	0.214
Intermediate social determinants				
Schooling level				
Elementary or higher	72.5	58.4	48.5	0.001
None	27.5	41.6	51.5	
Occupation*				
Housewife	72.6	61.0	63.4	0.111
Farmer	12.8	25.6	27.6	
Trader	6.8	5.2	4.5	
Other	7.8	8.2	4.5	
Use of medical care in the past 6 months				
Yes	78.4	77.5	71.6	0.366
No	21.6	22.5	28.4	
Structural social determinants				
Residence area				
Urban area	33.3	22.1	18.7	0.024
Rural area	66.7	77.9	81.3	
Type of institution of health care provision				
IMSS	0.9	1.8	1.5	0.948
Ministry of Health / SPSS	92.2	91.3	93.3	
Private	6.9	6.9	5.2	

*Proportions and median were compared with Pearson χ^2 test and Wilcoxon tests, respectively.
†Only for people of indigenous origin.
†SPSS: Social Protection Insurance in Health.

Table 2. Proximal, intermediate, and structural determinants of health by periodontal status among 467 adults.

	No periodontitis n=102 %	*Moderate periodontitis n =231 %*	*Severe periodontitis n =134 %*	*p**
Proximal determinants				
Self-reported evaluation				
How do you consider that the health of your gums is compared with other people of your age?				
Excellent/very good	16.8	12.2	18.3	0.439
Good	51.5	55.1	45.8	
Fair	22.8	22.7	21.4	
Bad	8.9	10.0	14.5	
How satisfied are you with your chewing ability?				
Very satisfied/satisfied	81.2	80.7	66.4	0.004
Unsatisfied/very unsatisfied	18.8	19.3	33.6	
In the past year, have your gums bled when you brushed your teeth?				
No	63.0	53.5	44.7	0.021
Yes	37.0	46.5	55.3	
In the past year, have you had bad breath?				
No	53.5	50.7	47.3	0.644
Yes	46.5	49.3	52.7	
In the past year, have you had tooth pain?				
No	58.4	56.6	52.7	0.652
Yes	41.6	43.4	47.3	
Toothbrushing times per day				
Twice or more	70.6	55.9	55.2	0.025
None or once	29.4	44.1	44.8	
Clinical evaluation				
Number of teeth (median, 25th-75th)	26 (21-28)	26 (23-28)	24 (17-28)	0.015
Dental plaque				
Good hygiene	62.8	31.6	20.2	<0.001
Poor hygiene	37.2	68.4	79.8	
Dental calculus				
Good hygiene	18.6	16.9	17.9	0.921
Poor hygiene	81.4	83.1	82.1	
Oral Hygiene Index (OHI)				
Good hygiene	25.5	10.0	9.7	<0.001
Poor hygiene	74.5	90.0	90.3	
Intermediate determinants				
Dental care in the past 12 months				
No	94.1	95.2	94.8	0.912
Yes	5.9	4.8	5.2	

*Proportions were compared with Pearson χ^2 test. Medians were compared with Wilcoxon rank-sum test.
Missing values: for self-perception of gum health and bad breath, no periodontitis 1, moderate periodontitis 2, and severe periodontitis 3; for satisfaction with chewing ability and tooth pain, no periodontitis 2, moderate periodontitis 3, and severe periodontitis 3; for bleeding of gums when brushing teeth, no periodontitis 2, moderate periodontitis, 3 and severe periodontitis 2.

Table 3. Age- and sex-adjusted prevalence of periodontal disease by determinants of health among 467 adults.

	Moderate periodontitis		*Severe periodontitis*	
	Prevalence % (95% CI)	*Prevalence ratio (95% CI)*	*Prevalence % (95% CI)*	*Prevalence ratio (95% CI)*
Proximal determinants				
Self-report of indigenous origin				
Yes	67.6 (60.4-74.0)	1 (reference)	57.9 (0.48-0.66)	1 (reference)
No	72.4 (64.6-79.0)	1.07(0.92-1.24)	58.5 (48.0-68.4)	1.03 (0.83-1.29)
Diabetes				
No	70.6 (65.2-75.5)	1 (reference)	60.2 (53.1-66.9)	1 (reference)
Yes	56.7 (35.0-76.1)	0.81 (0.55-1.18)	27.1 (9.8-55.9)	0.51 (0.23-1.15)
Smoking				
Never	69.4 (63.7-74.6)	1 (reference)	56.2 (48.7-63.4)	1 (reference)
Current	72.1 (51.8-86.2)	1.03 (0.82-1.28)	72.3 (48.1-88.0)	1.34 (0.92-1.94)
Toothbrushing/times per day				
Twice or more	64.6 (57.3-71.2)	1 (reference)	52.7 (43.7-61.9)	1 (reference)
None or once	76.3 (68.6-82.7)	1.18 (1.02-1.36)	65.3 (54.8-74.6)	1.22 (0.98-1.52)
Oral Hygiene Index				
Good hygiene	48.2 (34.5-62.1)	1 (reference)	32.1 (18.5-49.6)	1 (reference)
Poor hygiene	73.4 (67.9-78.2)	1.53 (1.12-2.08)	63.1 (55.6-70.0)	1.82 (1.17-2.84)
Intermediate social determinants				
Schooling level				
Elementary or higher	64.5 (57.4-71.0)	1 (reference)	49.1 (40.0-58.3)	1 (reference)
None	78.3 (69.6-84.9)	1.22 (1.04-1.42)	70.9 (60.1-79.8)	1.32 (1.03-1.70)
Occupation				
Housewife	78.5 (73.4-82.8)	1 (reference)	61.4 (52.9-69.2)	1 (reference)
Farmer	77.7 (72.9-81.8)	1.28 (0.97-1.68)	55.1 (46.7-63.2)	1.32 (0.85-2.05)
Trader	76.9 (67.6-84.2)	0.98 (0.66-1.45)	48.6 (33.3-64.2)	0.90 (0.50-1.64)
Other	76.1 (60.4-86.9)	1.09 (0.82-1.45)	42.2 (21.1-66.6)	0.80 (0.39-1.64)
Use of medical care in the past 6 months				
Yes	70.0 (64.0-75.4)	1 (reference)	56.4 (48.4-64.1)	1 (reference))
No	69.7 (64.5-74.5)	0.98 (0.82-1.16)	63.2 (49.5-75.0)	1.12 (0.88-1.43)
Dental care in the past 12 months				
Yes	67.2 (42.8-84.8)	1 (reference)	55.3 (28.3-79.5)	1 (reference)
No	69.9 (64.5-74.7)	1.04 (0.73-1.48)	58.3 (51.2-65.1)	1.02 (0.64-1.62)
Structural social determinants				
Affiliation to SPSS*				
Yes	69.4 (61.5-76.3)	1 (reference)	59.4 (49.2-68.8)	1 (reference)
No	70.0 (62.9-76.4)	1.00 (0.87-1.16)	57.1 (47.9-65.9)	0.96 (0.78-1.19)
Area of residence				
Urban	62.0 (51.1-71.8)	1 (reference)	41.6 (29.0-55.5)	1 (reference)
Rural	72.4 (66.4-77.6)	1.17 (0.96-1.43)	63.8 (55.8-71.1)	1.44 (1.05-1.98)
Age- and sex-adjusted prevalence	69.7 (64.5-74.5)	-	58.1 (51.3-64.7)	-

Age- and sex-adjusted prevalence (95% CI) was estimated by multiple logistic regression models.
*SPSS: Social Protection Insurance in Health.

In multiple logistic regression, moderate periodontitis was associated with poor oral hygiene (OR=2.63, 95% CI 1.36-5.08) and no schooling (OR=1.86, 95% CI 1.01-3.42). Severe periodontitis was associated with older age (OR=1.05, 95% CI 1.02-1.08), poor oral hygiene (OR=3.99, 95% CI 1.65-9.63), and no schooling (OR=2.08, 95% CI 1.02-4.25). There was a significant interaction where those living in rural areas were more likely to have severe periodontitis if they were of indigenous origin compared with persons with non-indigenous origin (OR=5.23, 95% CI 1.69-16.14) (Table 4).

Table 4. Multiple logistic regression for proximal, intermediate, and structural predictors of periodontitis among 467 adults.

	Unadjusted OR (95% CI)	*Adjusted OR (95% CI)*
Moderate periodontitis		
Age (years)	1.01 (0.99-1.03)	1.00 (0.98-1.02)
Sex (men)	1.78 (1.01-3.13)	1.68 (0.84-3.35)
Diabetes (yes)	0.56 (.23-1.38)	0.58 (0.21-1.59)
Current smoking	1.62 (0.71-3.69)	1.15 (0.43-3.04)
Toothbrushing (none or once a day)	1.88 (1.11-3.21)	1.63 (0.93-2.86)
Poor oral hygiene	3.09 (1.66-5.74)	2.63 (1.36-5.08)
Schooling (none)	1.87 (1.13-3.12)	1.86 (1.01-3.42)
Carbohydrate intake	1.03 (0.99-1.07)	-
Protein intake	0.96 (0.85-1.07)	-
Lipid intake	0.95 (0.91-1.00)	-
Indigenous origin	0.87 (0.54-1.40)	0.63 (0.37-1.06)
Residence area (rural)	1.76 (1.05-2.95)	0.95 (0.50-1.78)
Severe periodontitis		
Age (years)	1.05 (1.02-1.07)	1.05 (1.02-1.08)
Sex (men)	1.68 (0.91-3.11)	1.25 (0.51-3.08)
Diabetes (yes)	0.31 (0.09-1.06)	0.20 (0.05-0.82)
Current smoking	1.82 (0.75-4.37)	2.02 (0.61-6.69)
Toothbrushing (None or once a day)	3.14 (1.62-6.07)	1.30 (0.67-2.54)
Poor oral hygiene	3.18 (1.54-6.57)	3.99 (1.65-9.63)
Schooling (none)	2.80 (1.61-4.86)	2.08 (1.02-4.25)
Carbohydrate intake	1.02 (0.97-1.07)	-
Protein intake	1.01 (0.89-1.14)	-
Lipid intake	0.95 (0.90-1.01)	-
Interaction terms		
Indigenous origin	1.07 (0.63-1.82)	-
Rural residence	2.18 (1.19-3.96)	-
Interaction (rural residence and indigenous origin)*†	---	5.23 (1.69-16.14)

*Individual and joint p-value for the interaction terms were calculated through the likelihood ratio χ^2 test: severe periodontitis, $\chi^2 = 12.62$, $p = 0.005$.
†Calculation of the OR for the interaction in the adjusted model for severe periodontitis: OR=e(βrural area + βinteraction)=e(-0.659 + 2.314)=5.23 (95% CI 1.69-16.14). Indigenous rural residents were more likely to have severe periodontitis than non-indigenous rural residents.

Discussion

According to the 2017 Global Burden of Disease Study, periodontitis affects mostly low- and middle-income countries (Bernabe *et al.*, 2020). In high-income countries universal health coverage reduces oral health gaps through more equal access to prevention and treatment services (Palència *et al.*, 2014). Therefore, inequity in oral health must be addressed by working at the population and individual levels (Lee and Divaris, 2014).

This study identified a high prevalence of moderate and severe periodontitis in a population with great social disadvantage, rural areas of residence, people of indigenous origin, and lack of schooling. Studies in Brazil, Australia, India, Canada, the United States, and New Zealand have reported that rural residents experience a greater prevalence and severity of periodontitis, linked to general health status, level of schooling, access to oral health services, and health literacy (Mejia *et al.*, 2018; Gardiner *et al.*, 2020; Arantes *et al.*, 2021).

We also found that people of indigenous origin living in rural areas were more likely to experience severe periodontitis than non-indigenous ones. Ethnic minority groups, who often live in rural areas, have problems accessing health services and limited information on oral health care (Vettore *et al.*, 2013). Studies in Australia, Thailand, and Mexico show that indigenous or aboriginal populations in remote areas have a higher prevalence of periodontitis, as well as less access to oral health services neither for prevention nor for treatment. This makes them more likely to experience advanced periodontitis (García-Conde *et al.*, 2010; Gardiner *et al.*, 2020).

Residents of rural areas have less access to oral health services due to low availability and economic and transport difficulties (Ahn *et al.*, 2011). Although access to dental care in our sample was low, people from rural areas and of indigenous origin were less likely to be receiving dental care. Inequity in oral health services greatly affects populations living in rural and hard-to-reach areas, so it is necessary to improve dental care infrastructure to make it more available and affordable to these populations (Ahn *et al.*, 2011).

More people with no schooling also experienced periodontitis. Brazilians with 8 years or less of schooling and low socioeconomic status were also more likely to have severe periodontitis, as were Afro-American people in the US (de Macêdo *et al.*, 2006; Borrell and Talih, 2012). In our study, this association could be explained, in part, by the high proportion of people without schooling living in rural communities and with high perception of bad appearance of their gums, as well as with low frequency of toothbrushing, poor oral hygiene, and less access to oral health care. Low schooling has been consistently associated with periodontitis, as it may be related to oral health beliefs, habits, and practices (De Abreu *et al.*, 2021; Nath *et al.*, 2022).

Although oral health literacy was not assessed in this study, the low frequency of toothbrushing and the poor oral hygiene point to a lack of knowledge and adequate practices in oral health care in this population. People with poor oral hygiene were more likely to have periodontitis. A study in Australian communities with aboriginal populations associated periodontitis with low oral health literacy (Parker and Jamieson, 2010). Poor knowledge about periodontal disease hinders the maintenance of good oral health. The identification of some early signs of periodontal disease has been associated with improved attitudes toward oral health care, whereas poor knowledge and lack of access to dental treatment, particularly among disadvantaged populations, worsens oral health conditions (Hosadurga *et al.*, 2015).

Diabetes is well known to have a deleterious effect on the periodontium (Forbes *et al*., 2013), yet we identified a lower risk of severe periodontitis in participants with diabetes. This inverse relationship is probably explained by more participants with diabetes and severe periodontitis brushing their twice or more a day and so having good oral hygiene. It may be that oral health problems, including periodontitis had encouraged people with diabetes to improve their oral hygiene.

There is a clear dose response between tobacco use and periodontitis (Fiorini *et al.*, 2014; Ju *et al.*, 2022). However, we did not find any association between past or current smoking and periodontitis, perhaps owing to the low prevalence of smoking in our participants.

Among the strengths of this study is the measurement of dental bacterial plaque and dental calculus in all teeth, which allowed us to account for the effects of these causative agents. Measurement bias is possible for self-reported variables. The questionnaires, however, were administered in the same way to all participants, so if biases exist, they were not differential. The cross-sectional analysis did not permit us to establish causal associations between social health determinants and periodontal disease, which should be confirmed in a follow-up study. Another limitation is that, since the PSR does not measure epithelial attachment, comparability with other case definitions of periodontitis is reduced. Nevertheless, the PSR provides a detailed perspective of periodontal status by recording the presence of furcation involvement, defective margins, bleeding, and dental calculus (Landry and Jean, 2002).

In summary, this study demonstrated that social determinants of health, such as rural residence, indigenous origin, and no schooling predict the presence and severity of periodontitis. Preventive oral health programs should consider the social, economic, and geographical context of the population. In areas of difficult access due to lack of health infrastructure, emphasis should be placed on basic treatment with a model of care focused on reducing inequities in the detection and treatment of the disease.

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Authors' contribution

J.A.F-F. contributed to data analysis, wrote, and revised the manuscript, and contributed to the discussion. M.E.J.-C. contributed to the design of the study, reviewed the manuscript, and contributed to the discussion. L.M.-A. reviewed the manuscript and contributed to the discussion. I.R.-N. collected the data, reviewed the manuscript, and contributed to the discussion. S.A.B.-Y. reviewed the manuscript and contributed to the discussion. M.V.-D reviewed the manuscript and contributed to the discussion. A.J.-C designed the study, contributed to data analysis, reviewed the manuscript, and contributed to the discussion. In addition, she is responsible for this work and assumes responsibility for the integrity of the data and the accuracy of the analysis.

Conflict of interest

The authors declare that they have no conflict of interest.

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