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# Occurrence and predictors of gingivitis and supragingival calculus in a population of Brazilian adults

**Alex Nogueira HAAS**[a]
**Renan PRADO**[a]
**Fernando Silva RIOS**[a]
**Ricardo dos Santos Araújo COSTA**[a]
**Patricia Daniela Melchiors ANGST**[a]
**Mauricio dos Santos MOURA**[b]
**Marisa MALTZ**[b]
**Juliana Jardim JARDIM**[b]

[a]Universidade Federal do Rio Grande do Sul – UFRGS, Faculty of Dentistry, Periodontology, Porto Alegre, RS, Brazil

[b]Universidade Federal do Rio Grande do Sul – UFRGS, Faculty of Dentistry, Preventive and Social Dentistry, Porto Alegre, RS, Brazil

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**Corresponding Author:**
Alex Nogueira Haas
E-mail: alexnhaas@gmail.com

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**Abstract:** The aim of this study was to determine the occurrence of gingivitis and calculus and their predictors in a population of adults in Brazil. A representative sample of 758 adults from 35 to 59 years of age from Porto Alegre city was examined. A structured questionnaire was applied. The Gingival Bleeding Index and the presence of calculus were measured at 4 sites/tooth. Multivariable logistic models were fitted to determine the predictors for gingival bleeding at >20% of sites. Overall, 96.5% (95% confidence interval [CI]=95.1-98.0) of individuals had ≥ 1 bleeding site. The mean percentages of sites with gingivitis and calculus were 26.1% and 44.6%, respectively. The odds of gingivitis decreased by ~45% for individuals ≥40 years old compared to younger adults. Individuals that never performed interproximal cleaning and non-whites had an approximately two times higher chance of gingivitis. Smokers had lower chances of gingivitis than never-smokers (odds ratio=0.40; 95% CI=0.24-0.68). Higher numbers of missing teeth were associated with higher chances of gingivitis. The percentage of calculus was significantly associated with skin color, education, proximal cleaning, smoking exposure, dental visits, and tooth loss. It can be concluded that the occurrence of gingivitis and calculus was high in this Brazilian population, and it was associated with age, skin color, education, self-reported proximal cleaning, smoking, dental care, and tooth loss.

**Keywords:** Gingivitis; Dental Calculus; Risk Factors.

## Introduction

The etiology and clinical characteristics of gingivitis have been described in the literature since the classic study of experimental gingivitis in man.[1] The inflammation of the gingiva may be restricted to the marginal tissues over a lifetime or may act as a precursor to periodontitis leading to periodontal breakdown in susceptible individuals.[2,3] Studies have shown that sites that frequently present gingival inflammation are at a greater risk of developing clinical attachment loss (CAL) and even tooth loss.[4,5] As a consequence, gingivitis prevention by means of supragingival biofilm control has been considered the most important primary and secondary preventive measure for periodontitis.[6,7]

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Similarly, the presence of supragingival calculus is known to facilitate the formation and retention of biofilm along the gingival margin. Calculus can also be a surrogate indicator for long-term exposure to biofilm and of oral hygiene practices.[8] Its presence has been associated with greater CAL and gingival recession; both calculus and gingivitis are associated with the initiation and progression of CAL.[9,10]

Interestingly, the study of gingivitis and calculus at the population level has not followed the abovementioned attention and importance given at the immunological, microbiological and clinical levels. There are a limited number of epidemiological studies in the literature assessing the occurrence of gingivitis and calculus in adults. Representative data from the US population has only been analyzed from the third National Health and Nutrition Examination study (NHANES III), published more than 15 years ago.[11] More recently, studies in Latin American countries have assessed estimates of gingivitis, plaque and calculus showing that a great proportion of individuals still need to improve oral hygiene practices.[12,13] Similar findings of high levels of gingival inflammation were also observed in China[14] and Australia.[15] Moreover, studies identifying factors that may predict the occurrence of gingivitis and calculus are even scarcer. Additionally, very few epidemiological studies have applied multivariable risk assessment approaches to determine predictors of gingivitis and calculus. If a key element in periodontology is the prevention of gingivitis, then a better understanding of its occurrence and the identification of risk factors are essential and should guide the development of preventive actions.

The aim of this study was to determine the occurrence of gingivitis and calculus as well as to determine their predictors in a representative sample of Brazilian adults.

## Methodology

This cross-sectional study was part of the Caries-Perio Collaboration Studies[16,17] which assessed various oral outcomes using a representative sample of 1,225 individuals living in Porto Alegre, Brazil. The study was conducted between June 2011 and June 2012 and was approved by the Research Ethics Committee of the Federal University of Rio Grande do Sul, Brazil. Signed informed consent was obtained from all participants.

The sample size was estimated using a prevalence of 50% for any oral condition evaluated. A standard formula for prevalence estimation was used to adjust the sample size for a design effect of 50%. Considering a precision of 4% and a 95% confidence interval (CI), it was estimated that the required sample size was 940 individuals.

This study employed a multistage probability sampling strategy (Figure 1) based on governmental data.[18] In the first stage, the city was divided in 86 neighborhoods comprising the primary sampling units (PSUs). PSUs were stratified into two strata: high and low income of the head of the family. PSUs were randomly selected proportional to the number of PSUs in each stratum. The second stage consisted of a random selection of sectors proportional to the total number of sectors in each PSU. Forty-eight of the 373 eligible sectors were selected.

The third stage consisted of selecting households consecutively according to the sector starting point. The number of individuals to be selected within each sector was estimated based on the proportional distribution of the sample size according to the number of individuals 35 years and older living in each sector. All household members 35 years and older were considered eligible for the study.

A total of 1,600 individuals were eligible for the study. Of these, 375 (23.4%) did not participate. In total, the sample consisted of 1,225 individuals. Among those, 1,023 (83.5%) were dentate. For the present analyses elderly individuals were excluded, and 758 adult individuals (35 to 59 years old) comprised the final sample. Table 1 shows the demographic characteristics of the study sample.

Data and reasons for non-response are provided in Figure 1. Non-respondents were slightly older than respondents (55.5 ± 11.8 vs. 52.6 ± 11.8, p = 0.001). The percentages of individuals with high education and socioeconomic status were statistically higher in non-respondents compared to respondents. Statistical analyses accounted for non-response using the inverse probability weighting strategy.

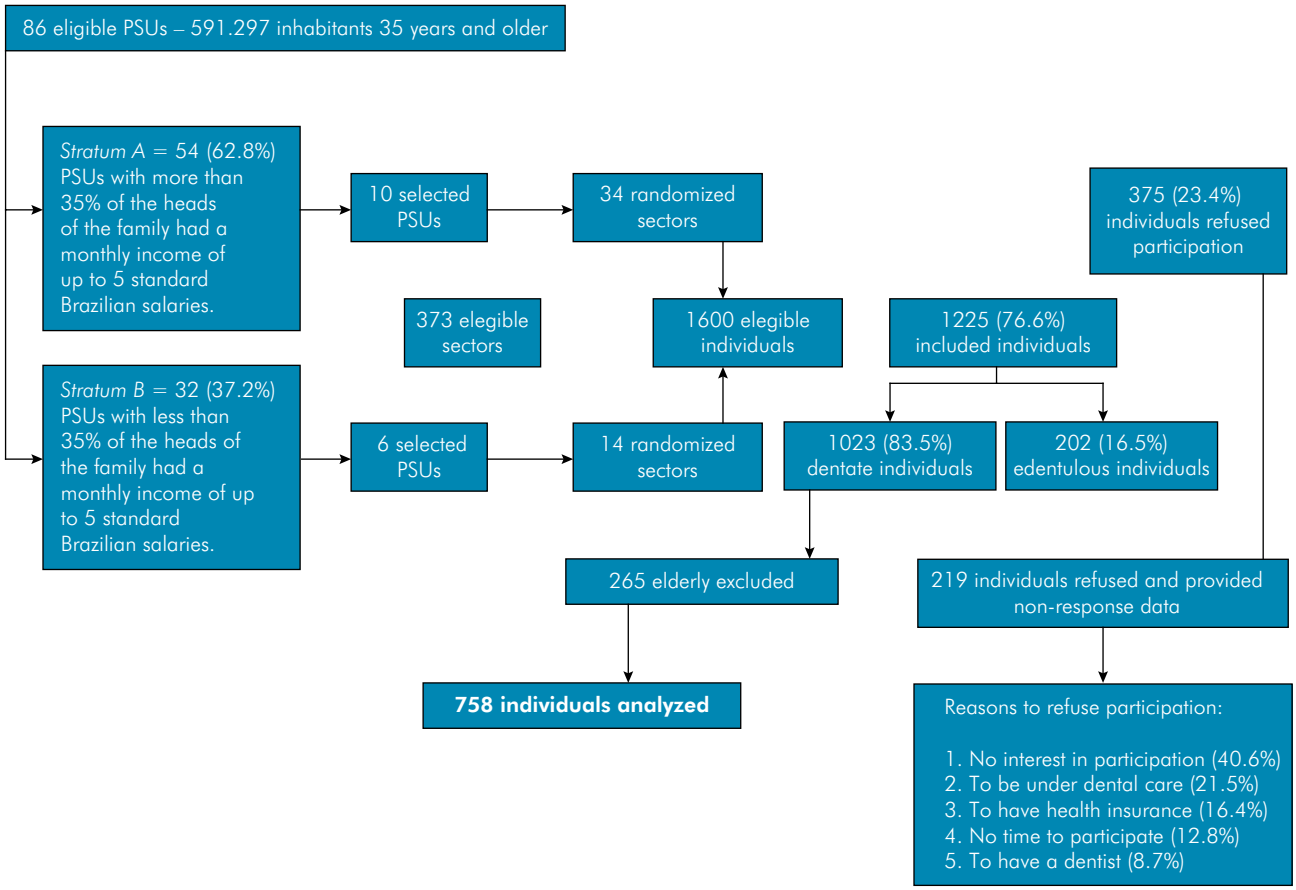


**Figure 1.** Flowchart of study sample.

## Data collection

Interviews and clinical examinations were conducted inside the household. Examinations were conducted using three portable devices: a medical headlight, a portable compressor and a bendable chair. Participants were interviewed using a structured questionnaire containing questions regarding sociodemographic variables, oral hygiene habits, access to dental services, and behavioral factors. Three trained and calibrated interviewers conducted the interview. The reliability of the questionnaire was assessed during the fieldwork using the test-retest approach in 50 participants. A set of key questions was used to assess the reproducibility of the questionnaire, and the Kappa coefficients varied from 0.91 to 0.99.

All permanent fully-erupted teeth, including third molars, were examined by two periodontists using a manual periodontal probe (PCP10-SE, Hu-Friedy Mfg. Co. Inc., Chicago, USA). Gingivitis and supragingival calculus were assessed at four sites per tooth at mesiobuccal, midbuccal, distobuccal and midlingual surfaces.

Gingivitis was assessed by the Gingival Bleeding Index (GBI),[19] which is a dichotomous index for bleeding of the gingival margin identified after inserting the probe 1mm inside the sulcus and running it from one papilla to the other. Supragingival calculus was assessed using the periodontal probe and was determined by the presence of calcified deposits located on tooth surfaces near to the gingival margin. The number of missing teeth per individual was also recorded.

## Outcomes

The prevalence of gingivitis was defined by the presence of at least one bleeding gingival unit. The extent of gingivitis was determined using the percentage of sites with gingival bleeding for each individual. Gingivitis was also arbitrarily

dichotomized using a cut-off point of >20% bleeding sites to fit multivariable logistic regression models.

The extent of calculus was determined by the percentage of sites with calculus per individual. The distribution of this variable allowed the use of linear models that were fitted using multiple linear regression.

### Predictors

Skin color was dichotomized into white and non-white. Educational level was categorized according to years of education into low (≤ 4 years), middle (5–10 years) and high (≥ 11 years) levels of education. Socioeconomic status was categorized using cut-off points adapted from the Brazilian classification system (ABEP) that considers the amount of owned consumer goods and the educational level of the head of the family as follows: low (≤ 20 points), middle (21–26 points) and high (≥ 27 points) status.

Tooth brushing frequency was categorized as ≤1 time/day, 2 times/day and ≥ 3 times/day. The frequency of interproximal cleaning was categorized as never, ≤ 1/day and ≥ 2/day.

Subjects were categorized by smoking exposure into never-smokers, former smokers and smokers. Those individuals reporting to have never smoked were categorized as the reference category (never-smokers), whereas those that reported having quit smoking for more than one year were classified as former smokers.

Individuals were categorized as having regular dental care if they reported going to the dentist for prevention at a frequency of one or more visits per year. Dental visits only for emergencies were classified as irregular dental care. No dental care was defined as when individuals reported no dental visits during the last three years.

Individuals were categorized into three groups according to the percentage of sites with calculus, using the amount of calculus considered to be clinically relevant [0–19% (~1$^{st}$quintile), 20–39% (~2$^{nd}$quintile) and ≥ 40% (~3$^{rd}$, 4$^{th}$and 5$^{th}$ quintile)]. This independent variable was only used for models of gingivitis.

Models for gingivitis included a categorical variable for tooth loss. Three categories were generated as follows: 1 to 5 missing teeth; 6 to 11 missing teeth; and 12 or more missing teeth. In the models for calculus, tooth loss was included as a count variable.

### Statistical analyses

Complex survey commands were used in all analyses to account for cluster correlations expected from the multistage sampling strategy. Pair-wise comparisons of crude estimates were carried out using a Wald test. The significance level was set at 0.05. Data analyses were performed using the statistical package Stata 14 for Macintosh (STATA Corp., College Station, USA).

Survey binary logistic regression models were fitted to assess predictors for gingivitis at > 20% of sites. Univariable models were fitted for each predictor, and those presenting p values < 0.25 were entered in the multivariable model. Maintenance of variables in the final model was determine using a purposeful approach.[20] Goodness-of-fit (GOF) was assessed with the Archer and Lemeshow GOF test for survey logistic regression that takes into account the sampling weights and design.

Predictors for calculus were determined with survey multivariable linear regression models using the same approach described above. Assumptions of the linear regression models were evaluated by examining the distribution of residuals.

## Results

The overall prevalence of gingivitis was 96.5% (95%CI 95.1–-98.0), and the extent of gingival bleeding was equal to 26.1% of sites (Table 1). The percentage of sites with gingivitis per subject was significantly higher in non-whites, in individuals with calculus at ≥40% of sites and in individuals with ≥ 12 missing teeth. Significantly lower percentages of bleeding sites were observed in individuals from high education and socioeconomic levels, in individuals reporting interproximal cleaning ≥ 2 times/day, those with regular dental visits and in smokers and former smokers. The overall percentage of sites with calculus was 44.6%. There were significant differences in the extent of calculus between categories of all predictors evaluated.

Gingivitis was mostly seen in molars from the upper and lower arches (Figure 2). The occurrence of calculus was more pronounced in lower incisors and molars from both arches.

**Table 1.** Mean percentage of sites per subject with gingival bleeding and calculus according to demographic, behavioral and clinical variables.

| Variable | Whole sample | Gingivitis | | Calculus | |
|---|---|---|---|---|---|
| | n (%) | Mean±SE | p-value* | Mean±SE | p-value* |
| Sex | | | | | |
| Women | 456 (60.2) | 26.4 ± 1.2 | Ref. | 47.3 ± 2.0 | Ref. |
| Men | 302 (39.8) | 25.8 ± 1.8 | 0.60 | 42.3 ± 2.9 | 0.02 |
| Age | | | | | |
| 35–39 years | 148 (19.5) | 29.8 ± 2.0 | Ref. | 42.9 ± 2.3 | Ref. |
| 40–49 years | 306 (40.4) | 24.5 ± 1.8 | 0.06 | 41.8 ± 2.8 | 0.67 |
| 50–59 years | 304 (40.1) | 25.4 ± 1.5 | 0.06 | 49.9 ± 2.6 | 0.03 |
| Skin color | | | | | |
| White | 509 (67.2) | 23.2 ± 1.5 | Ref. | 42.4 ± 2.4 | Ref. |
| Non-white | 249 (32.8) | 33.0 ± 1.3 | 0.001 | 49.8 ± 2.1 | 0.001 |
| Socioeconomic status | | | | | |
| Low | 349 (46.0) | 29.0 ± 1.6 | Ref. | 51.9 | Ref. |
| Middle | 267 (35.2) | 24.7 ± 2.3 | 0.11 | 42.4 | 0.001 |
| High | 142 (18.8) | 22.1 ± 2.1 | 0.04 | 32.1 | 0.001 |
| Education | | | | | |
| Low | 115 (15.2) | 32.7 ± 2.6 | Ref. | 59.5 ± 2.4 | Ref. |
| Middle | 349 (46.0) | 27.6 ± 1.8 | 0.09 | 49.7 ± 2.3 | 0.005 |
| High | 294 (38.8) | 22.5 ± 2.0 | 0.01 | 34.6 ± 2.7 | 0.001 |
| Brushing frequency | | | | | |
| ≤ 1/day | 74 (9.8) | 28.5 ± 5.1 | Ref. | 55.8 ± 5.8 | Ref. |
| 2/day | 265 (34.9) | 26.8 ± 1.7 | 0.68 | 47.3 ± 2.6 | 0.09 |
| ≥ 3/day | 419 (55.3) | 25.1 ± 1.2 | 0.50 | 40.3 ± 2.5 | 0.02 |
| Proximal cleaning | | | | | |
| Never | 234 (30.9) | 33.4 ± 2.6 | Ref. | 53.6 ± 2.5 | Ref. |
| ≤ 1/day | 288 (38.0) | 22.9 ± 1.3 | <0.001 | 40.9 ± 2.8 | 0.001 |
| ≥ 2/day | 236 (31.1) | 22.4 ± 1.7 | 0.001 | 39.8 ± 3.1 | 0.003 |
| Smoking exposure | | | | | |
| Never smokers | 328 (43.3) | 29.6 ± 1.7 | Ref. | 38.7 ± 3.1 | Ref. |
| Former smokers | 191 (25.2) | 24.2 ± 1.2 | 0.02 | 42.9 ± 2.3 | 0.13 |
| Smokers | 239 (31.5) | 22.4 ± 2.1 | 0.002 | 54.2 ± 3.2 | 0.001 |
| Dental visits | | | | | |
| None | 218 (28.8) | 33.4 ± 2.5 | Ref. | 56.3 ± 2.8 | Ref. |
| Irregular | 360 (47.5) | 25.5 ± 1.5 | 0.02 | 46.0 ± 1.9 | 0.001 |
| Regular | 180 (23.7) | 19.6 ± 2.3 | <0.001 | 29.4 ± 2.4 | < 0.001 |
| Calculus | | | | | |
| < 20% | 118 (15.6) | 21.9 ± 2.0 | Ref. | N/A | |
| 20–39% | 223 (29.4) | 19.8 ± 1.7 | 0.44 | N/A | |
| ≥ 40% | 417 (55.0) | 31.4 ± 2.0 | 0.01 | N/A | |
| Tooth loss | | | | | |
| 1–5 missing teeth | 173 (22.8) | 20.8 ± 2.2 | Ref. | 38.1 ± 2.3 | Ref. |
| 6–11 missing teeth | 306 (40.4) | 26.7 ± 1.5 | 0.21 | 40.8 ± 2.9 | 0.003 |
| ≥ 12 missing teeth | 279 (36.8) | 30.1 ± 2.3 | 0.004 | 55.5 ± 3.2 | < 0.001 |
| Total | | 26.1 ± 1.4 | | 44.6 ± 2.3 | |

*Wald test adjusted for multiple comparisons; Ref: reference category; SE: Standard Error; N/A: not applicable

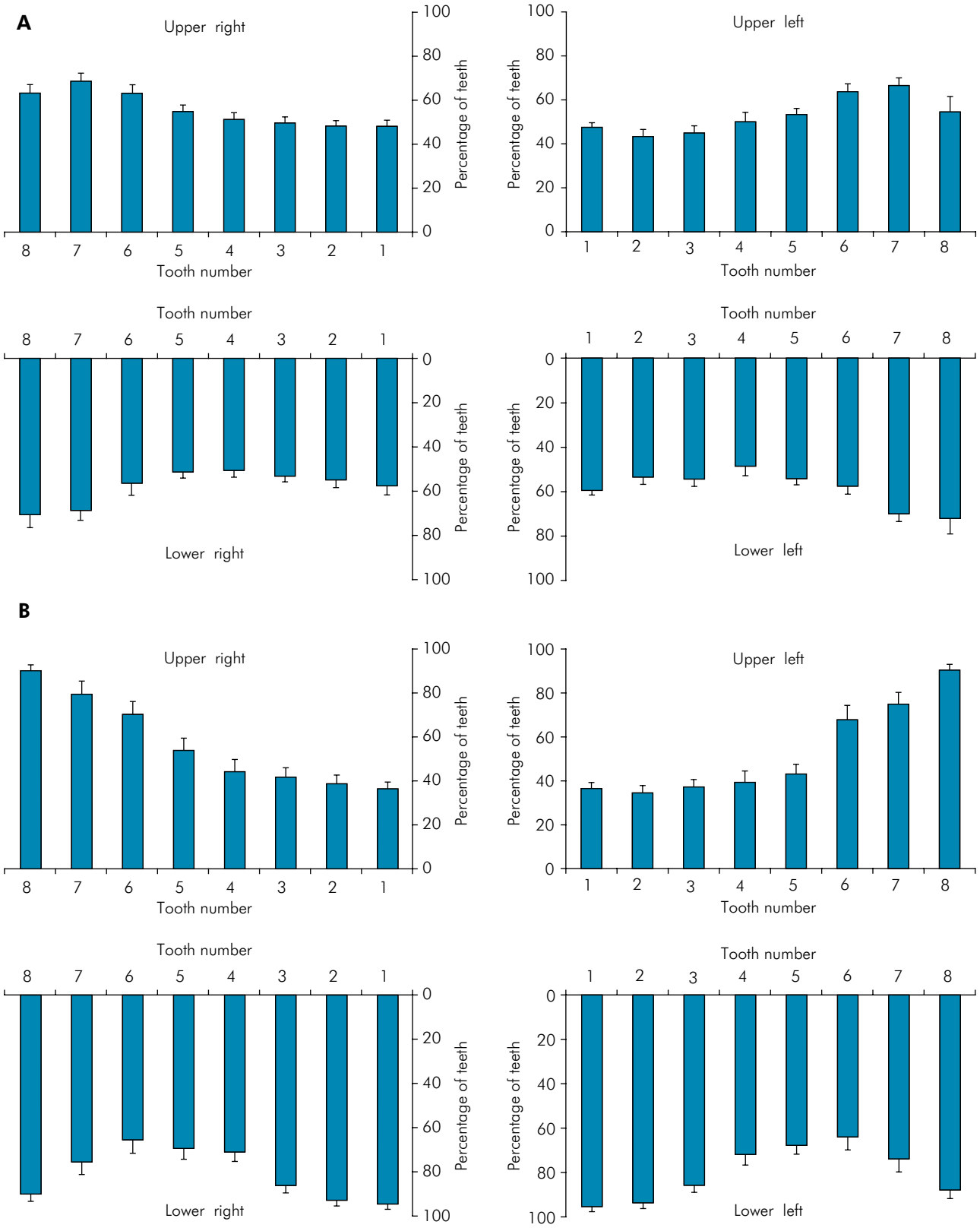


**Figure 2.** Intra-oral distribution of gingivitis (a) and calculus (b): percentage of teeth with at least one site with gingival bleeding or calculus according to tooth type and arch (central incisor:1, third molar:8).

The overall percentage of individuals with GBI > 20% was approximately 50%. The percentage of individuals with > 20% of sites exhibiting gingivitis was significantly higher in non-white than white individuals, in younger than older age groups, in individuals without dental care as compared to those with regular dental visits, and in individuals that did not perform interproximal cleaning when compared with those that report it (Figure 3). No significant differences were observed for the other variables.

In the multivariable model 1 (Table 2), the odds for gingivitis decreased more than 30% for individuals older than 40 years compared to young adults. Also, non-whites had 2 times higher chances of gingivitis compared to whites. Individuals that never perform interproximal cleaning had a 2.19 times higher chance of having gingivitis than those performing interproximal cleaning ≥ 2 times/day. Smokers had lower chances of presenting with gingivitis than never smokers. Individuals with no dental care had a 2.43 times higher chance of gingivitis than those with regular dental care. When calculus and tooth loss were included in the model, the dental visits variable was no longer significantly associated and was removed, whereas the other variables remained in the model.

The percentage of sites with calculus was significantly associated with age, skin color, education, proximal cleaning, smoking exposure and dental visits in the multivariable model 1 (Table 3). A higher number of missing teeth was significantly associated with a higher percentage of sites with calculus, and when this variable was included in the model age was removed due to absence of significance. In this final model, non-whites had 3.56% more sites with calculus than whites. Those patients of middle and low education levels had 8% and 14% more calculus, respectively, than those from a high education level. Individuals that reported never cleaning between teeth had 5.6% more calculus than the reference category. Smoking increased the percentage of sites with calculus by 12.86%. The absence of dental care was associated with an increase of 15.3% of calculus.

## Discussion

The present study demonstrated that gingivitis was highly prevalent and gingival bleeding was present at approximately one fourth of the sites in subjects from this sample. Calculus was observed in almost half of the sites in the mouths of individuals. Moreover, gingivitis and calculus could be predicted by a variety of variables.

The observed prevalence of gingival bleeding in this study (96.5%) is in accordance with the notion that gingivitis may be a universal finding in some populations. This may be more pronounced in Latin American adult populations and in other developing countries.[21,22] In contrast, in the US, Sweden and Australia gingivitis is present in 50%, 11% and 19% of the individuals, respectively.[11,15,23] The findings of the present study highlight the importance of developing future preventive actions targeting gingivitis in this and similar populations.

Although almost all individuals in the studied sample had gingivitis, gingival bleeding was present in approximately 25% of the sites. This estimate was lower than a previous estimate from a multicenter study conducted in Brazil, Chile and Argentina, which found that an average of 40% of sites had gingival bleeding.[13] Conversely, data from NHANES III, which used a partial recording protocol, showed lower (13.5%) mean gingival bleeding than found in this study.[11] In a 2003 study in Sweden, the average gingival bleeding was approximately 15%.[24] Studies that applied the Gingival Index (GI) from Löe and Silness[25] have found mean GI scores of 1.10 ± 0.24[14] and 1.05 ± 0.36.[26] The percentage of individuals with GI > 1.5, which may reflect moderate to severe inflammation, ranged between 5.7%[14] and 18.7%.[15] Making an indirect comparison with studies that applied GI and the percentage of sites with gingival bleeding, it may be argued that overt gingival inflammation may be present in no more than 25% of the adult population.

Non-whites had higher chances of having gingivitis and calculus than whites in this study. In multi-ethnic countries such as Brazil, skin color has previously been used as an indicator of social status.[27] Moreover, higher accumulations of calculus

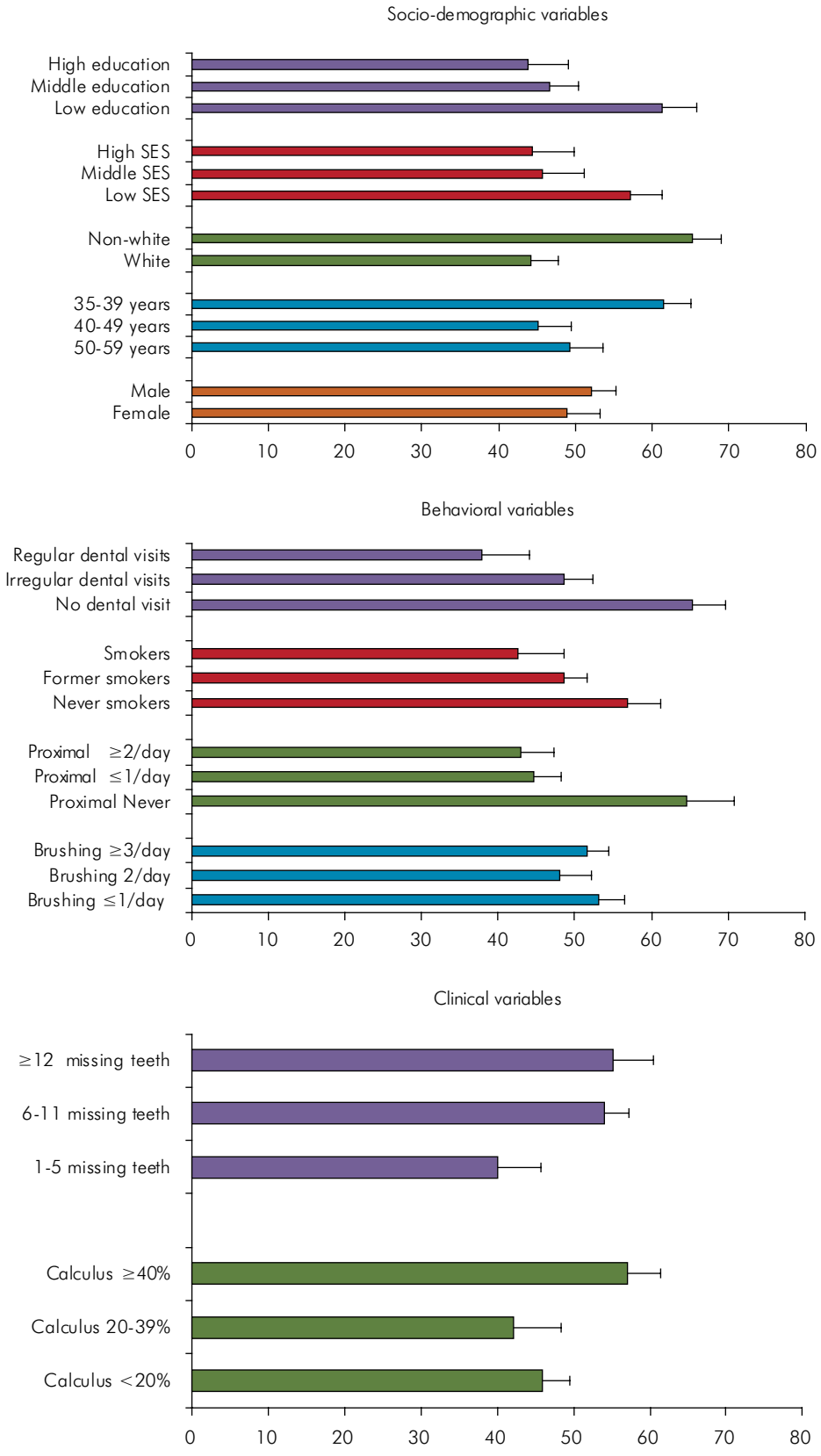


**Figure 3.** Distribution of individuals with gingival bleeding ≥20% according to demographic, behavioral and clinical variables.

**Table 2.** Logistic regression models of the association between gingival bleeding index (>20%) and demographic, behavioral and clinical variables.

| Variable | Univariable models | | | Multivariable model 1 | | | Multivariable model 1 + calculus + tooth loss | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95%CI | p–value | OR | 95%CI | p–value | OR | 95%CI | p–value |
| Sex | | | | | | | | | |
| Women | 1 | | | | | | | | |
| Men | 0.88 | 0.60–1.28 | 0.47 | | | | | | |
| Age | | | | | | | | | |
| 35–39 years | 1 | | | 1 | | | 1 | | |
| 40–49 years | 0.52 | 0.33–0.81 | 0.008 | 0.61 | 0.39–0.95 | 0.03 | 0.56 | 0.37–0.84 | 0.01 |
| 50–59 years | 0.61 | 0.37–0.99 | 0.047 | 0.67 | 0.38–0.99 | 0.04 | 0.54 | 0.31–0.94 | 0.03 |
| Skin color | | | | | | | | | |
| White | 1 | | | 1 | | | 1 | | |
| Non–white | 2.38 | 1.52–3.71 | 0.001 | 2.09 | 1.34–3.24 | 0.003 | 2.00 | 1.31–3.05 | 0.004 |
| Socioeconomic status | | | | | | | | | |
| High | 1 | | | | | | | | |
| Middle | 1.06 | 0.56–1.98 | 0.86 | | | | | | |
| Low | 1.67 | 0.86–3.25 | 0.12 | | | | | | |
| Education | | | | | | | | | |
| High | 1 | | | | | | | | |
| Middle | 1.47 | 0.86–2.52 | 0.14 | | | | | | |
| Low | 2.01 | 1.04–3.89 | 0.04 | | | | | | |
| Brushing frequency | | | | | | | | | |
| ≤1/day | 1 | | | | | | | | |
| 2/day | 0.94 | 0.29–2.99 | 0.91 | | | | | | |
| ≥3/day | 0.81 | 0.27–2.41 | 0.69 | | | | | | |
| Proximal cleaning | | | | | | | | | |
| ≥2/day | 1 | | | 1 | | | 1 | | |
| ≤1/day | 1.07 | 0.65–1.78 | 0.77 | 1.19 | 0.76–1.85 | 0.41 | 1.23 | 0.83–1.82 | 0.27 |
| Never | 2.43 | 1.32–4.49 | 0.008 | 2.19 | 1.07–4.49 | 0.04 | 2.10 | 1.10–4.01 | 0.03 |
| Smoking exposure | | | | | | | | | |
| Never smokers | 1 | | | 1 | | | 1 | | |
| Former smokers | 0.56 | 0.33–0.96 | 0.04 | 0.71 | 0.43–1.19 | 0.17 | 0.64 | 0.37–1.09 | 0.10 |
| Smokers | 0.72 | 0.44–1.18 | 0.17 | 0.50 | 0.30–0.85 | 0.01 | 0.40 | 0.24–0.68 | 0.003 |
| Dental visits | | | | | | | | | |
| Regular | 1 | | | 1 | | | | | |
| Irregular | 1.57 | 0.81–3.05 | 0.17 | 1.33 | 0.60–2.95 | 0.45 | | | |
| None | 3.12 | 1.65–5.90 | 0.002 | 2.43 | 1.10–5.39 | 0.03 | | | |
| Calculus | | | | | | | | | |
| <20% | 1 | | | NI | | | 1 | | |
| 20–39% | 0.73 | 0.54–1.49 | 0.55 | | | | 0.83 | 0.60–1.15 | 0.24 |
| ≥40% | 2.61 | 1.57–4.35 | 0.001 | | | | 2.84 | 1.68–4.79 | 0.001 |
| Tooth loss | | | | | | | | | |
| 1–5 missing teeth | 1 | | | NI | | | 1 | | |
| 6–11 missing teeth | 1.75 | 1.00–3.07 | 0.05 | | | | 1.52 | 0.78–2.96 | 0.20 |
| ≥12 missing teeth | 1.84 | 1.00–3.37 | 0.05 | | | | 1.81 | 1.16–2.80 | 0.01 |

NI: not included in the model.

**Table 3.** Linear regression models of the association between supragingival calculus and demographic, behavioral and clinical variables.

| Variable | Univariable models | | | Multivariable model 1 | | | Multivariable model 1 + tooth loss | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | 95%CI | p-value | Coef. | 95%CI | p-value | Coef. | 95%CI | p-value |
| Sex | | | | | | | | | |
| Women | Ref. | | | | | | | | |
| Men | 5.01 | 1.11–8.91 | 0.016 | | | | | | |
| Age | | | | | | | | | |
| 35–39 years | Ref. | | | Ref. | | | | | |
| 40–49 years | -1.15 | -6.84–4.53 | 0.67 | 0.14 | -6.36–6.63 | 0.96 | | | |
| 50–59 years | 6.99 | 1.00–12.97 | 0.026 | 6.27 | 1.61–10.92 | 0.01 | | | |
| Skin color | | | | | | | | | |
| White | Ref. | | | Ref. | | | Ref. | | |
| Non-white | 7.43 | 4.04–10.83 | < 0.001 | 3.41 | 0.48–6.33 | 0.03 | 3.56 | 0.43–6.70 | 0.03 |
| Socioeconomic status | | | | | | | | | |
| High | Ref. | | | | | | | | |
| Middle | 10.29 | -0.09–20.67 | 0.052 | | | | | | |
| Low | 19.78 | 10.88–28.67 | < 0.001 | | | | | | |
| Education | | | | | | | | | |
| High | Ref. | | | Ref. | | | Ref. | | |
| Middle | 15.13 | 8.79–21.47 | < 0.001 | 9.34 | 4.18–14.49 | 0.002 | 8.09 | 3.19–13.01 | 0.004 |
| Low | 24.96 | 17.69–32.22 | < 0.001 | 16.61 | 10.27–22.95 | <0.001 | 14.00 | 7.86–20.14 | < 0.001 |
| Brushing frequency | | | | | | | | | |
| ≤ 1/day | Ref. | | | | | | | | |
| 2/day | -8.50 | -18.60–1.59 | 0.09 | | | | | | |
| ≥ 3/day | -15.49 | -28.07–-2,91 | 0.02 | | | | | | |
| Proximal cleaning | | | | | | | | | |
| ≥ 2/day | Ref. | | | Ref. | | | Ref. | | |
| ≤ 1/day | 12.69 | 6.68–18.69 | 0.001 | 6.81 | 1.17–12.46 | 0.02 | 4.58 | 1.35–10.51 | 0.12 |
| Never | 13.78 | 5.64–21.91 | 0.003 | 7.54 | 2.60–12.47 | 0.01 | 5.60 | 0.86–10.33 | 0.02 |
| Smoking exposure | | | | | | | | | |
| Never smokers | Ref. | | | Ref. | | | Ref. | | |
| Former smokers | 4.19 | -1.49–9.87 | 0.134 | 2.46 | -2.53–7.45 | 0.31 | 2.58 | -1.82–6.99 | 0.23 |
| Smokers | 15.54 | 8.25–22.82 | < 0.001 | 13.40 | 7.92–18.86 | <0.001 | 12.86 | 8.12–17.60 | < 0.001 |
| Dental visits | | | | | | | | | |
| Regular | Ref. | | | Ref. | | | Ref. | | |
| Irregular | 16.60 | 12.15–21.05 | < 0.001 | 8.96 | 4.90–13.02 | <0.001 | 7.59 | 2.97–12.22 | 0.004 |
| None | 26.87 | 21.90–31.84 | < 0.001 | 16.94 | 13.39–20.48 | <0.001 | 15.30 | 11.42–19.18 | < 0.001 |
| Missing teeth | 1.28 | 0.92–1.64 | < 0.001 | NI | | | 0.70 | 0.46–0.94 | < 0.001 |

NI: not included in the model.

were also found in low education individuals. These findings show that oral hygiene practices are strongly associated with socioeconomic and educational conditions. Similar findings were described in two national studies conducted in the US and Hungary where high educational level and white skin color were associated with less gingivitis and calculus.[11,28] Additionally, in a recent study, a lower prevalence of gingivitis was associated with individuals with > 12 years of schooling.[13]

Age is known to affect various estimates of periodontal disease.[29,30] Surprisingly, in this study gingivitis decreased with increasing age. It should be noted that results in the literature regarding age and gingivitis are inconsistent. In the US[11] and Latin American countries,[13] a slight increase in mean gingival bleeding in older adults was observed as compared to young adults. In Hungary, bleeding scores measured with the Community Periodontal Index did not change with age among adults.[28] However, comparisons between studies should be made with caution because of differences regarding examination protocols and indices. Moreover, ours was the only study that adjusted this association for tooth loss, which is known to affect estimates of periodontal disease.

In this study, smoking was consistently associated with less gingival bleeding and more calculus. Although there is consistent evidence from clinical and laboratory studies that smoking leads to vasoconstriction in the marginal periodontium,[31,32] very few population-based studies have investigated the effect of smoking on clinical signs of gingivitis while adjusting for important confounding variables. Corroborating the findings observed in this study, male smokers and betel chewers in Sri Lanka[33] and Swedish cigarette smokers[34] have been observed to have significantly less gingivitis than non-users. In regards to the effect of smoking on calculus formation, another study in the city of Porto Alegre has also observed higher levels of calculus among smokers.[12] Other clinical and epidemiological evidences have consistently demonstrated that smoking habits increase calculus accumulation.[15,23,35]

The efficacy of interproximal devices, mainly dental floss, to reduce plaque and gingivitis has been questioned in the literature.[36] This is related to the lack of evidence from randomized trials showing that implementation of dental floss added to tooth brushing leads to additional benefits. However, in this observational study, self-reported use of interdental devices ≥ 2/day was associated with less gingivitis and calculus. A national survey conducted in Australia also found that frequent interdental cleaning was associated with less calculus and gingivitis.[15] Evidence from randomized trials is considered stronger than that from observational studies, and further research is needed; nevertheless, the present findings put into perspective the importance of oral hygiene habits related to the interproximal area that may result in better gingival health.

In the present study, frequency of dental visits was associated with gingivitis and calculus. Similar findings were obtained in a study carried out with an adult population in Sweden, where those who reported going to the dentist every year had significantly lower calculus and gingivitis than those who reported the last visit as occurring more than three years ago.[23] This association can be understood in the light that individuals who frequently seek dental care usually receive supragingival scaling and/or prophylaxis, and so are more likely to have less calculus and gingival inflammation. These findings highlight the importance of dental care in the prevention of periodontal diseases.

Gingivitis will not always progress into periodontitis, but is related to the initial stage of an inflammatory process that leads to destruction of the periodontal tissues. It has been also demonstrated that gingivitis increases the risk for tooth loss.[4] Not surprisingly, gingivitis was associated with tooth loss in the present study, corroborating previous findings from cohort studies.[4,37]

One possible limitation of this study is the partial recording protocol of 4 sites/tooth used to assess gingivitis and calculus, although there is no evidence that this protocol has any bias in the estimates of the evaluated outcomes. The findings should be generalized only to adults and do not relate to young age groups nor to the elderly. However, this study is unique in its analyses in comparison to other studies evaluating the epidemiology of gingivitis and calculus, due to its application of adjusted models to assess important predictive variables. Additionally, a broad range of predictors was assessed which may be of direct applicability in the development of preventive strategies.

## Conclusions

In conclusion, gingivitis and calculus were highly prevalent in this adult population. The extent of gingivitis

reached approximately 25% of the sites per individual, whereas calculus formation was found in almost 50% of the surfaces. The variation in the occurrence of gingivitis and calculus was explained by predictors such as age, skin color, education status, proximal cleaning, smoking exposure, dental visits and tooth loss.

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