# Prevalence, Severity, and Risk Factors of Gingival Inflammation in Caribbean Adults: A Multi-City, Cross-Sectional Study

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**Objective: To estimate the prevalence, severity, and associated risk factors of gingival inflammation in a group of adults from Kingston, Jamaica; Santo Domingo, Dominican Republic; and San Juan, Puerto Rico.**

**Methods: In this representative cross-sectional study, participants completed medical and oral health questionnaires and received an oral clinical examination by trained and calibrated examiners. Clinical assessments included: gingival health (modified Löe–Silness index), visible plaque and presence of calculus. Findings were summarized as mean overall and interproximal gingival indices (GI; IGI), gingival bleeding index (GBI), gingival inflammation prevalence (GI≥0.5) and severity (mild, moderate, severe), mean and interproximal visible plaque indices (VPI; IVPI), and calculus index. Multivariate logistic regression was used to evaluate the associations between risk factors and gingival bleeding on probing (BOP) at ≥40% sites;. odds ratios were estimated.**

**Results: All 1,847 participants presented gingival inflammation; most (81.9%) had moderate inflammation. Mean GI, VPI, IVPI, and calculus indices were 1.49, 0.94, 0.96, and 0.66, respectively; most participants presented a VPI ≥30%. BOP ≥40% of sites was significantly associated with education ($OR_{middle/technical\ vs.\ university\ education}$=1.61; p =0.001 and $OR_{none/basic\ vs.\ university}$= 2.86; p<0.001), calculus index (OR: 10.35), VPI ≥ 30% (OR: 7.85; p<0.001 for both), and being a resident of Kingston or Santo Domingo (vs. San Juan, OR: 4. 74 and OR: 7.09, respectively), after adjusting for age, gender, smoking, dental visit frequency, diabetes, and hypertension.**

**Conclusion: Gingival inflammation was highly prevalent. Most participants presented moderate gingival inflammation. Educational attainment, dental calculus, and VPI ≥ 30% were strongly associated with gingival inflammation. [*P R Health Sci J 2018;37:115-123*]**

*Key words: Prevalence, Gingivitis, Bleeding on Probing, Dental Plaque, Dental Calculus*

Gingivitis is the presence of gingival inflammation and is often a sign of periodontitis (1). Clinical features of gingivitis include a change in color, texture and bleeding upon probing of the gingiva in the absence of connective tissue attachment loss (2). Plaque biofilm accumulation is a main risk factor for gingival inflammation (3).

Periodontal disease onset and progression are mediated by an interaction between a dysbiosis of the commensal oral microbiota on the plaque biofilm and the host immune response leading to inflammation and disease (4). The severity of the resulting periodontal disease is influenced by modifiable environmental and host risk factors and non-modifiable factors (5). Dental calculus provides a substratum for plaque biofilm retention and plays a role in disease progression (6, 7).

Whether untreated or uncontrolled, gingivitis can potentially lead to more severe periodontal disease and tooth loss (8). Furthermore, there is evidence of an association between periodontal disease and systemic health (9). Periodontal disease prevention is attained through daily self-performed oral hygiene and periodical professional removal of the dental biofilm (5).

Epidemiological studies in several nations have reported high prevalences of gingivitis among their adult populations (10, 11). The prevalence of adult gingivitis in the US exceeds 50%

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(12, 13). Recent multinational studies conducted in various Latin American cities revealed high prevalence of gingival inflammation (1). Ethnic and gender variations have also been reported (8, 14).

Little is known about the prevalence and severity of gingivitis in the Caribbean. A recent pilot study conducted in adult residents of San Juan, Puerto Rico, revealed a high prevalence of gingival inflammation (8). Estimating the burden of gingival inflammation in the population and the strength of the association with potential risk factors will enable the design and implementation of strategies for improving oral health in the Caribbean. The purpose of this study was to estimate the overall prevalence, severity, and associated risk factors of gingival inflammation in a group of adults residing in 3 Caribbean cities: Kingston, Jamaica; Santo Domingo, Dominican Republic; and San Juan, Puerto Rico.

## Methods

This study was approved by the following official bodies: in Jamaica, the *Ethics and Medico-Legal Affairs Panel* of the Ministry of Health and the *UWI Ethics Committee* of the University of the West Indies, Mona Campus; in the Dominican Republic, the *Comité de Bioética de la Facultad de Ciencias de la Salud* (COBE-FACS) of the Pontificia Universidad Católica Madre y Maestra and the *Consejo Nacional de Bioética en Salud* (CONABIOS) of the Secretaría de Estado de Salud Pública; and in Puerto Rico, the *Institutional Review Board* of the University of Puerto Rico, Medical Sciences Campus (UPR-MSC).

### Study design, setting, sample sizes, and recruitment

This cross-sectional, epidemiological, population-based study was conducted in community settings. Based on an estimated prevalence of gingivitis of 93.9% (average GI≥0.5), the sample size required to obtain a 95% accuracy rate (confidence interval: 95%) with a margin of error of 2% was 550 (1, 13). An oversample of 10% was planned, for a total of 611 individuals in each city. In each city, 8 clusters (76–77 participants each) were selected using a systematic random sampling technique within neighborhoods of San Juan, Santo Domingo, and Kingston that were previously sorted according to their geographic distribution. Sampling weights were calculated according to selection probabilities with reference to the base populations of each city and with regard to gender and age differences.

Prior to the study's initiation, the investigators and the project coordinators/recruiters in each of the cities visited the selected neighborhoods. These visits were conducted to select appropriate study settings and to distribute invitation flyers to residents. Participant recruitment occurred from October 2016 to August 2017.

### Inclusion and Exclusion criteria

Potential subjects from the general population who expressed an interest in participating had to meet the following criteria: be of good general health (ASA I & II), be 18 years of age and older, have at least 4 permanent natural teeth (excluding third molars), and have signed an informed consent form. Pregnant or breastfeeding women; subjects having undergone extensive prosthodontic treatment (partial removable dentures and/or fixed prosthodontics); wearers of orthodontic appliances (except retainers); and individuals presenting gingival purulent exudate, tooth mobility, and/or extensive loss of periodontal attachment or alveolar bone were excluded from the study. Participants needing prophylactic antibiotic therapy, on anticoagulant medication/treatment (except aspirin, but including nifedipine, cyclosporine, or phenytoin). Potential participants taking other prescription medicines that on the judgment of the examiner (upon anamnesis and a rapid oral screening) might interfere with the study outcome were also excluded. Non-eligible candidates received an oral screening and were offered oral health advice/referrals, as necessary.

### Training and Calibration exercise

Prior to the initiation of the study, the examiners (AB, MB, and MJT) from each of the 3 cities participated in a training/clinical calibration exercise at the School of Dental Medicine, UPR, San Juan, Puerto Rico. After attending a half-day didactic training, the examiners participated in a clinical calibration to standardize diagnostic criteria with an experienced periodontist, reference examiner (RE). In addition, the study protocol was discussed. Each trainee examiner conducted 21-23 exams along with the RE. Calibration participants were recruited by an advertisement placed at the UPR-MSC and from a private dental office located in the Municipality of Trujillo Alto, San Juan Metropolitan Area. The participants included both periodontically healthy persons and individuals presenting a full range of periodontal conditions.

The inter-examiner Spearman's correlation coefficients for mean gingival index (GI) and the percent agreement for gingival inflammation prevalence and severity were calculated to compare the measurements from the 3 trainee examiners with those from the RE. Spearman's correlation coefficients for average GI ranged from 0.43 to 0.71 (p-values<0.05 for all); the prevalence of gingival inflammation as assessed by the trainees agreed with that of the RE in 100% of the calibration participants; the percent agreement for gingival inflammation severity ranged from 95.24% to 100%. The medical history/oral health (MH/OH) and the Oral Health Impact Profile (OHIP) structured questionnaires to be administered were discussed, validated, and standardized.

### Socio-demographic/behavioral interview and clinical evaluation

Prior to the clinical assessment, the prospective candidates reported to the study sites, received information regarding the potential benefits/risks of the evaluation, and signed an informed consent form.

The questionnaires were administered by a trained interviewer. The MH/OH elicited information regarding socio-demographics, oral hygiene habits and knowledge, frequency of dental visits, prosthesis use/ hygiene (if applicable), and smoking habits. The OHIP is a 14-item survey that was used to evaluate oral health–related quality of life in the participants.

Clinical examinations in each of the cities were performed by the same dentist. Portable dental equipment and compressed air were used. The equipment was set up in convenient locations, which included parks, churches, schools, and community centers. Examiners wore head-lamps and non-magnifying eye protectors.

After receiving an oral soft and hard tissue evaluation, the assessment were conducted (in the following sequence):

1. *Visible Dental Plaque*. The absence (0) or presence (1) of dental plaque was evaluated visually in the complete dentition (excluding third molars). Six dental surfaces were rated: mesial-facial,medial-facial, distal-facial, mesial-lingual, medial-lingual, and distal-lingual.
2. *Gingival Inflammation*. The modified Löe–Silness gingival index (15), as adapted from Talbott et al. (2), was used with the following scale: 0=absence of inflammation; 1= mild inflammation (slight change in color and little change in texture); 2= moderate inflammation (moderate glazing, redness, edema and/or hypertrophy, and a tendency to bleed upon probing); 3= severe inflammation (marked redness and hypertrophy and the tendency to spontaneously bleed, and/or ulceration). Marginal bleeding of the gingiva adjacent to each tooth (whole mouth, 6 sites/tooth, as previously indicated) was assessed by gently introducing the tip of a 15 UNC periodontal probe (Hu-Friedy Mfg. Co., LLC, Chicago, IL) and "walking" it around the gingival sulcus.
3. *Dental Calculus*. The absence (0) or presence (1) of calculus was rated at 3 sites (distal-lingual, medial-lingual, and mesial-lingual) of the antero-inferior dentition. A #17 explorer was used to aid calculus detection.

Study parameters were entered electronically into a file on a password-locked computer during the examination. Participants who completed the interview and the clinical examination were advised on oral health care and referred for treatment, as required.

### Statistical methods and data assessment

#### Definitions of variables

The prevalence of gingival inflammation was defined as the percentage of participants with a mean GI≥0.5. The gingival bleeding index (GBI) was defined as the percentage of sites with a GI≥2. Gingival inflammation severity was classified as mild (mean GI: 0.5–1), moderate (mean GI: 1.1–2), or severe (mean GI>2). Participants were categorized according to their self-reported smoking habits as never smokers, current smokers, and former smokers. The educational level of the participants was classified as none/primary (≤ 6 years of education), middle/technical (between 6 and 12 years of education), and university (>12 years of education).

#### Statistical analysis

All observations were weighted according to the distribution of the age and gender in each target population. The weights were later normalized and adjusted to represent an equal number of participants (610) at each location. Descriptive statistics were employed to estimate the mean and interproximal gingival indices (GI; IGI), gingival bleeding index (GBI), overall gingival inflammation prevalence, and severity; the overall average for mean and interproximal visible dental plaque indices (VPI; IVPI) and calculus index were calculated, with 95% confidence intervals. The distribution of continuous variables was compared across 5 age groups for all the participants and by location using the Kruskal–Wallis test; chi-square and Fisher's exact tests were used for similar comparisons for inflammation severity in 3 categories.

Multivariate logistic regression was used to estimate the odds ratios (OR) and 95% confidence intervals (CI) for having ≥40% of sites with BOP (as the outcome), with age (18–19, 20–29, 30–39, 40–49, 50+), gender (male, female), smoking (current, past, never), education (none/basic, middle/technical, university), frequency of dental visits (never, only when there is a problem, ≥ 1 a year, and missing information), mean calculus index, VPI (dichotomized at 30%), city of residence (Kingston, Santo Domingo, San Juan), self-reported diabetes, and self-reported hypertension as predictors. This regression analysis was repeated for each city, separately. All analyses were conducted using SAS statistical software version 9.3 (SAS institute, Cary, NC) at statistical significance level of 0.05, using 2-sided tests, and accounted for the clustering effect.

## Results

The present multi-city study contacted 2,241 potential participants, of whom 394 were excluded. A total of 1,847 adults (609 in Kingston, 614 in Santo Domingo, and 624 in San Juan) completed both the interview and the clinical evaluations; observations were reweighted according to the age and gender distribution in each city so as to result in 610 participants at each location (1,830 in total). Mean age was 40.30 years (SE: 0.60); 54.11% were females.

### Prevalence of gingival inflammation

All participants presented gingival inflammation (Table 1). Table 2 shows the distribution of gingival inflammation risk indicators, overall and per city. Most participants had an intermediate level of educational attainment (54.60%), with the majority of San Juan participants (57.70%) having a university-level education. The majority of participants reported no history of smoking (64.37%); the proportion of current smokers was the highest in Kingston (38.22%), followed by San Juan (12.76%) and Santo Domingo (8.80%). In addition, 20.03% of participants reported having a history of hypertension, and 7.5% having been diagnosed with diabetes. The hypertension and diabetes prevalences were the highest in San Juan (24.05%

**Table 1**. Age distribution per city and among all participants

| | Kingston | | | | Santo Domingo | | | | San Juan | | | | All | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | N* | % | Wt N† | Wt % | N* | % | Wt N† | Wt % | N* | % | Wt N† | Wt % | N* | % | Wt N† | Wt % |
| 18–19 | 30 | 4.93% | 34 | 5.54% | 31 | 5.05% | 37 | 6.07% | 25 | 4.01% | 25 | 4.03% | 86 | 4.66% | 95 | 5.21% |
| 20–29 | 173 | 28.41% | 162 | 26.61% | 166 | 27.04% | 167 | 27.40% | 122 | 19.55% | 122 | 19.92% | 461 | 24.96% | 451 | 24.64% |
| 30–39 | 190 | 31.20% | 185 | 30.28% | 136 | 22.15% | 137 | 22.39% | 108 | 17.31% | 109 | 17.94% | 434 | 23.50% | 431 | 23.54% |
| 40–49 | 107 | 17.57% | 113 | 18.51% | 118 | 19.22% | 114 | 18.76% | 124 | 19.87% | 113 | 18.51% | 349 | 18.90% | 340 | 18.59% |
| ≥ 50 | 109 | 17.90% | 116 | 19.06% | 163 | 26.55% | 155 | 25.39% | 245 | 39.26% | 241 | 39.59% | 517 | 27.99% | 513 | 28.01% |
| All | 609 | 100.00% | 610 | 100.00% | 614 | 100.00% | 610 | 100.00% | 624 | 100.00% | 610 | 100.00% | 1,847 | 100.00% | 1,830 | 100.00% |

*Number of participants in each group; †Number of participants in each group after applying statistical weights

**Table 2**. Distribution of potential risk factorsa for gingival inflammation, per city, and among all participants

| Variables | Categories | Kingston (N = 609, Wt N = 610) | | Santo Domingo (N = 614, Wt N = 610) | | San Juan (N = 624, Wt N=610) | | All (N = 1,847, Wt N = 1,830) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Wt N* | Wt % | Wt N* | Wt % | Wt N* | Wt % | Wt N* | Wt % |
| Gender | Female | 333 | 54.67 | 324 | 53.14 | 333 | 54.53 | 990 | 54.11 |
| | Male | 277 | 45.33 | 286 | 46.86 | 277 | 45.47 | 840 | 45.89 |
| Education | None/basic | 75 | 12.37 | 159 | 26.10 | 30 | 4.99 | 265 | 14.49 |
| | Middle/Technical | 493 | 80.76 | 281 | 46.07 | 226 | 36.98 | 999 | 54.60 |
| | University | 40 | 6.56 | 170 | 27.84 | 352 | 57.70 | 562 | 30.69 |
| | Missing information | 2 | 0.31 | 0 | 0 | 2 | 0.32 | 4 | 0.22 |
| Smoking | Never | 290 | 47.55 | 469 | 76.91 | 419 | 68.68 | 1,178 | 64.37 |
| | Past | 84 | 13.74 | 87 | 14.29 | 113 | 18.56 | 284 | 15.53 |
| | Current | 233 | 38.22 | 54 | 8.80 | 78 | 12.76 | 365 | 19.93 |
| | Missing information | 3 | 0.49 | 0 | 0 | 0 | 0 | 3 | 0.17 |
| Self-reported diabetes | No | 579 | 94.87 | 579 | 94.98 | 535 | 87.64 | 1,693 | 92.49 |
| | Yes | 31 | 5.13 | 31 | 5.02 | 75 | 12.36 | 137 | 7.50 |
| Self-reported hypertension | No | 501 | 82.06 | 499 | 81.88 | 463 | 75.95 | 1,463 | 79.97 |
| | Yes | 109 | 17.94 | 111 | 18.12 | 147 | 24.05 | 367 | 20.03 |
| Plaque index | <30% | 53 | 8.71 | 0 | 0 | 1 | 0.16 | 54 | 2.96 |
| | ≥30% | 557 | 91.29 | 610 | 100 | 609 | 99.84 | 1,776 | 97.04 |
| Frequency of dental visits | Never | 13 | 2.08 | 42 | 6.96 | 5 | 0.83 | 60 | 3.29 |
| | Only when there is a problem | 493 | 80.87 | 444 | 72.78 | 148 | 24.28 | 1,085 | 59.31 |
| | Once a year or more often | 36 | 5.92 | 122 | 19.96 | 444 | 72.82 | 602 | 32.90 |
| | Missing information | 68 | 11.13 | 2 | 0.31 | 13 | 2.07 | 82 | 4.50 |
| Last visit to the dentist | <1 year ago | 115 | 18.92 | 217 | 35.53 | 399 | 65.46 | 732 | 39.97 |
| | 1–2 years ago | 20 | 3.26 | 89 | 14.53 | 87 | 14.20 | 195 | 10.66 |
| | >2 years ago | 376 | 61.69 | 93 | 15.20 | 103 | 16.89 | 572 | 31.26 |
| | Don't remember | 18 | 2.92 | 184 | 30.18 | 17 | 2.81 | 219 | 11.97 |
| | Missing information | 81 | 13.21 | 28 | 4.56 | 4 | 0.64 | 112 | 6.14 |

*Weighted number (WtN) and percentage (Wt %) are presented for each category of a potential risk factor

and 12.36%, respectively). Nearly all the participants (97.04%) presented a plaque index of ≥30%.

Among all the participants, the mean GI, PI, and calculus indices were estimated at 1.49, 0.94, and 0.66, respectively (Table 3). The mean and median gingival indices (GI, IGI, GBI) were the highest in Kingston, followed by Santo Domingo and San Juan (Table 3). The participants from Kingston also presented a higher calculus index (0.88) than did the participants from Santo Domingo (0.56) and San Juan (0.54). On average, 23.73 teeth per participant were evaluated (missing teeth: 3.69; unscorable: 0.58).

The average GI, IGI, and GBI indices by age and city are illustrated in Table 4. In Kingston and San Juan, the mean gingival indices increased with the increasing age of the participants; differences in age groups in these 2 cities, as well as in the overall group, were statistically significant (p<0.001 for Kingston and San Juan, and p=0.001 for the overall group).

### Severity of gingival inflammation

Moderate gingival inflammation was detected in 81.95% (95% CI, 75.41-88.49) of the participants (Table 5), mild in 8.67% (95% CI, 4.52-12.83), and severe in 9.38% (95% CI, 4.14-14.62). The distribution of gingival inflammation severity was significantly different across the age groups (chi-square/Fisher's exact test p-value<0.05) for the overall group, and in Kingston and San Juan; however, nearly all the Santo

Domingo participants were classified in the moderate-gingival-inflammation group, regardless of their age.

### Risk factors for gingival inflammation

Table 6 shows the association of gingival inflammation (sites with BOP ≥ 40%) with selected indicators, using a multivariate logistic regression model. In general, the older participants had higher odds of gingival bleeding on probing, compared to those who were 18 to 19 years old, with the exception of the Santo Domingo participants. No significant differences in the odds of gingival inflammation were observed between genders (OR for female: 1.17, 95% CI, 0.81-1.69; p = 0.42); however, in Santo Domingo, females had 2.46 times higher odds of having 40% or more of sites with BOP (95% CI, 1.40-4.35, p<0.01).

**Table 3**. Distribution* of gingival index (GI), interproximal gingival index (IGI), gingival bleeding index (GBI), visible plaque index (VPI), interproximal plaque index (IVPI), and calculus index (CI), per city, and among all participants

| Oral health indicator | Kingston (Wt N† = 610) | | | | Santo Domingo (Wt N† = 610) | | | | San Juan (Wt N† = 610) | | | | All (Wt N† = 1,830) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SE | 95% CI | Median | Mean | SE | 95% CI | Median | Mean | SE | 95% CI | Median | Mean | SE | 95% CI | Median |
| GI | 1.74 | 0.02 | 1.69; 1.80 | 1.67 | 1.49 | 0.03 | 1.42; 1.56 | 1.49 | 1.24 | 0.05 | 1.13; 1.34 | 1.14 | 1.49 | 0.05 | 1.39; 1.59 | 1.43 |
| IGI | 1.76 | 0.02 | 1.70; 1.82 | 1.70 | 1.49 | 0.03 | 1.41; 1.56 | 1.49 | 1.30 | 0.05 | 1.18; 1.42 | 1.19 | 1.52 | 0.04 | 1.42; 1.61 | 1.44 |
| GBI | 58.10 | 2.12 | 53.09; 63.11 | 64.20 | 49.26 | 2.97 | 42.23; 56.29 | 49.08 | 24.65 | 4.36 | 14.34; 34.96 | 14.27 | 44.00 | 3.47 | 36.83; 51.17 | 42.77 |
| VPI | 0.88 | 0.01 | 0.85; 0.92 | 0.996 | 0.99 | 0.003 | 0.98; 1.00 | 0.996 | 0.93 | 0.01 | 0.91; 0.95 | 0.98 | 0.94 | 0.01 | 0.92; 0.96 | 0.995 |
| IVPI | 0.89 | 0.01 | 0.85; 0.92 | 0.99 | 1.00 | 0.001 | 0.99; 1.00 | 0.99 | 0.99 | 0.003 | 0.98; 1.00 | 0.99 | 0.96 | 0.01 | 0.93; 0.98 | 0.99 |
| CI | 0.88 | 0.01 | 0.85; 0.92 | 0.90 | 0.56 | 0.01 | 0.52; 0.59 | 0.56 | 0.54 | 0.03 | 0.47; 0.60 | 0.53 | 0.66 | 0.03 | 0.59; 0.73 | 0.76 |
| Number of missing teeth | 4.16 | 0.25 | 3.58; 4.74 | 1.29 | 4.05 | 0.17 | 3.65; 4.44 | 1.78 | 2.86 | 0.24 | 2.29; 3.42 | 0.75 | 3.69 | 0.17 | 3.33; 4.04 | 1.30 |
| Number of evaluated teeth | 23.24 | 0.26 | 22.63; 23.86 | 25.17 | 23.00 | 0.16 | 22.62; 23.38 | 24.21 | 24.95 | 0.22 | 24.43; 25.47 | 25.99 | 23.73 | 0.22 | 23.28; 24.18 | 25.16 |

*Means, standard errors (SE), 95% confidence intervals (CI) around the mean, and medians are presented for each indicator; †Number of participants after applying statistical weights

**Table 4**. Average gingival index (total and interproximal) and average gingival bleeding index, and the corresponding 95% confidence intervals (CI), according to age group, per city and among all

| City | Age | Gingival Index | | | Interproximal Gingival Index | | | Gingival Bleeding Index | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | 95% CI | p-value* | Mean | 95% CI | p-value* | Mean | 95% CI | p-value* |
| Kingston | 18–19 | 1.43 | 1.17; 1.68 | <0.001 | 1.43 | 1.17; 1.69 | <0.001 | 38.30 | 17.35; 59.24 | <0.001 |
| | 20–29 | 1.61 | 1.50; 1.73 | | 1.63 | 1.52; 1.74 | | 51.97 | 42.68; 61.25 | |
| | 30–39 | 1.66 | 1.60; 1.72 | | 1.68 | 1.61; 1.74 | | 54.14 | 49.16; 59.11 | |
| | 40–49 | 1.77 | 1.62; 1.92 | | 1.79 | 1.64; 1.95 | | 58.91 | 49.04; 68.78 | |
| | ≥ 50 | 2.12 | 1.94; 2.30 | | 2.14 | 1.97; 2.31 | | 77.92 | 71.59; 84.24 | |
| Santo Domingo | 18–19 | 1.42 | 1.32; 1.51 | 0.23 | 1.39 | 1.29; 1.50 | 0.13 | 42.70 | 33.81; 51.60 | 0.21 |
| | 20–29 | 1.50 | 1.43; 1.57 | | 1.49 | 1.41; 1.56 | | 50.21 | 43.08; 57.35 | |
| | 30–39 | 1.50 | 1.40; 1.59 | | 1.50 | 1.40; 1.59 | | 50.39 | 41.24; 59.54 | |
| | 40–49 | 1.51 | 1.43; 1.59 | | 1.51 | 1.42; 1.59 | | 50.94 | 42.69, 59.19 | |
| | ≥ 50 | 1.48 | 1.41; 1.55 | | 1.48 | 1.41; 1.56 | | 47.55 | 40.74; 54.35 | |
| San Juan | 18–19 | 1.10 | 1.02; 1.17 | <0.001 | 1.15 | 1.06; 1.24 | <0.001 | 12.97 | 5.35; 20.60 | <0.001 |
| | 20–29 | 1.13 | 1.04; 1.23 | | 1.21 | 1.11; 1.31 | | 16.43 | 8.15; 24.71 | |
| | 30–39 | 1.19 | 1.03; 1.35 | | 1.26 | 1.09; 1.44 | | 21.09 | 6.44; 35.73 | |
| | 40–49 | 1.24 | 1.12; 1.37 | | 1.32 | 1.17; 1.46 | | 25.20 | 13.66; 36.73 | |
| | ≥ 50 | 1.32 | 1.20; 1.43 | | 1.38 | 1.25; 1.50 | | 31.33 | 20.15; 42.51 | |
| Total | 18–19 | 1.34 | 1.24; 1.44 | 0.001 | 1.35 | 1.25; 1.45 | <0.001 | 33.48 | 24.79; 42.17 | <0.01 |
| | 20–29 | 1.44 | 1.35; 1.53 | | 1.46 | 1.38; 1.55 | | 41.74 | 34.28; 49.21 | |
| | 30–39 | 1.49 | 1.40; 1.58 | | 1.51 | 1.43; 1.60 | | 44.55 | 37.47; 51.63 | |
| | 40–49 | 1.51 | 1.40; 1.62 | | 1.54 | 1.43; 1.64 | | 45.04 | 37.21; 52.87 | |
| | ≥ 50 | 1.55 | 1.41; 1.69 | | 1.58 | 1.45; 1.72 | | 46.72 | 37.70; 55.74 | |

*p-values were obtained from a Kruskal–Wallis test to compare gingival indices between age groups, in each city and among all.

**Table 5**. Distribution* of severity (mild, moderate, and severe) of gingival inflammation† according to age group, per city and among all

| | | mild gingival infammation | | | moderate gingival inflammation | | | severe gingival inflammation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age | Wt N | Wt % | 95% CI | Wt N | Wt % | 95% CI | Wt N | Wt % | 95% CI | p-value‡ |
| Kingston | 18–19 | 8 | 23. 61 | 3.33; 43.88 | 21 | 63.24 | 45.31; 81.17 | 4 | 13.15 | 0.00; 29.47 | <0.001 |
| | 20–29 | 19 | 11.56 | 0.00; 25.71 | 114 | 70.45 | 59.25; 81.66 | 29 | 17.99 | 9.97; 26.01 | |
| | 30–39 | 15 | 7.91 | 0.00; 16.37 | 138 | 74.76 | 67.05; 82.46 | 32 | 17.34 | 11.62; 23.05 | |
| | 40–49 | 11 | 9.64 | 1.87; 17.41 | 68 | 60.35 | 45.03; 75.66 | 34 | 30.01 | 16.43; 43.60 | |
| | ≥ 50 | 1 | 0.88 | 0.00; 2.97 | 58 | 49.52 | 34.61; 64.43 | 58 | 49.60 | 34.73; 64.47 | |
| | All | 53 | 8.73 | 0.26; 17.20 | 400 | 65.50 | 58.04; 72.95 | 157 | 25.77 | 20.68; 30.86 | |
| Santo Domingo | 18–19 | 1 | 3.47 | 0.00; 11.64 | 36 | 96.53 | 88.36; 100.00 | 0 | 0 | - | 0.12¶ |
| | 20–29 | 0 | 0 | - | 167 | 100 | - | 0 | 0 | - | |
| | 30–39 | 0 | 0 | - | 137 | 100 | - | 0 | 0 | - | |
| | 40–49 | 0 | 0 | - | 114 | 100 | - | 0 | 0 | - | |
| | ≥ 50 | 1 | 0.63 | 0.00; 2.13 | 153 | 98.77 | 96.83; 100.00 | 1 | 0.60 | 0.00; 2.02 | |
| | All | 2 | 0.37 | 0.00; 0.95 | 607 | 99.48 | 98.86; 100.00 | 1 | 0.15 | 0.00; 0.51 | |
| San Juan | 18–19 | 10 | 42.17 | 20.32; 64.01 | 14 | 57.83 | 35.99; 79.68 | 0 | 0 | - | <0.001 |
| | 20–29 | 29 | 23.69 | 12.57; 34.82 | 93 | 76.31 | 65.18; 87.43 | 0 | 0 | - | |
| | 30–39 | 33 | 29.82 | 17.52; 42.12 | 74 | 67.44 | 56.19; 78.69 | 3 | 2.74 | 0.00; 7.41 | |
| | 40–49 | 14 | 12.09 | 4.00; 20.18 | 96 | 84.67 | 75.64; 93.70 | 4 | 3.24 | 0.00; 9.12 | |
| | ≥ 50 | 18 | 7.36 | 2.73; 11.99 | 217 | 89.82 | 85.06; 94.59 | 7 | 2.82 | 1.09; 4.54 | |
| | All | 103 | 16.92 | 10.61; 23.24 | 493 | 80.87 | 75.18; 86.56 | 14 | 2.21 | 0.30; 4.12 | |
| All combined | 18–19 | 20 | 20.58 | 10.30; 30.87 | 71 | 74.76 | 64.07; 85.44 | 4 | 4.66 | 0.00; 10.30 | <0.001 |
| | 20–29 | 48 | 10.54 | 4.19; 16.89 | 374 | 82.98 | 75.73; 90.23 | 29 | 6.47 | 1.98; 10.97 | |
| | 30–39 | 47 | 10.97 | 4.90; 17.04 | 348 | 80.90 | 74.22; 87.59 | 35 | 8.13 | 3.79; 12.47 | |
| | 40–49 | 25 | 7.21 | 3.34; 11.08 | 278 | 81.75 | 73.18; 90.33 | 38 | 11.03 | 3.98; 18.09 | |
| | ≥ 50 | 21 | 4.03 | 1.58; 6.48 | 427 | 83.22 | 75.46; 90.98 | 65 | 12.75 | 4.58; 20.91 | |
| | All | 158 | 8.67 | 4.52; 12.83 | 1500 | 81.95 | 75.41; 88.49 | 172 | 9.38 | 4.14; 14.62 | |

*Weighted number (Wt N) and percentage (Wt %) of participants with each severity level, as well as 95% confidence intervals (CI) around the percentage are presented for each age and city subgroup; †Gingival inflammation severity was defined as mild if the average gingival index ranged between 0.5 and 1, moderate if ranged between 1.1 and 2, and severe if it was >2; ‡P-values were obtained from the chi-square test, comparing gingivitis severity across the age groups, unless otherwise indicated; ¶Fisher's exact test was used for this location.

Level of education was significantly associated with gingival inflammation (OR middle/technical education vs. university= 1.61, 95% CI, 1.23-2.11; p < 0.001, and OR none/basic vs. university = 2.86, 95% CI, 1.88-4.35; p<0.001). Calculus and plaque were strongly associated with bleeding on probing (ORcalculus index = 10.35, 95% CI, 5.96-17.96, and OR VPI ≥ 30% = 7.85, 95% CI, 2.36-26.11). In addition, residents of Kingston or Santo Domingo had increased odds of gingival inflammation (OR:4.74, 95% CI, 2.27-9.89, and OR:7.09, 95% CI, 2.74-16.30, for Kingston and Santo Domingo, respectively) compared to residents of San Juan. An in-depth analysis of the risk indicators of gingival inflammation and the oral health–related quality of life implications in this population will be presented in future publications.

## Discussion

This study was composed of a random sample of adults from Kingston, Santo Domingo, and San Juan. To our understanding, this is the first study to estimate the prevalence of gingival inflammation in a representative sample of the adult population from different geographic areas within the Caribbean basin.

Virtually all the participants in this multi-city study presented gingival inflammation. The prevalence of gingival inflammation observed in the participants of the present study was marginally higher than those prevalences reported for American (13), Chinese (16), and South American (1) adults and similar to those reported for Northern Latin American (17) adults. Studies from other countries and using a GI≥0.5 have reported lower prevalences (18). The findings of other reports, these derived from studies of Saudi (11) and Puerto Rican adults (8) and using more strict criteria to define gingival inflammation (GI≥0.1), are in complete agreement with our own. With regard to severity, moderate gingival inflammation (mean GI:1.74) was the most commonly observed type. Our findings are in agreement with those of previous studies that have reported moderate levels of disease and similar mean GIs (1, 19).

Some reports have indicated higher prevalences of gingival inflammation in males (8, 19). Our overall findings are in concordance with those of other reports (20) that have found no statistically significant differences in gingival inflammation between genders. Interestingly, female participants from Santo Domingo were found to have higher odds of having at least 40% of sites with BOP. This finding is in agreement with those of other reports indicating a similar sex-based predisposition (1). Hormonal fluctuations, genetics, smoking patterns, and stress variations, among others, may account for this difference (with regard to male prevalence).

Our results in San Juan and Kingston, as well as those of the overall group, suggested a positive association between age and the severity of the disease; no similar trend was observed in the participants from Santo Domingo. Previous reports on

this association also showed mixed results, with some studies presenting positive associations between age and gingivitis prevalence/severity (13, 18) and others reporting lack of such an association (11, 21). These differences between three populations of our study could be attributable to variations in oral hygiene and dietary habits and to a more uniform educational attainment distribution in the participants from Santo Domingo compared to the distribution of same in the participants from the other 2 cities.

Educational attainment has been strongly associated with periodontal status (22, 23). Our findings were in agreement with those of previous studies that have reported a higher prevalence of gingivitis and periodontitis in individuals with lower educational achievement (23, 24). Inconsistent oral-hygiene performance due to poor periodontal health knowledge may result in higher levels of dental plaque, and, therefore, subsequent gingival inflammation.

Infrequent dental visits have been related to cost, dental anxiety, availability of public dental care, and dental insurance access (25). In addition, low educational attainment has been associated with less frequent dental visits (26). While almost three-fourths of the participants from San Juan claimed to make dental visits once a year or more often, the same proportion of participants from Kingston and Santo Domingo declared that they visited a dentist only when they had a problem or not at all. Our findings may be attributed to a high level of educational attainment and/or access to government-sponsored health insurance in San Juan.

Gingival inflammation has been correlated with the presence of dental plaque (1, 27); our study confirms this strong association. The high VPIs and IVPIs in virtually all the participants of the study suggest that inadequate or insufficient oral hygiene is practiced in all 3 cities.

Our findings were in agreement with those of a recent study 1 that observed a solid association between the presence of dental calculus and gingival inflammation, being stronger in participants from Kingston than in those of the other 2 cities in our study. Interestingly, more than half of these participants were current or past smokers. A significant association between smoking and subgingival calculus has been reported previously (28).

**Table 6**. Multivariate-adjusted odds ratios (OR) and 95 % confidence intervals (CI) for extensive bleeding on probing (≥ 40% of probing sites, yes/no), according to potential risk factors, among all participants, and per city*

| Risk factors | | All (Wt N* = 1,822) | | | Kingston (Wt N* = 604) | | | Santo Domingo (Wt N* = 608) | | | San Juan (Wt N* = 608) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value |
| Age, years | 50+ | 1.95 | 1.13; 3.36 | 0.02 | 7.88 | 2.94; 21.10 | <0.001 | 0.74 | 0.35; 1.60 | 0.45 | 2.82 | 0.99; 8.02 | 0.05 |
| | 40–49 | 1.75 | 1.06; 2.90 | 0.03 | 2.70 | 1.08; 6.76 | 0.03 | 1.71 | 0.87; 3.35 | 0.12 | 1.87 | 0.54; 6.49 | 0.32 |
| | 30–39 | 1.46 | 0.93; 2.28 | 0.10 | 2.47 | 1.28; 4.77 | <0.01 | 1.25 | 0.62; 2.51 | 0.54 | 1.93 | 0.58; 6.36 | 0.28 |
| | 20–29 | 2.01 | 1.30; 3.11 | <0.01 | 2.15 | 1.00; 4.62 | 0.05 | 2.63 | 1.48; 4.67 | <0.001 | 1.91 | 0.56; 6.52 | 0.30 |
| | 18–19 (ref.) | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - |
| Gender | Female | 1.17 | 0.81; 1.69 | 0.42 | 0.82 | 0.46; 1.48 | 0.51 | 2.46 | 1.40; 4.35 | <0.01 | 0.63 | 0.33; 1.21 | 0.17 |
| | Male (ref.) | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - |
| Smoking | Current | 0.85 | 0.55; 1.31 | 0.46 | 1.31 | 0.79; 2.18 | 0.30 | 0.35 | 0.19; 0.67 | <0.01 | 0.80 | 0.32; 2.00 | 0.63 |
| | Past | 0.84 | 0.61; 1.15 | 0.28 | 0.81 | 0.55; 1.19 | 0.28 | 1.19 | 0.56; 2.56 | 0.65 | 0.73 | 0.47; 1.12 | 0.14 |
| | Never (ref.) | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - | 1.0 | | - |
| Education (years) | None/basic | 2.86 | 1.88; 4.35 | <0.001 | 2.88 | 0.94; 8.77 | 0.06 | 3.71 | 1.68; 8.21 | <0.01 | 3.33 | 2.19; 5.07 | <0.001 |
| | Middle/Technical | 1.61 | 1.23; 2.11 | <0.001 | 0.76 | 0.51; 1.13 | 0.18 | 2.18 | 1.27; 3.77 | <0.01 | 1.61 | 1.27; 2.05 | <0.001 |
| | University (ref.) | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - |
| Frequency of dental visits | Never | 0.52 | 0.21; 1.33 | 0.17 | 0.59 | 0.27; 1.28 | 0.18 | 0.33 | 0.08; 1.31 | 0.11 | 1.33 | 0.43; 4.18 | 0.62 |
| | Only when there is a problem | 0.90 | 0.64; 1.26 | 0.53 | 0.34 | 0.16; 0.72 | <0.01 | 0.72 | 0.42; 1.25 | 0.24 | 1.11 | 0.60; 2.05 | 0.74 |
| | Missing (no response) | 0.58 | 0.29; 1.14 | 0.11 | 0.24 | 0.09; 0.68 | 0.01 | exc. | - | - | 0.86 | 0.18; 4.11 | 0.85 |
| | ≥1 a year (ref.) | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - | 1.0 | - | - |
| CI | | 10.35 | 5.96; 17.96 | <0.001 | 22.28 | 15.81; 31.38 | <0.001 | 6.28 | 3.44; 11.46 | <0.001 | 45.20 | 25.36; 80.54 | <0.001 |
| VPI | ≥30% | 7.85 | 2.36; 26.11 | <0.001 | 6.22 | 1.29; 30.05 | 0.02 | - | - | - | - | - | - |
| | <30% (ref.) | 1.0 | - | - | 1.0 | - | - | - | - | - | - | - | - |
| City | Kingston | 4.74 | 2.27; 9.89 | <0.001 | - | - | - | - | - | - | - | - | - |
| | Santo Domingo | 7.09 | 2.74; 18.30 | <0.001 | - | - | - | - | - | - | - | - | - |
| | San Juan (ref.) | 1.0 | - | - | - | - | - | - | - | - | - | - | - |

*Odds ratios, 95% confidence intervals and p-values were obtained from logistic regression models for bleeding on probing at ≥ 40% of the sites, which included age (5 groups), gender (male, female), smoking (never, past, current), educational level (3 categories), frequency of dental visits (never, only when there is a problem, once a year or more frequently, missing), mean calculus index (CI), visible plaque index (≥ 30% vs. <30% sites), self-reported diabetes, self-reported hypertension, and location/city. For Santo Domingo and San Juan, the visible plaque index was not included in the model due to small number of participants in the referent category of this variable (0 participants in Santo Domingo and 1 in San Juan). For the analysis in Santo Domingo, 2 participants with missing information on frequency of dental visits were excluded; †Number of participants after applying statistical weights. Observations (8 in the overall analysis, 6 in Kingston, 2 in Santo Domingo, 2 in San Juan) were excluded from this analysis due to missing information on education, smoking, calculus status, or frequency of dental visits (Santo Domingo only).

There is strong evidence that smoking influences periodontal disease (29). In contrast, it has been reported that duration (years) of smoking has been associated with a dose-dependent reduction in gingival bleeding (30). In the present study, the highest GIs, IGIs, and GBIs were observed in participants from Kingston, the city with the highest proportion of current or past smokers; however, smoking did not increase their odds of having gingival inflammation. Since participants from Kingston also have the highest mean calculus index, the highest percentage of infrequent dental visits, and the lowest university graduation rate, the relative contribution of tobacco as a risk factor for gingival inflammation needs to be clarified. A more detailed analysis including smoking frequency, number of years smoking, and types of smoking products used will be included in a future publication.

One of the strengths of the present study was its representative and balanced sample of participants, which reflected the age and gender distribution in the target populations. Other strengths include the calibration of clinical examiners and the full-mouth evaluations for gingival and dental plaque parameters. These results cannot be extrapolated to other Caribbean nations; therefore, further studies are required to determine gingival health statuses in other Caribbean cities/countries.

Our findings indicate that gingival inflammation is a significant oral health problem in the participating nations. Gingival inflammation is a reversible condition; thus, appropriate self-performed plaque control and professional dental care are imperative for preventing periodontal disease progression (31). We endorse increasing community self-awareness through better oral health instruction using an appropriate level of health literacy (32) and implementing tailored national programs to prevent/control gingival inflammation.

## Conclusion

The prevalence of gingival inflammation in adults from 3 Caribbean cities was very high. Most participants presented moderate gingival inflammation. Educational attainment, dental calculus, and having a VPI of 30% or greater were strongly associated with gingival inflammation. The findings in this study suggest that there are inequities in access to dental care in these areas.

## Resumen

Objetivo: Estimar la prevalencia de inflamación gingival, severidad, y factores de riesgo en un grupo de adultos de Kingston, Jamaica; Santo Domingo, República Dominicana; y San Juan, Puerto Rico. Métodos: En este estudio representativo, los voluntarios fueron evaluados por examinadores calibrados y entrenados. Los participantes completaron cuestionarios médicos y de salud oral. La evaluación clínica incluyó: salud gingival, placa visible, y presencia de cálculo. Los hallazgos se resumieron como índices gingivales globales e interproximales (GI;IGI), índice de sangrado gingival al sondaje (BOP), prevalencia de inflamación gingival (GI≥0.5) y severidad, índices promedio e interproximal de placa visible (VPI;IVPI) e índice de cálculo. La regresión logística multivariada se utilizó para evaluar asociaciones entre factores de riesgo de inflamación y BOP en ≥40% de los sitios; los odds-ratios fueron estimados. Resultados: Los 1,847 participantes presentaron inflamación gingival; la mayoría (81.9%) tenían inflamación moderada. Los índices promedios de GI, VPI, IVPI y cálculo fueron 1,49, 0,94, 0,96 y 0,66, respectivamente; la mayoría de los participantes presentaron un VPI≥30%. BOP≥40% de sitios se asoció significativamente con educación ($OR_{\text{media/técnico vs. educación universitaria}} = 1.61$; $p = 0.001$ y $OR_{\text{ninguna/básico vs. universidad}}=2.86$; $p<0.001$), índice de cálculo (OR:10.35), VPI≥30% (OR:7.85, $p <0.001$; ambos), y residir en Kingston o Santo Domingo (vs. San Juan, OR:4.74 y OR:7.09, respectivamente), después de ajustar por edad, sexo, fumar, frecuencia de visitas dentales, diabetes e hipertensión. Conclusión: La inflamación gingival fue altamente prevalente. La mayoría de los participantes presentaron inflamación moderada. El logro educativo, cálculo dental y VPI≥30% se asociaron fuertemente con inflamación.

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