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Occurrence and risk indicators of increased probing depth in an adult Brazilian population

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Abstract

Background/Aims: There is little information about the occurrence and risk indicators for periodontal diseases in Latin America. The present study describes the prevalence, extent and severity of periodontal probing depth (PPD) and assesses the association between demographic, behavioural and environmental risk indicators and the extent and severity of PPD in this population.

Materials and Methods: The target population was urban adults aged ⩾30 years in Rio Grande do Sul state in South Brazil. A representative sample was selected using a multi-stage, probability, cluster sampling strategy and included 853 dentate subjects 30–103 years of age. A full-mouth clinical examination was carried out at six sites per tooth on all permanent teeth, excluding third molars, and was conducted in a mobile examination centre.

Results: Approximately 65% and 25% of the subjects and 19% and 5% teeth per subject had PPD ⩾5 and ⩾7 mm, respectively. 31.6%, 33.7% and 34.7% subjects had generalized, localized or no PPD ⩾5 mm, respectively. Probing depth increased in prevalence with increasing age, and leveled off at around 50 years of age and beyond. PPD ⩾5 mm was significantly higher in males than in females, and in non-Whites than in Whites. Cigarette smokers had a significantly higher occurrence of PPD ⩾5 mm than non-smokers, and this relationship was dose dependent. A multivariate model showed that generalized PPD ⩾5 mm was associated with subjects aged ⩾40 years, males, non-Whites and moderate or heavy cigarette smokers (relative risk ratios: 2.0, 2.0, 2.2, 2.4 and 6.8, respectively).

Conclusion: Moderate and deep probing depth was a common finding in this urban adult Brazilian population. Older age, male gender, non-White race and moderate and heavy cigarette smoking were significant risk indicators of increased PPD, and these may be useful indicators of periodontal disease high-risk groups.

Key words: cigarette smoking; Latin America; oral hygiene; periodontal diseases/epidemiology; pocket depth; risk factors

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Chronic periodontal diseases are inflammatory disorders caused by dental biofilm microorganisms and may lead to loss of periodontal attachment, including destruction of the periodontal ligament and adjacent supporting bone. In addition to the loss of attachment, the chronic inflammatory process may result in gingival recession and/or deepening of the periodontal sulcus and the formation of a pathological pocket. The measurement of periodontal attachment loss is a valuable measure of the severity of periodontal tissue loss, and may be indicative of a previous destructive disease process, and as such is merely a historic measure of the extent and severity of past disease activity. Periodontal probing depth (PPD), on the other hand, provide useful information about the present inflammatory status of periodontal tissue, and may also be indicative of the chronicity of the local inflammation.

A significant amount of PPD data have been generated describing the periodontal status of various populations and groups around the world (Albandar & Rams 2002). Many studies have used the Community Periodontal Index of Treatment Needs (CPITN) or a modification of this index, and most have used convenience study samples. However, the validity of the CPITN as a measure of periodontal status of populations has been questioned (Baelum & Papapanou 1996, Kingman & Albandar 2002).

Few studies have investigated the occurrence of periodontal diseases in

Brazil. A survey conducted in 1986 (MS 1988) used the CPITN methodology and estimated that 0.7%, 5.2% and 7.4% of Brazilians in the age groups 15–19, 35–44 and 50–59 years, respectively, had one or more teeth with PPD $\geqslant$5.5 mm (CPITN score 4). There are scarce data on risk factors of periodontal diseases in the Brazilian population.

This study assessed the prevalence, extent and severity of PPD in the Brazilian state of Rio Grande do Sul using a sample representative of a large segment of the adult urban population, and investigated the association between demographic, behavioural and environmental risk indicators, and the extent and severity of PPD in this population.

Table 1. Number and percentage* of subjects in the study sample by gender and age group, and the corresponding number and estimated percentage of subjects they represent in the target population according to the 1996 census

Age (years)	Dentate sample*				Whole sample*				Target population†	
	males		females		males		females		males, $N = 773{,}739$ (%)	females, $N = 898{,}047$ (%)
	N	%	*N*	%	*N*	%	*N*	%		
30–39	137	16.1	158	18.5	137	14.1	160	16.4	17.5	18.9
40–49	108	12.7	146	17.1	109	11.2	151	15.5	13.2	14.5
50–59	84	9.8	91	10.7	91	9.3	109	11.2	7.9	9.1
60–69	40	4.7	45	5.3	58	6.0	69	7.1	4.9	6.5
$\geqslant$70	19	2.2	25	2.9	33	3.4	57	5.9	2.8	4.8
Total	388	45.5	465	54.5	428	43.9	546	56.1	46.3	53.7

*Percentages are not adjusted for sampling bias.
†1996 population census (IBGE 1996, 2001).

Material and Methods

Population

The target population in the present study was adults aged 30 years and older living in 14 major municipalities (total population approximately 3 million) in the Porto Alegre metropolitan area in the state of Rio Grande do Sul, which is located in the southern part of Brazil, neighbouring Argentina and Uruguay.

Study sample

The study sample included 974 individuals with an age range of 30–103 years, and comprised 388 (45.5%) males and 465 (54.5%) females, and included 686 (80.4%) Whites and 167 (19.6%) non-Whites. The study group comprised of 853 dentate and 121 edentulous subjects (Table 1). The periodontal findings of dentate persons are reported in this study. The mean tooth loss was 9.2 (SD: 7.2); ranging between 5.2 teeth (SD: 5.0) among 30–39 years old, and 16.2 teeth (SD: 6.9) for persons 70 years of age and older.

Study design

The study sample was drawn from a larger sample representative of subjects aged 14 years and older among the target population. A representative sample was derived using a multi-stage probability sampling method and based on information provided by Rio Grande do Sul state government agency for metropolitan affairs (METROPLAN) and the Brazilian Institute of Geography and Statistics (IBGE). Using area maps, the Porto Alegre metropolitan area was divided into 90 geographic areas 10 km^2 each. Using the 1991 census data (IBGE 1991) and other relevant municipal information (METROPLAN 1997) these geographic areas were stratified into 13 (14.4%) high-income and 77 (85.6%) low-income status areas. Low-income geographic areas were defined as areas in which more than 40% of the head of the households had a monthly income $\leqslant$2 standard Brazilian salaries (about US$ 180), and high-income areas were those with a higher level of income. Within each of these two income strata, primary sampling units (PSUs) were selected randomly with a probability proportional to size and using a sampling frame of these PSUs. A total of 11 geographic areas were selected, and included two (18.2%) areas with high-income status, and nine (81.8%) areas with low-income status.

The second stage consisted of selecting area sectors within each geographical area. The area sectors have been defined by IBGE as map areas comprising approximately 300 households each. The sectors were selected randomly within each geographic area, and the number of sectors selected was proportional to the number of sectors in each area. Thirty (3.5%) sectors were selected, out of a total of 846 eligible sectors. Approvals for conducting the study were sought separately in each sector from key community, religious and/or administrative leaders. Permission and support were granted to access 29 of these sectors, whereas permission to access 1 sector was not granted.

The third stage included selecting households within each of the 29 sectors. We estimated that approximately 25 households were needed per sector to provide a sufficient number of subjects in the sample. In each sector, a starting point for the selection of households was established on area maps and was provided independently by the IBGE. Households were sampled consecutively beginning with the next block after the starting point, and until the preset number of households was reached.

Consenting household members who were 14 years of age or older were included in the study. Exclusion criteria were presence of diseases/conditions that may pose health risks to the participant or examiner, or that may interfere with the clinical examination. Hence, subjects were excluded if they were diagnosed with serious psychiatric problems, or were intoxicated with alcohol or drugs. Individuals requiring a prophylactic regimen of antibiotics were provided with the appropriate medicine before the clinical examination.

Clinical examinations

The clinical examinations were performed in a mobile examination unit consisting of a trailer equipped with a complete dental unit, including a dental chair, light, compressor and other basic amenities. The examination unit was moved from one examination location to the next according to the survey schedule. The examination team consisted of four dentists and two dental assistants, conducted the fieldwork between June and December 2001. Letters were sent to households and explained the aims of the study and solicited participation. A few days later, a dentist visited the households and provided further information about the study and encouraged participation. Eligible subjects who consented to participate

were interviewed to gather demographic, socioeconomic oral health and other health-related data using a structured written questionnaire.

Trained dental assistants recorded the data on prepared record sheets. All permanent, fully erupted teeth, excluding third molars, were examined with a manual periodontal probe (PCP10-SE, Hu-Friedy Mfg. Co. Inc., Chicago, IL, USA) colour coded at 1, 2, 3, 5, 7, 8, 9, 10 mm. Six sites per tooth were assessed at the mesiobuccal, midbuccal, distobuccal, distolingual, midlingual and mesiolingual sites. Probing depth was defined as the distance from the free gingival margin to the bottom of the pocket/sulcus. All measurements were made in millimetres and were rounded to the lowest whole millimetre.

Ethical considerations

The study protocol was reviewed and approved by the following committees: Research Ethics Committee, Federal University of Rio Grande do Sul, Porto Alegre, Brazil; the National Commission on Ethics in Research, Ministry of Health, Brasilia, Brazil; Ethics in Medical Research Committee, University of Bergen, Bergen, Norway. Subjects who agreed to participate signed a written informed consent. At the conclusion of the study the participants were provided with a written report detailing their oral status and any diagnosed mucosal lesions. Patients with diagnosed pathological conditions were advised to seek specialist consultation and treatment.

Non-response analysis

Two thousand four hundred and thirty-five individuals aged 14 years and older were eligible in the original survey. Of these, 1586 (65.1%) subjects were clinically examined. Among those who did not participate, 127 (5.2%) subjects declined to participate, 26 (1.1%) subjects were unable to attend the examination site because of an impairing physical condition, and 636 (26.1%) subjects were not at home. Subsequent to the completion of the examinations, a random sample of 339 (39.9%) subjects was selected out of 849 eligible subjects who either refused to participate or were not available during the normal survey schedule. Attempts were made to contact the selected subjects by telephone in order to collect data for the non-response analysis. Of the 339 subjects selected for interview, 50 (14.7%) subjects and their household were not available on two telephone call attempts, and an additional 18 (5.3%) subjects refused to be interviewed.

Non-response data were obtained for 271 (79.9%) subjects (will be referred to as the non-respondents). Of these, 127 subjects were present and agreed to the telephone interview. The other 144 subjects were not available on two telephone call attempts, and the non-response data were therefore obtained through a first-degree relative living in the same household. The information collected included the subject's gender, age, education, dental care visits and income level. In addition, information about the number of teeth present was collected for the 127 subjects who were present during the telephone interview.

The mean age of the non-respondents group was 35.2 years, and included 51.3% males and 48.7% females and 90.8% Whites and 9.2% non-Whites. In contrast, the mean age of the study group was 38 years and included 45.3% males and 54.7% females, and 82.5% Whites and 17.5% non-Whites. By the number of years of education, the non-respondents and respondents groups included 7.4% and 22.3% subjects with 4 or fewer years, 22.5% and 40.0% subjects with 5–8 years and 70.1% and 37.8% subjects with more than 8 years, respectively. This suggests that the non-respondents were similar to the study group in the mean age, but included somewhat higher percentages of males and Whites, and had a higher number of years of education than the study participants. A weight variable was used in the data analysis to minimize the bias in the population parameter estimation (Korn & Graubard 1999) that may arise because of the sample non-response. The calculation of the weight variable was based on Census information provided by IBGE (1996).

Measurements reproducibility

The examiners were trained and calibrated in performing the clinical measurements at two time points, before and 3 months after the start of the study. The examination team followed a quality control protocol that involved standard examination environment and methodology, standard equipment and detailed written instructions for clinical procedures, and the protocol was aimed at reducing systematic and random measurement errors and to quantify what error remained.

Assessment of measurement reproducibility used replicate periodontal measurements performed during the fieldwork. An experienced clinician served as the ''gold standard'' examiner. A total of 57 subjects, divided into four groups ranging from 8 to 20 subjects, were used for the reproducibility assessment. In one of the groups, the replicate measurements consisted of repeated measurements by the gold standard examiner. In each of the remaining three groups, the replicate measurements were made by one examiner and the gold standard examiner. Measurement reproducibility at the subject level was assessed by the intra-class correlation coefficient (Shrout & Fleiss 1979) and weighted κ, and at the site level by the weighted κ (Hubert 1977). The intra-class correlation coefficients for mean PPD ranged between 0.92 and 0.99, and for extent scores of PPD $\geqslant 5$ and $\geqslant 7$ mm ranged between 0.81 and 0.97. The weighted κ's ($\pm$ 1 mm) for subject-level PPD prevalence measurements were between 0.90 and 1.00. The weighted κ's ($\pm$ 1 mm) for site-level PPD measurements ranged between 0.85 and 0.92.

Data analysis

Prevalence was defined as the percentage of individuals having at least one tooth with the condition, and extent was defined as the percentage of teeth per person having at least one site with the condition. Severity was assessed as thresholds of PPD.

The race variable was scored as White or non-White. Only two categories of race were used because reliable criteria to classify Brazilian subjects into blacks and mulattos were not available, and since this population included only a small percentage of other ethnic groups.

The questionnaire assessed a number of health-related variables. The subjects were grouped by the frequency of use of inter-dental oral hygiene devices. Regular users were defined as subjects who used toothpick, dental floss or other inter-dental tools at least once a day. Individuals using inter-dental oral hygiene devices less often than once a day were categorized as irregular users of inter-dental oral hygiene. The study subjects were classified according to the self-reported frequency and reasons for dental visits. Individuals who had visited a dentist on a regular basis for

maintenance care during the last 5 years were classified as having regular dental visits. Subjects who had visited a dentist only for emergency dental treatment, or had not visited a dentist during the last 5 years were classified as having irregular dental visits.

Socioeconomic status was scored by combining information about family economy using a standard Brazilian economy classification (CCEB) (ANEP Task Force 1997) and the level of education of the individual. High socioeconomic status was defined as having $\geqslant 9$ years of education and being in the upper two tertiles of the CCEB economy classification, or having 5–8 years of education and being in the highest tertile of the CCEB classification. Low socioeconomic status was defined as having 1–4 years of education, and being in the lowest two tertiles of the CCEB classification, or having 5–8 years of education and being in the lowest tertile of the CCEB classification. Individuals who had higher economy and education than the low socioeconomy group, but less than the high socioeconomy group were classified as having medium socioeconomic status.

Exposure to smoking was calculated for current and former smokers combined. Number of cigarettes consumed per day was multiplied by number of years of habit and divided by 20 (1 pack) to calculate the total number of packs of cigarettes consumed. The subjects were classified into four groups: non-smokers, light (1–2734 packs), moderate (2735–7300 packs) and heavy smokers (>7300 packs).

Data analysis was performed using STATA software (Stata 7.0 for Windows, Stata Corporation, College Station, TX, USA) and utilizing survey commands that take into account survey design, including stratification, clustering and weighting and robust variance estimation. A weight variable was used to adjust for the probability of selection and deviations in the sample distributions from the target population distribution by age, gender and education (IBGE 1996, Korn & Graubard 1999). Pairwise comparisons of crude estimates were carried out using the Wald test (Korn & Graubard 1999). The chosen level of statistical significance was 5%, and the 95% confidence intervals (CI) were calculated.

Survey Multinomial Logistic Regression (Hosmer & Lemeshow 2000, Long & Freese 2001) was used to assess the contribution of potential risk indicators of moderate and deep PPD. The dependent variable was presence of localized or generalized occurrence of moderate or deep PPD. Generalized and localized PPD was defined as subjects having $>20\%$ teeth or 1–20% teeth with PPD $\geqslant 5$ mm, respectively. Individuals with no teeth showing PPD $\geqslant 5$ mm were used as the reference group. Univariate and multivariate models used the multinomial logistic regression method to compare the localized and generalized groups, separately, with the reference group. In the multinomial logistic model the estimate of risk in the population is reported as relative risk ratio (RRR), which is equivalent to odds ratio in the dichotomous or binary logistic regression analysis. Eight hundred and forty-eight subjects were included in the multivariate analysis.

Results

Approximately 65% and 25% of the subjects, and a mean of 19% and 5% teeth per subject had PPD $\geqslant 5$ and $\geqslant 7$ mm, respectively (Table 2). A weak relationship was disclosed between PPD and age. The prevalence and extent of PPD increased significantly between 30–39 and 40–49 years age groups, whereas in the older age groups PPD either remained unchanged or decreased slightly. PPD $\geqslant 5$ mm was more prevalent in the maxillary than in the mandibular teeth, and occurred mainly in molars (Fig. 1).

Males and non-Whites had significantly higher prevalence and extent of PPD $\geqslant 4$ and $\geqslant 5$ mm than females and Whites, respectively (Table 3). Compared with the high socioeconomic status group, subjects in the low and medium socioeconomic status groups had similar prevalence, and significantly higher extent of PPD $\geqslant 5$ mm ($p<0.01$) and $\geqslant 7$ mm ($p<0.05$) (Fig. 2). Individuals with a history of irregular dental visits showed significantly higher prevalence ($p<0.05$) and extent ($p<0.01$) of PPD $\geqslant 5$ mm than individuals with regular dental visits (Fig. 3). Individuals who did not perform inter-dental hygiene, or performed it irregularly had significantly higher extent ($p<0.05$) of PPD $\geqslant 7$ mm than individuals who had performed inter-dental hygiene daily (Fig. 4). Compared with non-smokers, heavy and moderate smokers had significantly higher prevalence (88% and 73% *versus* 56%, $p<0.001$) and extent (33% and 24% *versus* 14%, $p<0.001$) of PPD $\geqslant 5$ mm (Fig. 5). There were, however, no significant differences in the prevalence or extent of PPD $\geqslant 5$ mm between light smokers and non-smokers, or between subjects who self-reported to be diabetics or non-diabetics.

31.6% and 33.7% of the subjects had generalized and localized PPD, respectively, and 34.7% subjects had no sites with PPD ≥ 5 mm. The univariate analysis showed that generalized PPD $\geqslant 5$ mm was associated with subjects who were 40–49 ($p<0.05$) or $\geqslant 50$ years old ($p<0.01$), males ($p<0.01$), of non-White race ($p<0.01$), moderate or heavy smokers ($p<0.01$) and with a history of irregular dental visits ($p<0.01$) (Table 4). Localized PPD $\geqslant 5$ mm was associated with males ($p<0.01$), non-Whites ($p<0.05$) and heavy smokers ($p<0.01$). Socioeconomic status, inter-dental hygiene and the self-reported diabetic status were not significantly associated with the subject's PPD status.

The multivariate analysis showed that generalized PPD $\geqslant 5$ mm was associated with older age (40–49 years: RRR = 2.1; 50–59 years: RRR = 2.3), males

Table 2. Percentage of subjects (prevalence) and percentage of teeth per subject (extent), by thresholds of probing depth and age group

Probing depth	30–39		40–49		50–59		60–69		70+		Total	
	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Prevalence (mm)												
$\geqslant 4$	79.1	2.6	83.0	3.7	78.5	4.1	76.1	4.5	71.0	8.3	79.6	2.6
$\geqslant 5$	61.6	3.0	69.5	4.9	68.3	3.3	64.5	4.3	58.7	13.6	65.2	2.1
$\geqslant 6$	30.8	3.0	41.0	6.0	38.3	3.3	34.0	4.8	27.1	8.3	35.3	2.4
$\geqslant 7$	19.8	3.1	32.9	4.7	27.8	1.9	21.8	4.7	23.1	8.8	25.4	2.2
Extent (mm)												
$\geqslant 4$	24.0	1.3	34.2	3.2	33.4	1.8	32.2	4.2	32.4	5.7	29.7	1.1
$\geqslant 5$	13.7	0.9	23.5	2.9	21.9	1.3	20.2	3.2	23.0	5.6	19.0	0.7
$\geqslant 6$	4.5	0.5	9.9	1.3	8.0	1.0	6.4	1.3	5.7	1.6	7.0	0.4
$\geqslant 7$	2.6	0.4	7.0	0.8	5.1	0.7	3.8	0.9	4.4	1.2	4.5	0.3

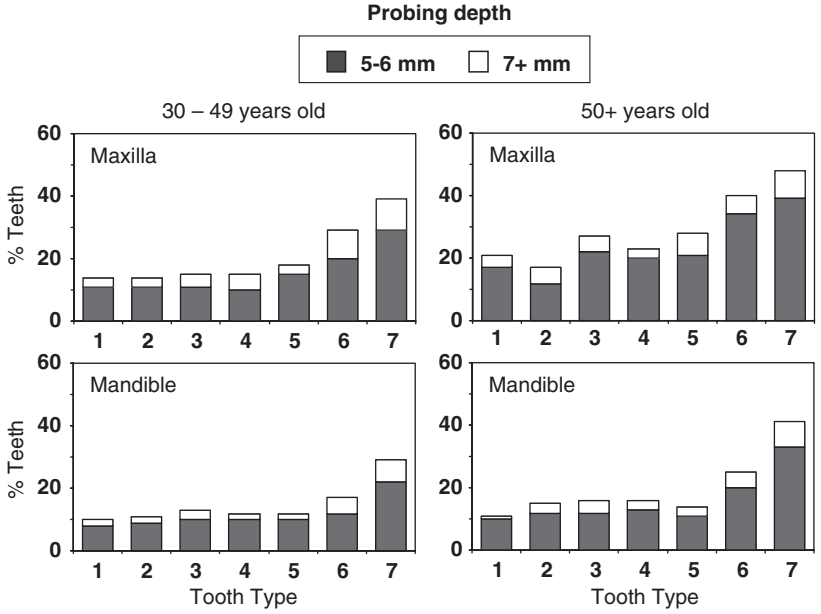

Fig. 1. Percentage of teeth, by threshold of probing depth, tooth type, and age group. 1, central incisor; 7, second molar.

Table 3. Percentage of subjects (prevalence) and percentage of teeth per subject (extent), by threshold of probing depth, gender and race

Probing depth	Gender					Race				
	males		females		*p*	Whites		non-Whites		*p*
	%	SE	%	SE		%	SE	%	SE	
Prevalence (mm)										
⩾4	87.8	1.2	72.2	4.1	0.004	77.6	2.7	87.9	2.6	0.004
⩾5	75.9	1.6	55.6	2.8	0.0001	62.9	2.0	74.8	2.1	0.0002
⩾6	43.8	2.3	27.6	2.6	0.0001	33.3	2.8	43.5	3.3	0.05
⩾7	31.0	1.9	20.3	2.5	0.0007	23.3	2.6	34.0	3.8	0.07
Extent (mm)										
⩾4	34.4	1.2	25.4	1.2	0.0001	28.0	1.3	36.7	1.8	0.006
⩾5	22.6	1.0	15.7	0.8	0.0001	18.0	0.9	22.9	1.0	0.01
⩾6	8.7	0.6	5.4	0.4	0.001	6.7	0.7	8.2	1.1	0.36
⩾7	5.7	0.4	3.5	0.4	0.002	4.2	0.5	5.8	0.9	0.22

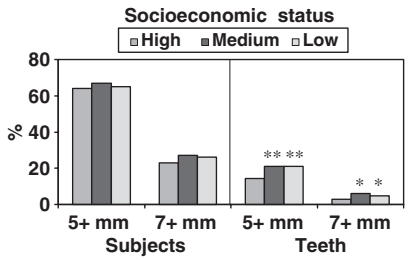

Fig. 2. Percentage of subjects, and the percentage of teeth per subject with probing depth ⩾5 and ⩾7 mm, by socioeconomic status ($^{*}p<0.05$; $^{**}p<0.01$; reference: high socioeconomic status group).

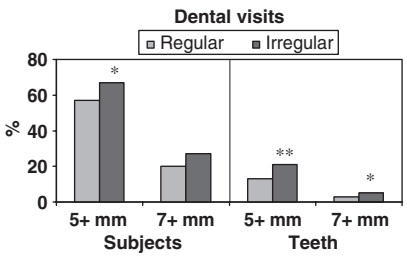

Fig. 3. Percentage of subjects, and the percentage of teeth per subject with probing depth ⩾5 and ⩾7 mm, by pattern of dental visits ($^{*}p<0.05$; $^{**}p<0.01$).

(RRR = 2.0), non-Whites (RRR = 2.2) and moderate (RRR = 2.4) or heavy smokers (RRR = 6.8) (Table 5). Localized PPD ⩾5 mm was associated with males (RRR = 2.0) and heavy smokers (RRR = 3.2).

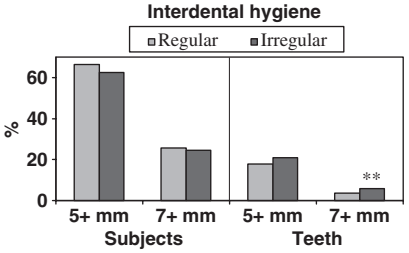

Fig. 4. Percentage of subjects, and the percentage of teeth per subject with probing depth ⩾5 and ⩾7 mm, by inter-dental oral hygiene status ($^{*}p<0.05$; $^{**}p<0.01$).

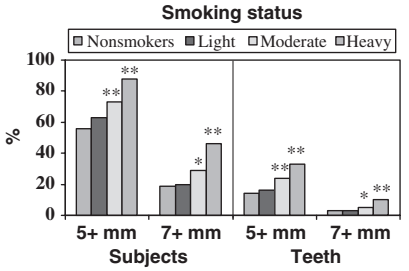

Fig. 5. Percentage of subjects, and the percentage of teeth per subject with probing depth ⩾5 and ⩾7 mm, by cigarette smoking status ($^{*}p<0.05$; $^{**}p<0.01$; reference: non-smokers).

Discussion

The results of this study show that moderate and deep probing depth was a common finding in this urban adult Brazilian population. Approximately two-thirds of the subjects, and on average 19% of teeth per subject had PPD ⩾5 mm. Probing depth increased in prevalence during early adulthood, and leveled off around 50 years of age and beyond. PPD ⩾5 mm was significantly higher in males than in females, and in non-Whites than in Whites.

A survey performed in Brazil in 1986 used the CPITN method to assess the periodontal status of diverse Brazilian communities, and reported that 5.2% of 35–44 years olds, and 7.4% of 50–59 years olds had one or more sites with PPD ⩾5.5 mm (CPITN code 4) (MS 1988). However, the latter survey sampled only the capital cities of 16 major Brazilian states, and therefore its findings may only be representative of part of the urban Brazilian population. In a random sample of Rio de Janeiro residents, Flores-de-Jacoby et al. (1991), found that 19.8% of 35–44 years olds, and 48.4% of 55–64 years olds had PPD ⩾5 mm. In contrast, the prevalence of PPD ⩾6 mm in the present study was

Table 4. Univariate analysis of the association of demographic and other variables with the occurrence of a localized or generalized pattern of probing depth $\geqslant 5$ mm[†]

Risk indicators	Group	*N*	Probing depth					
			localized			generalized		
			RRR	95% CI		RRR	95% CI	
Age (years)	30–39	294	1.0			1.0		
	40–49	253	0.9	0.5	1.7	2.4*	1.1	5.2
	50–59	175	0.8	0.5	1.3	2.5**	1.7	3.7
	60+	126	0.7*	0.5	0.9	1.8**	1.2	2.7
Gender	Female	385	1.0			1.0		
	Male	463	2.3**	1.6	3.4	2.7**	2.1	3.6
Race	White	681	1.0			1.0		
	Non-White	167	1.4*	1.1	1.8	2.2**	1.6	3.0
Socioeconomic status	High	342	1.0			1.0		
	Medium	235	0.8	0.6	1.2	1.4	0.9	2.3
	Low	271	0.9	0.5	1.7	1.5	1.0	2.4
Smoking	Non-smokers	419	1.0			1.0		
	Light smokers	147	1.3	0.8	2.3	1.4	0.9	2.2
	Moderate smokers	139	1.8	1.0	3.3	2.7**	1.5	4.9
	Heavy smokers	143	3.7**	2.0	7.0	8.9**	5.1	15.4
Interdental hygiene	Regular	536	1.0			1.0		
	Irregular	304	0.8	0.6	1.1	0.9	0.6	1.4
Dental visits	Regular	188	1.0			1.0		
	Irregular	655	1.3	0.8	2.0	1.9*	1.1	3.4
Diabetic status	Non-diabetic	789	1.0			1.0		
	Diabetic	59	1.3	0.9	2.0	1.2	0.5	2.8

*$p<0.05$.
**$p<0.01$.
[†]The reference group is subjects without PPD $\geqslant 5$ mm.
RRR, relative risk ratio; CI, confidence interval.

Table 5. Multivariate analysis of the association of demographic and other variables with the occurrence of a localized or generalized pattern of probing depth $\geqslant 5$ mm[†]

Risk indicators	Group	Probing depth					
		localized			generalized		
		RRR	95% CI		RRR	95% CI	
Age (years)	30–39	1.0			1.0		
	40–49	0.9	0.5	1.5	2.1*	1.1	4.1
	50–59	0.8	0.5	1.2	2.3**	1.7	3.3
	60+	0.7	0.5	1.0	1.9	0.9	3.8
Gender	Female	1.0			1.0		
	Male	2.0**	1.4	2.9	2.0**	1.5	2.6
Race	White	1.0			1.0		
	Non-White	1.4	0.9	2.0	2.2**	1.8	2.8
Smoking	Non-smoker	1.0			1.0		
	Light smokers	1.2	0.7	2.2	1.3	0.8	2.3
	Moderate smokers	1.5	0.9	2.7	2.4**	1.5	4.0
	Heavy smokers	3.2**	1.7	5.7	6.8**	4.3	10.7

*$p<0.05$.
**$p<0.01$.
[†]The reference group is subjects without PPD $\geqslant 5$ mm.
RRR, relative risk ratio; CI, confidence interval.

comparable with the prevalence of PPD $\geqslant 5.5$ mm in the Rio de Janeiro sample, and higher than the overall estimates for the Brazilian population reported in the 1986 survey.

The prevalence of PPD in this population seems comparable with that of populations in other developing countries. In a sample comprising various age groups of Kenyans, 75–95% of the subjects had PPD $\geqslant 4$ mm, and 3–38% of subjects had PPD $\geqslant 7$ mm (Baelum et al. 1988). In South Thailand, 84% and 10% of 30–39-year-old subjects, and 93% and 28% of 50–59 years old had PPD $\geqslant 4$ and $\geqslant 7$ mm, respectively (Baelum et al. 2003). The prevalence of PPD $\geqslant 6$ mm in our population also was similar to the prevalence of PPD >5.5 mm reported for the 10 poorest European countries (approximately 36% subjects in the age group 35–44 years had CPITN code 4) (Sheiham & Netuveli 2002). Other studies using CPITN also showed a relatively high frequency of increased probing depth in Latin American populations (Gjermo et al. 2002).

Comparisons with other surveys suggest a higher prevalence of increased probing depth in this Brazilian population than in developed countries. The prevalence and extent of PPD $\geqslant 5$ and $\geqslant 7$ mm were much higher in our study than those reported by Albandar et al. (1999) in the US population of a similar age group (prevalence: 65.2% *versus* 8.9% and 25.4% *versus* 1.9% subjects; and extent: 19% *versus* 1.6%, and 4.5% *versus* 0.4% teeth, respectively). It should be noted, however, that the US estimates were based on a partial recording protocol whereby a half-mouth clinical examination was performed, and only two sites per tooth were examined, whereas in the present study we used a full-mouth examination, and six sites per tooth. It has been shown that a partial recording system similar to the one used in the US survey significantly underestimates the population estimates of periodontal disease (Kingman & Albandar 2002).

In this 30+ years old population, over 30% of the subjects had PPD $\geqslant 6$ mm. A recent study found that fewer than 7% of subjects aged 35–44 and 65–74 years in South China had PPD >5.5 mm (Corbet et al. 2001). The prevalence rates of PPD $\geqslant 4$ and $\geqslant 6$ mm in this study also was higher than that reported by Morris et al. (2001) in the British population aged 35 years and older for PPD >3.5 and >5.5 mm (CPITN codes 3 and 4). The CPITN method uses a partial recording protocol in which index teeth are examined, and the highest score of a sextant is recorded. This index underestimates the population estimates of periodontal disease (Kingman & Albandar 2002) in addition to other limitations described by others (Baelum & Papapanou 1996).

Males in this study had a significantly higher occurrence of PPD $\geqslant 7$ mm than females, which is in agreement with findings in other studies (Martinez-Canut

et al. 1995, Albandar et al. 1999, Morris et al. 2001, Albandar 2002a). Non-Whites had higher occurrence of PPD $\geqslant 7$ mm than Whites, and this is consistent with findings in a national survey in the USA showing higher prevalence and extent of PPD in blacks than Whites (Albandar et al. 1999, Albandar 2002b).

Population studies suggest that a high level of oral hygiene is correlated with a low level of periodontal diseases (Abdellatif & Burt 1987, Amarasena et al. 2002, Al-Wahadni & Linden 2003). In the present study regular inter-dental hygiene was associated with low levels of plaque and supragingival calculus (data not shown), and subjects practicing regular inter-dental hygiene had lower extent of PPD $\geqslant 7$ mm. Nevertheless, after adjusting for the effect of other important covariates, inter-dental hygiene was no longer associated with the occurrence of PPD $\geqslant 7$ mm. Most participants in this study (97.4%) claimed using a toothbrush regularly at least once a day, and this parameter was therefore not used in the present analysis.

Our analysis showed that cigarette smokers had a significantly higher occurrence of PPD $\geqslant 5$ mm than non-smokers, and that this relationship was dose dependent. In addition, the multivariate model showed that smoking was a major risk factor for PPD $\geqslant 5$ mm even after controlling for several other covariates in the model. This corroborates findings of other studies of an important role of smoking in the pathogenesis of periodontal diseases (Stoltenberg et al. 1993, Martinez-Canut et al. 1995, Albandar et al. 2000, Albandar 2002a).

In this Brazilian population, subjects older than 40 years of age, males, non-Whites, and moderate or heavy cigarette smokers were at significantly higher risk for having a periodontal status demonstrating a generalized pattern of probing depth $\geqslant 5$ mm (RRRs: 2.1, 2.0, 2.2, 2.4, and 6.8, respectively). Effective methods of periodontal disease control may involve the identification of high-risk subjects, or may employ a population-focused strategy. For both strategies, risk assessment would be an important tool in the control of periodontal diseases in the population, and the use of the above risk indicators in a community prevention programme may be valuable in improving the oral and general health of populations.

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