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# Social inequalities and periodontal disease: multilevel approach in SBBrazil 2010 survey

## ABSTRACT

**OBJECTIVE:** To estimate the prevalence and geographical distribution of periodontal disease in the Brazilian adult population and its associations with contextual and individual social inequalities.

**METHODS:** Data from adults aged 35 to 44 who participated in the 2010 Brazilian Oral Health Survey (SBBrazil 2010) (n = 9,564) were used. The Community Periodontal Index (CPI) and clinical attachment loss (CAL) were used to define “moderate to severe” periodontal disease (CPI > 2 and CAL > 0) and “severe” periodontal disease (CPI > 2 and CAL > 1). Contextual social inequalities assessed were Human Development Index and income inequality (Gini Index). Other contextual variables were integration of oral health teams in the Family Health Programme and the percentage of adult smokers. Multilevel logistic regression models for participants with complete data (n = 4,594) were used to estimate odds ratios (OR) and 95% confidence intervals (95%CI) between social inequalities and periodontal disease.

**RESULTS:** The prevalence of “moderate to severe” and “severe” periodontal disease in Brazilian adults was 15.3% and 5.8%, respectively, with considerable variation across municipalities. Of the contextual variables, income inequality was independently associated with “severe” periodontal disease (OR = 3.0, 95%CI 1.5;5.9). Lower oral health teams coverage was associated with both definitions of periodontal disease whereas the percentage of smokers remained associated with “moderate to severe” periodontal disease. Older adults, brown skin color, males and those with lower family income and less schooling were more likely to both periodontal conditions.

**CONCLUSIONS:** In Brazil, the prevalence of periodontal disease varied across the municipalities and according to definition of periodontal disease. Income inequality played a significant role in the occurrence of “severe” periodontal disease. Individual characteristics of social position were associated with both forms of periodontal disease.

**DESCRIPTORS:** Periodontal Diseases, epidemiology. Socioeconomic Factors. Dental Health Surveys. Oral Health. Multilevel Analysis. Health Inequalities.

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## INTRODUCTION

The interest on the relationship between social inequalities and population health conditions is not recent. The central idea of this subject is that the distribution of wealth in a society or country is more relevant in shaping the epidemiological profile than the overall wealth.<sup>10</sup> Studies published in recent years have shown that such relationship is still inconclusive and remains under debate.<sup>7,10,19,20</sup> Despite the strong correlation found between social inequalities and morbimortality, some studies have failed to find robust evidence to support such an association.<sup>10,19</sup> The inconsistency of the findings on the association between social inequalities and health outcomes is understandable as this relationship is not found for all diseases, nor is it found in all societies or countries and it is not consistent over time.<sup>10,19</sup> This topic must also be analysed taking methodological choices into account. For instance, on how social inequalities were conceptualized and measured, what contextual and individual variables were considered in adjusted analysis and the analytical choices to deal with multi-level data.<sup>10,19</sup>

The early studies on social inequalities and socio-economic conditions in oral health were mainly on dental caries in young people.<sup>9</sup> However, the interest in other oral health outcomes and population groups, including periodontal disease in adult populations has increased recently.<sup>1,16</sup> Studies on social determinants of inequalities in oral health were initially supported by evidence that oral diseases, including periodontal disease, are more common in socially deprived population groups.<sup>9</sup> Moreover, the gradient between socio-economic position and chronic diseases has also been observed with regards to periodontal disease.<sup>17</sup> Another explanation for the possible influence of social inequalities on periodontal disease is that periodontal disease and chronic diseases share common risk factors, such as smoking and psychosocial stress, in other words, exposures associated with the social environment.<sup>17</sup>

In spite of the large number of studies published on sociodemographic risk factors and periodontal disease, there are few studies on the socio-contextual determinants of periodontal diseases.<sup>1</sup> Even in countries where periodontal conditions were registered in national oral health surveys, the individual-level perspective of the analyses between sociodemographic conditions and periodontal disease is still predominant.<sup>3,13</sup> The findings of studies on the possible effect of contextual social inequalities on periodontal disease is inconsistent, which raises the need for more studies.<sup>2,4,5,16</sup>

The Brazilian National Oral Health Survey (SBBrazil 2010) was carried out in 2010 and included assessments

of periodontal conditions and sociodemographic characteristics.<sup>15</sup> The availability of data from SBBrazil 2010 and from social indicators, such as those from the Atlas of Human Development in Brazil means that the relationship between contextual and individual variables and periodontal disease can be evaluated. This study aimed to describe the prevalence of periodontal disease in Brazilian adult population and to investigate the association of contextual social inequalities and individual sociodemographic characteristics with periodontal disease.

## METHODS

This study was conducted using data from the SBBrazil 2010 survey and contextual characteristics of the state Capitals and the Federal District.

The SBBrazil 2010 was a nationwide epidemiological survey of oral health in which various oral health outcomes were investigated in children, adolescents, adults and elderly people. The sample consisted of 27 geographic domains regarding the State capitals and the Federal District, and five domains corresponding to the interior municipalities from every Brazilian macro geographical region (North, Northeast, Central-West, Southeast and South), comprising a total of 32 domains. The primary sampling units were: (a) municipality, with regards to the interior of the geographical regions and (b) census tract, for the state Capitals. Oral examinations and interviews were carried out at home for children aged five and 12, adolescents aged 15 to 19, adults aged 35 to 44 and elderly people aged 65 to 74.<sup>a</sup> Full details of the sampling process is described elsewhere.<sup>15</sup>

Data for adult individuals aged between 35 and 44 from the SBBrazil2010 was used in this study. The descriptive stage included participants of all domains (state Capitals, Federal District and municipalities). In order to assess the association of contextual and individual variables with periodontal disease, the sample consisted of adults with complete data from the state Capitals and the Federal District.

Oral examinations were carried out at home. Trained fieldwork teams were composed by one dentist and an assistant. The state Capitals had ten fieldwork teams each and the interior municipalities had between two and six, depending on the population size. Agreement between examiners and the results obtained by team consensus was evaluated using weighted kappa statistics. The acceptable lowest kappa value was 0.65.<sup>21</sup>

<sup>a</sup> Ministério da Saúde (BR). Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Coordenação Nacional de Saúde Bucal. SB Brasil 2010: Pesquisa Nacional de Saúde Bucal. Resultados principais. Brasília (DF); 2011.

Periodontal exams were performed using a ball end Community Periodontal Index (CPI) probe. Bleeding on probing, dental calculus, shallow (4-5mm) and deep ( $\geq 6$ mm) pockets depths were registered for each sextant and excluded sextant, according to CPI index.<sup>21</sup> In addition, loss of periodontal attachment was assessed in each sextant using Clinical Attachment Loss (CAL), according to the follow categories: up to 3 mm, 4-5 mm, 6-8 mm, 9-11 mm and 12 mm or more and excluded sextant.<sup>21</sup>

Pocket depth and CAL measures have been used to define periodontal disease in different studies.<sup>5,13,16</sup> Two definitions of periodontal disease based on a combination between the occurrence of pocket depth and CAL were considered. "Moderate to severe" periodontal disease was defined as the presence of at least one sextant with pocket depth  $\geq 4$  mm (CPI  $> 2$ ) and at least one sextant with CAL  $\geq 4$  mm (CAL  $> 0$ ).<sup>13</sup> "Severe" periodontal disease was defined as the presence of at least one sextant with pocket depth  $\geq 4$  mm (CPI  $> 2$ ) and at least one sextant with CAL  $\geq 6$  mm (CAL  $> 1$ ). In both definitions, the pocket depth and CAL were not necessarily in the same sextant.

Individual interviews were carried out at home using a structured questionnaire to obtain information concerning sex, age, self-reported skin colour, schooling and family income. They were considered as independent variables.<sup>15</sup> Age was registered using full years and those aged between 35 and 44 were selected; self-perceived skin colour was assessed according to the classification proposed by the *Instituto Brasileiro de Geografia e Estatística* (Brazilian Institute of Geography and Statistics) as follows: white, brown, black, yellow or indigenous. Family income was recorded in Brazilian reais (R\$) using the following categories: below R\$ 500.00; R\$ 501.00-1,500.00; R\$ 1,501.00-2,500.00; over R\$ 2,500.00. Concluded years of schooling were recorded as: up to four years, between five and eight years, between nine and 11 years and 12 or more years.

The contextual characteristics used to evaluate social inequalities in the state Capitals and the Federal District were the Human Development Index (HDI) and the Gini index for the year 2000. The HDI is a composite measure encompassing information on income, education and longevity. HDI index ranges from 0 to 1 and the higher the value the better the social conditions.<sup>b</sup> The Gini index is a measure of income inequality, varying between 0 and 1. The value 0 represents total equality while the value 1 means total inequality.<sup>b</sup>

The level of integration of oral health care teams into Family Health Programme (*Estratégia de Saúde da Família*) (OHT/FHP) was analysed since it has been considered an indicator of provision and accessibility of oral health care services. Information regarding OHT/FHP was gathered from the public health care system development index (*Índice do Desenvolvimento do Sistema Único de Saúde*) for the year 2010.<sup>c</sup> In addition, the percentage of adult smokers aged 18 and older (% of smokers) was also registered for the year 2006.<sup>d</sup>

The contextual variables Gini index, HDI, integration of OHT/FHP and % of smokers were categorized into three equal groups according to tertiles of distribution into low, moderate and high. The prevalence of periodontal disease, using the two pre-established definitions, and 95% confidence intervals (95% CIs) were estimated for Brazil, the state Capitals, the Federal District and interior municipalities for the five Brazilian geographical macro regions.

Multilevel models were used to estimate the variation of periodontal disease across cities (random effects) and the effects of contextual variables on periodontal disease, adjusted for individual socio-demographic characteristics (fixed effects). The association between independent variables and the two definitions of periodontal disease was tested through multilevel logistic regression using fixed effect models with random intercept based on the *logit* function. All results are presented as odds ratios (OR) and 95% confidence intervals (95% CIs).

First, associations between contextual and individual variables and the two definitions of periodontal disease were tested in bivariate analysis. The variable self-reported skin colour was analysed for all participants. However, only estimates for "brown" and "black" categories were shown, using "white" as the reference due to imprecision in the values of "indigenous" and "yellow" categories. Variables that presented  $p < 0.10$  in bivariate analysis were considered for the multivariate multilevel analysis. In the multivariate analysis, model 1 was composed by contextual characteristics (second-level variables) for the state Capitals and the Federal District, which were adjusted for each other. In model 2, individual sociodemographic characteristics (first-level variables) were included. Variables that remained significant at 10% ( $p < 0.10$ ) were retained in the analysis for adjustment. Interaction between Gini index and family income was tested by including an interaction term in model 2.

<sup>b</sup> Programa das Nações Unidas para o Desenvolvimento. Instituto de Pesquisa Econômica Aplicada. Fundação João Pinheiro. Atlas do Desenvolvimento Humano no Brasil. Brasília (DF); 2003[cited 2012 Mar 03]. Available from <http://www.pnud.org.br/atlas/>

<sup>c</sup> Ministério da Saúde (BR). Índice do Desenvolvimento do Sistema Único de Saúde (IDSUS). Brasília (DF); 2011[cited 2012 Mar 03]. Available from: [http://portal.saude.gov.br/portal/saude/area.cfm?id\\_area=1080](http://portal.saude.gov.br/portal/saude/area.cfm?id_area=1080)

<sup>d</sup> Ministério da Saúde (BR). Secretaria de Vigilância em Saúde. Secretaria de Gestão Estratégica e Participativa. VIGITEL Brasil 2006. Vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico. Brasília (DF); 2007[cited 2012 Mar 13] Available from: [http://bvsms.saude.gov.br/bvs/publicacoes/relatorio\\_vigitel\\_2006\\_marco\\_2007.pdf](http://bvsms.saude.gov.br/bvs/publicacoes/relatorio_vigitel_2006_marco_2007.pdf)

Variance and standard error for periodontal disease across cities (random effects) were used to evaluate the variation in the outcomes at contextual level. The city-level variance in periodontal disease between areas (cities) in relation to the individual variables was assessed using the median of Odds Ratio (MOR) between areas. If the MOR is 1, there is no variation between cities. MOR is a measure of variation of periodontal disease which is not explained by individual variables. The higher the MOR, the greater the area-level variation.

The descriptive analysis was carried out using the SPSS, version 17.0, taking complex samples and sampling weights into account. The MLwiN 2.24 software (Centre for Multilevel Modelling, University of Bristol, Bristol, UK) was used for multilevel logistic data analyses.

The SBBrazil 2010 Project was in accordance with the Declaration of Helsinki and was approved by the Brazilian National Council of Ethics in Research, protocol no. 15498, 7<sup>th</sup> January 2010.

## RESULTS

The response rate for adults aged 35 to 44 at the interior municipalities of the Brazilian geographical macro regions varied between 68.3% (Northeast region) and 100% (South region), whereas in the state Capitals and the Federal District, the response rate varied between 27.6% (Cuiabá) and 100% (Porto Alegre). The total sample of adults between 35 and 44 years old in the SBBrazil 2010 project was 9,564 individuals. Of them, 7,173 lived in the state Capitals and the Federal District. In order to investigate the association between contextual and individual characteristics and periodontal disease, the sample was composed of 4,594 adults with complete data for all investigated variables.

The prevalence of “moderate to severe” periodontal disease in Brazilian adults was 15.3%. Among the state Capitals, this outcome varied between 5.7% in Maceió and 34.9% in Macapá. In the interior municipalities of geographical macro regions, the lowest prevalence was observed in the South region (8.4%), while the highest was found in the Central-West region (20.0%). The estimate of “severe” periodontal disease prevalence for Brazil was 5.8%. Belém was the state Capital with the lowest prevalence (0.9%) and the highest prevalence was found in Manaus (15.5%). The prevalence in the interior municipalities of geographical macro regions varied from 1.6% in the North region to 7.8% in the Southeast region (Figures 1 and 2).

The distribution of the prevalence of periodontal disease according to individual and contextual variables is shown in Table 1. The prevalence of periodontal disease was lower in cities with less income inequality, whereas

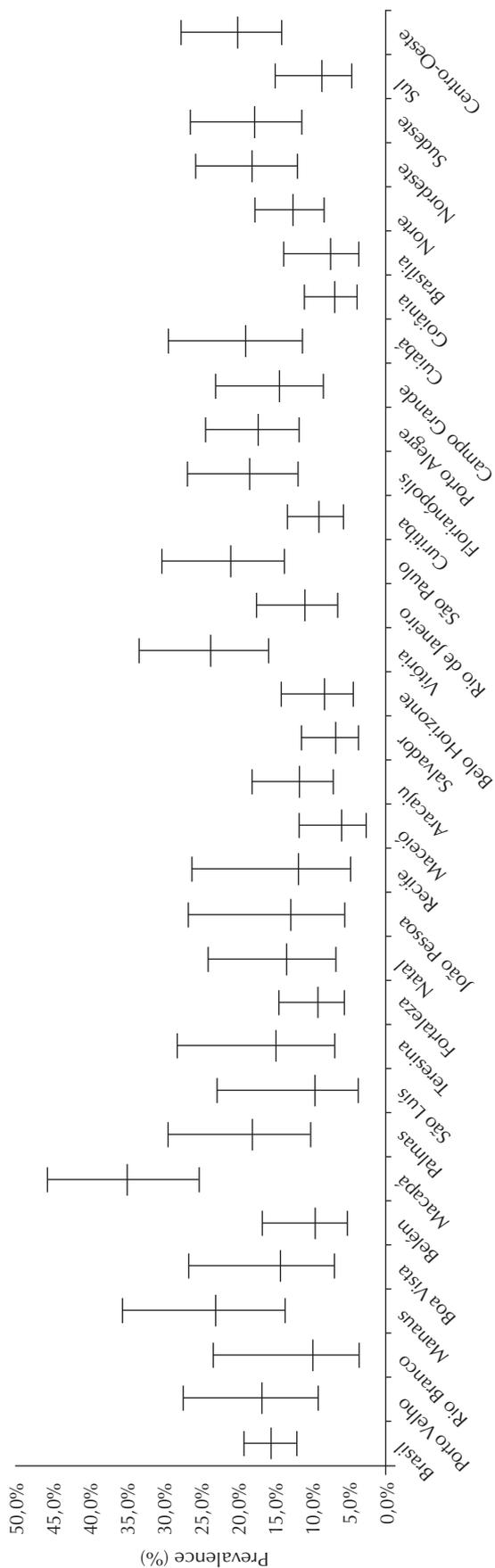
**Table 1.** Prevalence of periodontal disease according to contextual and individual sociodemographic variables. SBBrazil, 2010.

Variable	PD “moderate to severe” <sup>a</sup>		PD “severe” <sup>b</sup>	
	%	95%CI	%	95%CI
Contextual				
Gini index (2000)				
Low	8.6	6.6;11.1	1.6	1.0;2.7
Moderate	15.6	11.8;20.5	4.8	3.2;7.1
High	13.6	10.6;17.2	4.8	3.4;6.8
HDI municipality (2000)				
Low	11.9	9.2;15.4	2.9	1.7;4.8
Moderate	16.0	11.3;22.1	5.5	3.8;7.7
High	12.6	10.2;15.4	3.7	2.3;5.9
% smokers (2006)				
Low	10.1	7.1;14.1	1.9	1.0;3.4
Moderate	10.6	8.5;13.2	3.5	2.4;5.1
High	18.6	13.6;24.9	6.5	4.7;8.8
Integration of OHT/FHP(2011)				
Low	15.3	11.8;19.6	4.7	3.2;6.7
Moderate	9.3	7.5;11.5	3.0	2.1;4.2
High	16.9	13.4;21.1	3.4	2.3;5.1
Individual				
Age (years)				
35-39	10.2	8.0;12.8	2.9	1.8;4.5
≥ 40	19.1	15.0;23.9	6.0	4.3;8.3
Sex				
Female	13.5	10.4;17.4	3.6	2.4;5.3
Male	14.9	11.6;19.1	5.7	3.7;8.7
Skin color				
White	12.7	9.3;17.1	3.4	2.2;5.2
Yellow	26.4	5.2;70.3	10.7	1.7;44.9
Indigenous	2.3	0.5;9.3	1.2	0.2;7.2
Brown	14.8	11.7;18.4	4.8	3.4;6.8
Black	16.1	10.0;24.9	5.3	2.7;10.2
Family income (R\$)				
> 2,501.00	7.3	4.6;11.2	1.2	0.5;3.0
1,501.00-2,500.00	12.8	8.9;18.1	3.1	1.6;6.0
501.00-1,500.00	15.2	11.4;20.0	5.5	3.8;8.0
< 500.00	21.3	15.9;28.0	5.1	2.6;9.8
Years of schooling				
> 11	6.5	3.7;11.0	1.1	0.5;2.5
9 a 11	14.2	11.0;18.2	3.7	2.2;5.9
5 a 8	16.7	12.8;21.6	6.5	4.4;9.5
0 a 4	24.7	16.1;36.0	8.1	5.2;12.6

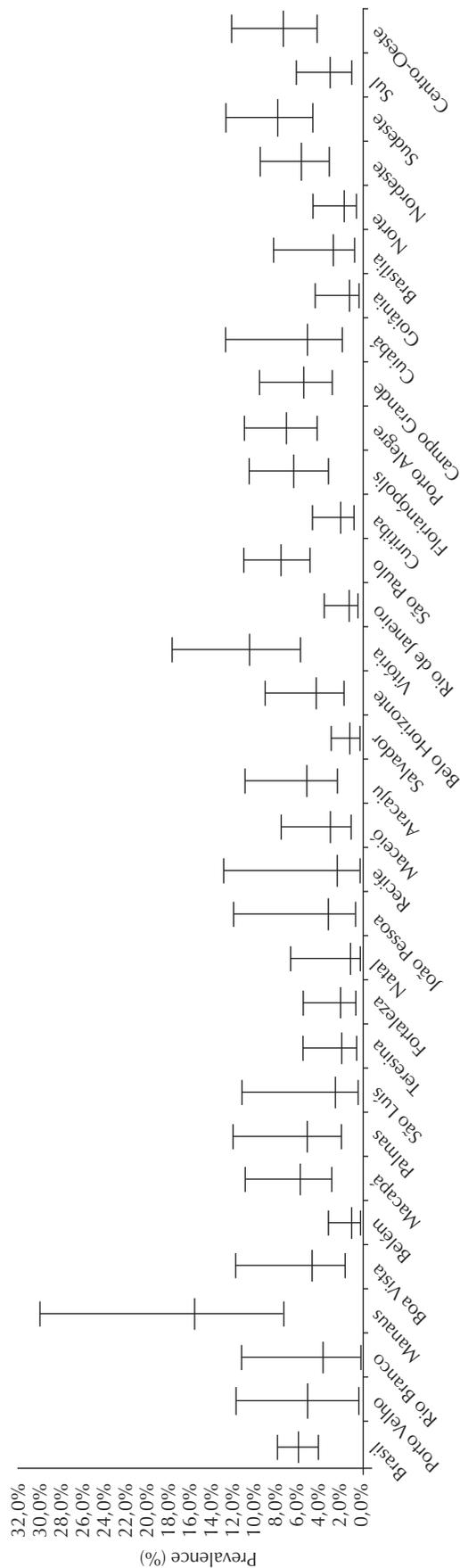
ESB/ESF:oral health care teams from the Family Health Care Strategy - *Estratégia de Saúde da Família*; HDI: Human Development Index.

<sup>a</sup>“moderate to severe” periodontal disease:presence of at least one sextant with pocket depth ≥ 4mm and at least one sextant with loss of periodontal attachment ≥ 4mm (Clinical Attachment Level> 0).

<sup>b</sup>“severe” periodontal disease:presence of at least one sextant with pocket depth ≥ 4 mm and at least one sextant with loss of periodontal attachment ≥ 6 mm (Clinical Attachment Level>1).



**Figure 1.** Prevalence of moderate to severe periodontal disease in Brazil, in the state Capitals and the Federal District and in the interior municipalities of Brazilian geographical regions.SBBrazil 2010.



**Figure 2.** Prevalence of severe periodontal disease in Brazil, in the state Capitals and the Federal District and in the interior municipalities of Brazilian geographical regions.SBBrazil 2010.

the cities with moderate level of HDI showed the highest values. The prevalence of periodontal disease was greater according to the proportion of smokers and lower integration of OHT/FHP. With regards the individual variables, periodontal disease was more prevalent among older adults, males, black skin colour and those with lower income and less schooling.

There was variation in the prevalence of periodontal disease between the cities based on the models with the

intercept. The variation (standard error) for “moderate to severe” and “severe” periodontal disease between the cities was 0.266 (0.088) and 0.475 (0.175), respectively. The variation of periodontal disease between cities was greater for the “severe” form of the disease (MOR = 1.93) than for the “moderate to severe” form (MOR = 1.64). This suggests that, if a healthy person moves to an area with higher prevalence of “severe” periodontal disease, the likelihood for the disease increases by 1.93 times.

**Table 2.** Non-adjusted association between contextual and individual variables and moderate to severe periodontal disease determined using multi-level logistic regression. SBBrazil, 2010.

Variable	Variance <sup>a</sup>	MOR <sup>b</sup>	$\beta$	Standard error	OR	95%CI
Contextual						
Gini index (2000)	0.236 (0.080)**	1.6				
Moderate			0.315	0.246	1.4	0.9;2.2
High			0.238	0.271	1.3	0.8;2.2
HDI municipality (2000)	0.256 (0.085)**	1.6				
Moderate			-0.137	0.247	0.9	0.5;1.4
Low			0.013	0.235	1.0	0.4;1.6
% smokers (2006)	0.196 (0.069)**	1.5				
Moderate			0.238	0.229	1.3	0.8;2.0
High			0.562	0.244	1.8	1.1;2.8*
Integration of OHT/FHP (2011)	0.154 (0.058)**	1.5				
Moderate			-0.725	0.214	0.5	0.3;0.7*
High			-0.333	0.217	0.7	0.5;1.1
Individual						
Age (years)					1	
35-39					1.5	1.3;1.8*
≥ 40						
Sex					1	
Female					1.3	1.1;1.5*
Male						
Skin colour					1	
White					1.5	1.2;1.8*
Brown					1.5	1.1;2.0*
Black						
Household income (R\$)					1	
> 2,501.00					2.0	1.4;2.7*
1,501.00-2,500.00					2.4	1.9;3.2*
501.00-1,500.00					3.1	2.2;4.3*
< 500.00						
Years of schooling					1	
> 11						
9 a 11					2.4	1.9;3.1*
5 a 8					3.6	2.7;4.6*
0 a 4					4.2	3.1;5.7*

OHT/FHP: oral health teams in the Family Health Programme - *Estratégia de Saúde da Família*; HDI: Human Development Index.

\*  $p < 0,05$ ; \*\*  $p < 0,01$

<sup>a</sup>Variance at city level ( $\Omega\mu$ [standard error]) obtained through random effects

<sup>b</sup>MOR: median of OR.

In the unadjusted analysis between contextual variables and periodontal disease, while the higher proportion of smokers and the lower integration of OHT/FHP were associated with “moderate to severe” periodontal disease, only the Gini index was positively associated with severe periodontal disease. All individual sociodemographic variables were statistically associated with both definitions of periodontal disease (Tables 2 and 3).

Table 4 shows the multivariate association between the predictors for the two definitions of periodontal

disease. The results of two models are shown for both definitions of periodontal disease. Model 1 shows the OR and 95% CIs of the contextual variables adjusted for each other and were significant ( $p < 0.10$ ) in the unadjusted analysis. Individual variables were inserted in the model 2 and the results refer to contextual and individual variables adjusted for each other. In the final model (model 2), the contextual variables associated with “moderate to severe” periodontal disease were the higher proportion of smokers in the city and lower

**Table 3.** Non-adjusted association between contextual and individual variables and severe periodontal disease determined using multi-level logistic regression. SBBrazil, 2010.

Variable	Variance <sup>a</sup>	MOR <sup>b</sup>	$\beta$	Standard Error	OR	95%CI
Contextual						
Gini index (2000)	0.350 (0.142)*	1.8				
Moderate			0.592	0.342	1.8	0.9;3.5
High			0.723	0.367	2.1	1.0;4.2*
HDI Municipality (2000)	0.473 (0.175)**	1.9				
Moderate			0.032	0.360	1.0	0.5;2.1
Low			0.367	0.348	1.4	0.7;2.9
% smokers (2006)	0.495 (0.181)**	2.0				
Moderate			0.118	0.370	1.1	0.5;2.3
High			0.224	0.397	1.3	0.6;2.7
Integration of OHT/FHP (2011)	0.340 (0.139)*	1.7				
Moderate			-0.597	0.339	0.6	0.3;1.1
High			-0.231	0.337	0.8	0.4;1.5
Individual						
Age (years)						
35-39					1	
$\geq 40$					2.0	1.5;2.7*
Sex						
Female					1	
Male					1.3	1.0;1.7*
Skin color						
White					1	
Brown					1.8	1.3;2.6*
Black					2.1	1.3;3.4*
Family income (R\$)						
> 2,501.00					1	
1,501.00-2,500.00					2.2	1.2;4.1*
501.00-1,500.00					3.4	2.0;5.8*
< 500.00					4.3	2.3;8.0*
Years of schooling						
> 11					1	
9 to 11					2.8	1.6;4.7*
5 to 8					4.9	2.9;8.3*
0 to 4					8.4	4.9;4.7*

OHT/FHP: oral health care teams from the Family Health Care Strategy - *Estratégia de Saúde da Família*; HDI: Human Development Index.

\*  $p < 0.05$ ; \*\*  $p < 0.01$

<sup>a</sup>Variance at city level ( $\Omega\mu$  [standard error]) obtained through random effects.

<sup>b</sup>MOR: median of OR.

integration of OHT/FHP. The odds of “moderate to severe” periodontal disease was 1.9 times greater for individuals in cities in the third tertile of the proportion of smokers (95%CI 1.3; 2.8) compared with those in cities in the first tertile. Moreover, adults in cities in the third tertile of integration of OHT/FHP had 30% lower odds (OR = 0.7; 95%CI 0.4; 0.9) of “moderate to severe” periodontal disease compared with adults in cities in the first tertile (Table 4).

In the final model, income inequality and lower integration of OHT/FHP remained associated with “severe”

periodontal disease. The third tertile of the Gini index remained associated with “severe” periodontal disease (OR = 3; 95%CI 1.5; 5.9). Integration of OHT/FHP also remained associated with “severe” periodontal disease. Individuals in cities in the second tertile of integration of OHT/FHP had 60% lower odds (OR = 0.4; 95%CI 0.2; 0.8) of “severe” periodontal disease compared to those in cities in the first tertile (Table 4).

All individual variables maintained statistical significance with the two definitions of periodontal disease. The chance of periodontal disease was greater in older

**Table 4.** Adjusted association between contextual and individual variables and “moderate to severe” and “severe” periodontal disease determined using multi-level logistic regression. SBBrasil, 2010.

Variable	“Moderate to severe” periodontal disease <sup>a</sup>				“Severe” periodontal disease <sup>b</sup>			
	Model 1		Model 2		Model 1		Model 2	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
<b>Contextual (2<sup>nd</sup> level)</b>								
Gini index (2000)								
Moderate	–	–	–	–	1.7	1.0;3.2	1.8	1.0;3.2
High	–	–	–	–	2.3	1.2;4.3*	3.0	1.5;5.9*
% smokers (2006)								
Moderate	1.4	1.0;2.9	1.4	1.0;2.1	–	–	–	–
High	1.7	1.1;2.5*	1.9	1.3;2.8*	–	–	–	–
Integration of OHT/FHP (2011)								
Moderate	0.5	0.3;0.7*	0.6	0.4;0.9*	0.5	0.3;0.9*	0.4	0.2;0.8*
High	0.8	0.5;1.1	0.7	0.4;0.9*	0.8	0.5;1.5	0.9	0.5;1.7
<b>Individual (1<sup>st</sup> level)</b>								
Age (years)								
35-39			1				1	
≥ 40			1.6	1.4;1.9*			2.0	1.5;2.7*
Sex								
Female			1				1	
Male			1.3	1.1;1.6*			1.2	0.9;1.7
Skin color								
Whithe			1				1	
Brown			1.3	1.1;1.6*			1.6	1.1;2.3*
Black			1.1	0.8;1.5			1.6	1.0;2.5
Family income (in reais)								
> 2,500.00			1				1	
1,501.00 - 2,500.00			1.7	1.3;2.4*			1.8	0.9;3.5
500.00 - 1,500.00			1.8	1.3;2.5*			2.2	1.2;4.1*
≤ 500.00			2.2	1.5;3.3*			2.7	1.3;5.4*
Years of schooling								
> 11			1				1	
9 to 11			2.1	1.6;2.8*			2.1	1.2;3.7*
5 to 8			3.0	2.3;4.1*			3.5	2.0;6.1*
0 to 4			3.4	2.4;4.7*			5.3	3.0;9.9*
Variance at city level (Ωμ [Standard error]) <sup>c</sup>	0.107 (0.044)*		0.102(0.044)*		0.236 (0.110)*		0.101(0.044)*	
MOR <sup>d</sup>	1.4		1.4		1.6		1.6	

OHT/FTP: Oral health care teams from the Family Health Care Strategy - *Estratégia de Saúde da Família*.

\* p < 0.05

<sup>a</sup> “Moderate to severe” periodontal disease: presence of at least one sextant with pocket depth ≥ 4mm and at least one sextant with loss of periodontal attachment ≥ 4mm (Clinical Attachment Level > 0).

<sup>b</sup> “Severe” periodontal disease: presence of at least one sextant with pocket depth ≥ 4 mm and at least one sextant with loss of periodontal attachment ≥ 6 mm (Clinical Attachment Level > 1).

<sup>c</sup> Variance at city level (Ωμ [standard error]) obtained through random effects

<sup>d</sup> MOR: Median of OR

adults, males, dark skin colour, lower income and less schooling. A gradient was found for the variables family income and years of schooling, in other words, the lower the income and the fewer the years of schooling, the greater the chance of periodontal disease. The magnitude of the associations of the individual variables was higher for “severe” periodontal disease compared with the “moderate to severe” form (Table 4). The term of interaction between Gini index and family income was not statistically significant for both outcomes at the significance level of 5%.

## DISCUSSION

This study described the prevalence and the geographical distribution of periodontal disease in Brazilian adults in 2010. In addition, there was a groundbreaking investigation in the Brazilian population into the possible role of contextual social determinants in the occurrence of the disease, considering individual sociodemographic characteristics.

The prevalence of “moderate to severe” periodontal disease in Brazilian adults in 2010 was 6.3% higher than in the 2003 oral health survey.<sup>13</sup> In a previous population based study of adults in Brazil, the prevalence of moderate and severe periodontal disease were 22% and 6%, respectively.<sup>14</sup> In spite of these variations, the studies were consistent in reporting a higher prevalence of periodontal disease among older adults, dark black skin colour, men and those with lower income and less schooling.<sup>13,14,e,f</sup>

The high variation in the prevalence of periodontal disease between municipalities is explained by the diversity of its determinants and the method used to evaluate periodontal disease. In this study, both lifelong accumulated periodontal breakdown and current periodontal disease were considered when defining “case” of periodontal disease since combined measures of pocket depth and loss of periodontal attachment, based on CPI and CAL measures, were taken into account in the definition of periodontal disease.<sup>3</sup> Although the use of indices make possible to record periodontal conditions in epidemiological surveys, their use is not free from critique. In general, the use of index teeth and the tooth loss underestimate the prevalence of periodontal disease since the periodontal condition is only recorded when there are at least two teeth not indicated for extraction.<sup>8,21</sup> Thus, to some extent, the variation of periodontal disease between municipalities can be attributed to the use of periodontal indices, as the percentage of individuals who were classified as excluded condition for CPI ranged from 28% to 54% between the regions.<sup>f</sup> The increase in

the prevalence of periodontal disease in Brazilian adults between 2003 and 2010 may also be explained, at least in part, by the reduction on tooth loss over the last few years. While 35% of sextants were deemed excluded in the periodontal examinations in 2003, this figure dropped to 32% in 2010.<sup>e,f</sup>

Although the proportion of adult smokers in the population at municipality level was considered in this study, the lack of individual information on smoking is an important limitation.

This study shows that “severe” periodontal disease in adults was associated with higher levels of income inequality of the cities. This relationship remained after adjustment for individual characteristics, including family income. Therefore, our findings confirm previous reports on the role of social inequalities as a determinant of periodontal disease, not only at the individual level, but also in the context.<sup>2,16</sup>

Despite the time span of ten years between the measure of income inequalities and the data on periodontal disease, it is possible to argue whether this interval would be sufficient to affect the course of periodontal disease, due to its chronic nature. Moreover, this was a cross-sectional study, and the limitation regarding inference should be recognized as the data was on the prevalence of periodontal disease.

Studies on the association between income inequalities and periodontal disease are relatively recent.<sup>2,4,5,16</sup> In the USA, based on the 3<sup>rd</sup> National Health and Nutrition Examination Survey (NHANES III) conducted in 1994, low socioeconomic conditions at neighborhood level were associated with higher prevalence of periodontal disease.<sup>2</sup> In an ecological study involving the 17 rich countries, a positive correlation was found between higher levels of income inequality and percentage of adults with pockets depths  $\geq 4$  mm and  $\geq 6$  mm.<sup>16</sup> In 1998, data from the Adult Dental Health Survey in the United Kingdom did not show association between social deprivation at postcode area level and periodontal disease.<sup>4</sup>

The findings of the current study differ from those obtained using the data from the 2003 Brazilian oral health survey. The Gini index for the years 1991 and 2000 was not associated with periodontal conditions in 2003, which may have been due to the adopted criteria for periodontal disease.<sup>5</sup>

The explanatory mechanisms on the link between social determinants and periodontal disease vary. Social inequalities may have an indirect negative impact on

<sup>e</sup> Ministério da Saúde (BR). Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Coordenação Nacional de Saúde Bucal. SB 2000: condições de saúde bucal da população brasileira 2002-2003. Resultados Principais. Brasília (DF); 2004.

<sup>f</sup> Ministério da Saúde (BR). Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Coordenação Nacional de Saúde Bucal. SB Brasil 2010: Pesquisa Nacional de Saúde Bucal: resultados principais. Brasília (DF); 2011.

the characteristics of the society through degradation of interpersonal relationships between its members.<sup>18</sup> Periodontal disease has been associated with fewer social networks and less participation in social activities.<sup>11</sup> Thus, feelings of relative deprivation of goods, increased violence and reduction of social cohesion may negatively influence health through reducing diffusion of health information, less access to health care services and poor development of health policies.<sup>7,18,20</sup>

One possible direct mechanism of social inequalities on periodontal conditions is related to the immunosuppressive effect of stress in response to environmental determinants. Several studies have described the association between psychosocial factors and periodontal disease.<sup>12</sup> Psychosocial stressors may compromise the immune system through alterations in the levels of inflammatory mediators and defence cells.<sup>6</sup> Furthermore, psychosocial factors may modify behaviours associated with periodontal health, such as smoking and increased alcohol consumption.<sup>12</sup>

Integration of OHT/FHP was the only contextual variable associated with both definitions of periodontal disease. This finding suggests a possible effect of actions in the primary health care to prevent and control periodontal disease. However, research using appropriate study design to evaluate health care programs and public health policies are necessary to confirm the effectiveness of actions developed within primary health care on the reduction of periodontal disease. Expansion in the provision and access in oral health care in primary health care may be important in preventing and promoting periodontal health.

Income Inequality was independently associated with “severe” periodontal disease, but not with “moderate to severe” periodontal disease. Monitoring oral health problems, including periodontal disease, through population oral health surveys should be on the agenda of epidemiological surveillance actions and should be a priority to enable adequate evaluation and development of public policies in oral health.

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