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Association between BMI and periodontitis in women living with or at risk for HIV

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Abstract

Aims: Currently, there is no data available assessing the association between body mass index (BMI) and periodontitis among women living with HIV (WLWH). This study aims to investigate this association among WLWH and women at risk for HIV (WRH) in the United States.

Methods and results: Data from 351 WLWH and 52 WRH participants from the Women's Interagency HIV Study having pocket depths and clinical periodontal attachment loss assessments in 2003–2004 were included. Multinomial logistic regression analyses in the full sample assessed the relationship between BMI (underweight/normal, overweight, or obese) and periodontitis by severity (mild, moderate, severe), adjusting for study sites, age, education, annual household income, smoking, alcohol consumption, and diabetes.

Overall, 75.2% women (76.0% WLWH; 69.0% WRH) had periodontitis. Moreover, 75.0% obese and 75.3% overweight women were affected by periodontitis. In the full sample, adjusted odds ratio (aOR) of having mild, moderate, and severe periodontitis in obese women were: 1.14 (95% confidence interval [CI]: 0.51–2.52), 1.02 (95% CI: 0.46–2.29), and 0.24 (95% CI: 0.06–1.07), respectively, and in overweight

women: 0.70 (95% CI: 0.31–1.58), 0.85 (95% CI: 0.38–1.90), and 0.31 (95% CI: 0.08–1.15), respectively.

Conclusions: Even with high prevalence of periodontitis among women with or without HIV infection in this cohort, this study does not provide evidence of an association between BMI and periodontitis.

KEYWORDS
BMI, HIV, obesity, periodontal disease

1 | INTRODUCTION

Described as an "'epidemic"' by the World Health Organization (WHO), obesity is now prevalent in not only high-income but also middle and low-income countries. Overweight and obesity are defined as an abnormal or excessive accumulation of fat and are categorized by a person's body mass index (BMI).[1] Within USA, the prevalence of obesity has increased from 30.5% in the year 2000 to 42.4% in 2018.[2] As this obesity prevalence is increasing, there is a growing concern of obesity and overweight-related adverse consequences on oral health, which is a crucial factor in maintaining overall health and quality of life.

Periodontitis, an inflammatory condition of tissues surrounding the teeth, is among the most common oral diseases and is the leading cause of tooth loss in adults.[3] When the oral epithelium is exposed to pathogenic bacterial flora, an interaction between oral epithelial cells and bacterial biofilm triggers the host inflammatory immune response. Certain endogenous factors associated with the pathogens, such as lipopolysaccharides, bind to the toll-like receptors located in the periodontium.[4] The oral epithelium then differentially activates a local as well as a systemic inflammatory state. This inflammatory response of the periodontium is clinically characterized by bleeding on probing, periodontal pocket formation, loss of epithelial attachment, and alveolar bone loss, which ultimately results in the loss of teeth.

Both obesity and periodontitis are highly common non-communicable, chronic inflammatory diseases. Certain proinflammatory cytokines, such as interleukin (IL)-1, tumor necrosis factor (TNF)-α, and IL-6, are present in higher concentrations in gingival crevicular fluid of people with periodontitis.[5] Interestingly, studies have also shown a higher concentration of these inflammatory cytokines in obesity.[6] This mutual factor between the two made scientists interested in investigating the link between obesity and periodontitis.

Various epidemiological studies conducted to evaluate the association between obesity and periodontal disease to date have provided limited evidence of any causal link or clear mechanism of the association. In healthy adult populations, some studies have yielded a positive relationship between obesity/overweight and periodontitis,[7–12] while others have revealed either no association[13–17] or an inverse relationship between obesity and periodontitis.[15] While these studies were performed across diverse populations, thus far, none of the studies have assessed whether obesity/overweight is a risk factor for periodontitis in people living with HIV (PLWH).

A constant state of chronic inflammation and immunosuppression observed in HIV infection leads to many inflammatory diseases in PLWH, including obesity and periodontal disease.[18] With early diagnosis and improved antiretroviral therapy (ART), there is now an increasing trend of PLWH being overweight/obese, similar to the general population.[19,20] In the oral cavity, PLWH are exhibiting more conventional forms of periodontitis, similar to the one observed in healthy adult population rather than the more destructive forms noted in pre-ART era.[21–23] However, prevalence of severe periodontitis has been shown to be still higher among HIV-infected individuals compared to general population.[24] Managing periodontal disease is very important in PLWH as inflammatory products from periodontal infection can adversely affect progression of HIV infection and effectiveness of antiviral therapy.[18] Therefore, it is necessary to make similar efforts in PLWH and the general population to explore risk factors for chronic periodontitis. Understanding the link between obesity and periodontitis in those living with HIV can help oral healthcare providers to not only educate patients appropriately but also control unfavorable outcomes of both HIV infection and periodontitis. In this study, we investigated BMI as a potential risk factor for periodontitis in women living with HIV (WLWH) and women at risk for HIV (WRH).

2 | METHODS

The Women's Interagency HIV Study (WIHS) was a multicenter, prospective, observational cohort study to

investigate the impact and progression of HIV infection in women in the United States. Details of recruitment and study design have previously been described.[25,26] WIHS core visits consisted of detailed sociodemographic, behavioral, and medical interviews, physical and gynecological examinations, and laboratory testing.[26,27] Between 1995 and 2004, a subset of WIHS women had a detailed oral health assessments with periodontal measurements semiannually, typically within 2 weeks of a WIHS core visit. Calibration of dental examiners across all participating sites (Bronx, Chicago, San Francisco, Los Angeles) was done every 2 years, comparing each examiner to each other and to the gold standard examiner on recording and assessing the clinical data.[23,27]

The WIHS-oral study initially recruited 731 participants. However, loss of participants due to death and drop out resulted in almost 50% loss of participants by the year 2003–2004.[23] Our cross-sectional analysis uses the last available oral substudy visits conduced in 2003–2004. Local institutional review board approval and written informed consent from all individuals enrolled in the study were obtained by each participating WIHS location.

This study includes data from 351 WLWH and 52 WRH who completed at least one visit during 2003–2004 in the oral substudy. All edentulous women, as well as those missing any sociodemographic and health information, were excluded. HIV seroconverters were excluded. Women, who were excluded for the stated reasons or who were disenrolled due to death/loss to follow up, did not demographically differ from the study sample.

The periodontal examination was performed on a random half mouth (one upper and one lower quadrant) using a mouth mirror and National Institute of Dental and Craniofacial Research (NIDCR) periodontal probe (Hu-Friedy, Chicago, IL, USA). For participants with <10 natural teeth, each tooth in the mouth was examined. Distance from the free gingival margin (FGM) to the cemento-enamel junction (CEJ) and from the FGM to the bottom of the sulcus (pocket depth [PD]) were measured on four sites per tooth: distal, midbuccal, mesial, and midlingual.

PD and loss of tissue attachment (LOA) were the two periodontal disease measures used in this cross-sectional analysis. The PD values were taken from the original substudy data and the LOA values were calculated by subtracting the FGM to CEJ distance from the FGM to the bottom of the sulcus distance. Periodontitis was defined according to the guidelines of American Academy of Periodontology[28] as presence of one or more sites with PD > 3 mm and LOA > 1 mm per tooth with >30% of teeth involved. Participants who did not meet these criteria were classified as "no periodontitis" and were included as the reference group. The severity of periodontitis was further categorized into mild (if PD > 3 and <5 mm, or LOA 1–2 mm), moderate (PD ≥ 5 and <7 mm, or LOA 3–4 mm), and severe (PD≥7 mm, or LOA ≥5 mm) levels, based on American Academy of Periodontology guidelines.[28]

For this study, the primary exposure was BMI. Each participant's height and weight were measured to the nearest inch and pound and converted to metric units followed by computerized calculation of BMI. WHO guidelines[29] were used to categorize participants into underweight (≤18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), or obese (≥30 kg/m^2). Demographic information, such as race/ethnicity (Black non-Hispanic, Hispanic, White non-Hispanic, or other), education (<High school, =High school, or >High school), annual household income(<$6000, $6000–18 000, >$18 000–36 000, or >$36 000), as well as data on age (divided into two categories based on minimum and maximum age of participants, ≥18 to <40 years or ≥40 years of age), alcohol consumption (abstainers, one–seven drinks/week, or >seven drinks/week, based on "National Institute on Alcohol Abuse and Alcoholism" definitions and "dietary guidelines for Americans"),[30] current smoker (yes or no), and general health information, such as absence or presence of diabetes (using summary variables that combine self-report of diagnosis, report of diabetic medication, or any of fasting glucose ≥126 mg/dL, or HbA1C ≥ 6.5%)[31] were included. A subset of analysis restricted to WLWH was also performed and included duration on antiretroviral medication (initiation <1 year prior, or ≥1 year prior), and current CD4 count (<200 or ≥200 cells/mm^3).

SAS version 9 was used for statistical analysis (SAS Institute Inc., Cary, NC). Descriptive analysis was performed with mean and standard deviation (SD) for continuous variables and percentage for categorical variables. Values were compared using Kruskal–Wallis and Chi-square tests as appropriate. Multinomial logistic regression with generalized logit link function was used to calculate odds ratios (ORs) and adjusted odds ratios (aORs), with 95% confidence intervals (CIs) in the full sample as well as subset analysis restricted to WLWH. The covariates such as age, study sites, race/ethnicity, education, annual household income, smoking, alcohol consumptions, and diabetes were recognized as potential risk factors for periodontitis in the bivariate model ($p < .05$), and were adjusted in the multivariable model.[32]

3 | RESULTS

This study population consisted of 351 WLWH and 52 WRH. Mean (±SD) BMI in WRH was significantly higher than WLWH (32.4 ± 9.6 vs. 28.6 ± 7.3; $p = .001$). A total of 64.7% WLWH and 75.0% of WRH were either overweight

or obese. Both WLWH and WRH were comparable for all socioeconomic variables (Table 1).

The prevalence of periodontitis in WLWH and WRH was 76.1% and 69.2%, respectively. There was no difference in the prevalence of periodontitis by HIV status ($p = .29$) in our cohort, which is consistent with the results by Alves et al. using WIHS data from 1995 to 2001.[23] The association of periodontitis by severity and HIV status was not investigated before in this cohort. We discovered that the adjusted odds of mild (aOR: 1.51, 95% CI: 0.57–4.00), moderate (aOR: 1.10, 95% CI: 0.43–2.83), and severe periodontitis (aOR: 1.02, 95% CI: 0.20–5.14) were not different by HIV status, confirming that the periodontal disease in PLWH has shifted to common forms of periodontitis, similar to healthy population. In the full sample, periodontitis prevalence among underweight/normal, overweight, and obese participants was 75.2%, 75.0%, and 75.3% respectively and not significantly different ($p = .99$).

BMI was not associated with prevalence of periodontitis in the full sample. The bivariate analysis indicated that overweight (aOR: 1.07, 95% CI: 0.57–2.02) and obesity (aOR: 1.23, 95% CI: 0.65–2.30) were not associated with increased odds of periodontitis. Furthermore, overweight and obesity were also not associated with the severity of periodontitis (Table 2).

Results were similar when analysis restricted to only WLWH was performed. Adjusted odds of periodontitis were not significantly different in women who were overweight (aOR: 0.91, 95% CI: 0.48–1.73) or obese (aOR: 1.26, 95% CI: 0.64–2.49), compared to normal or underweight women. The multinomial analysis demonstrated the association between either overweight or obesity and mild, moderate, or severe periodontitis to be statistically nonsignificant in WLWH (Table 3).

4 | DISCUSSION

Obesity and overweight were not associated with periodontitis among women overall in this study, or among the WLWH subset alone. These findings are in agreement with a recent large cross-sectional study ($N = 4170$) as well as several other studies that did not find an association between BMI and periodontitis in healthy adults.[13–17,33] Our study confirms that these prior findings also hold true for WLWH. The lack of association between overweight or obesity and periodontitis among WLWH could be attributed to a complex relationship between periodontitis, overweight/obesity, and HIV infection. Some common characteristics between periodontitis and obesity, such as age, poor eating habits, less education, low income, stress, and unhealthy lifestyle, are also prevalent in PLWH. These common factors can confound the findings and make it difficult to draw any conclusion.[15] The relationship between BMI and periodontitis becomes more complex when evaluated in PLWH compared to healthy population. Even though the basic pathogenesis of periodontitis is the same in individuals with HIV and without HIV, patterns of the periodontal disease differ by HIV status with respect to irreversible damage to the soft tissues.[18,21] Regarding obesity, HIV infection and antiviral medication can influence adipose tissue distribution and deposition in PLWH, exhibiting more fat in visceral and cervical area than periphery.[32] This different presentation of periodontal disease and obesity in HIV infection may impact the association between the two.

In contrast to our findings, some studies support a positive association between obesity and periodontitis.[7–12] Although these published studies support a link, none of the findings give us a clear knowledge about the association and the results were inconclusive. For example, one prospective study demonstrated that obesity was a risk factor for loss of periodontal attachment in females, but not in males.[8] Similarly, another study found the overall obesity to be associated with increased prevalence of periodontitis in young adults (age 18–34 years), but not in middle (35–59 years) or older (60–90 years) adults.[12] A recent systematic review and meta-analysis reported that subjects who became overweight or obese had a greater risk of developing periodontitis.[34] However, this finding was based on a limited number of observations. Dissimilarities in the findings of our study and above-mentioned studies may be attributed to variations in the study populations with regards to gender, ethnicity, geographical locations, economics, and social and cultural practices. All of these factors influence the risk of obesity/overweight and periodontitis. Additionally, differences in the study designs, use of different periodontal parameters, and the lack of a uniform definition of periodontitis may contribute to the differences in study findings. Our study defined periodontitis according to American Academy of Periodontology guidelines that are accepted as the gold standard for clinical practice. An advantage of using both PD and LOA as measures of periodontitis is that the participants with true pockets are categorized as diseased, while those with only gingival recession are categorized as nondiseased.[12]

Our study had the benefit of including a demographically diverse WLWH group and a comparable negative group. There were several limitations to our study. First, we did not investigate participants' oral hygiene habits, access or prevention and treatment visits to the oral health care providers, or nutritional habits including the amount of sugar intake. These unmeasured variables could have confounded some of the findings. Second, there was a

TABLE 1 Characteristics of the WLWH and WRH groups

Characteristic	WLWH *N* (%)	WRH *N* (%)	*p*-value
	N = 351	*N* = 52	
Sites			.34
Bronx	80 (22.8%)	8 (15.4%)	
Chicago	95 (27.1%)	20 (38.5%)	
San Francisco	79 (22.5%)	11 (21.1%)	
Los Angeles	97 (27.6%)	13 (25.0%)	
Race/ethnicity			.21
Black non-Hispanic	181 (51.6%)	33 (63.5%)	
Hispanic	127 (36.2%)	13 (25.0%)	
White non-Hispanic	33 (9.4%)	6 (11.5%)	
Other	10 (2.8%)	0.0 (0%)	
Education			.76
<High school	154 (43.9%)	20 (38.5%)	
=High school	103 (29.3%)	17 (32.7%)	
>High school	94 (26.8%)	15 (28.8%)	
Annual household income			.48
<$6000	84 (23.9%)	9 (17.3%)	
$6000–$18 000	191 (54.4%)	28 (53.9%)	
>$18 000–$36 000	60 (17.1%)	13 (25.0%)	
>$36 000	16 (4.6%)	2 (3.8%)	
18≤ Age <40 years	149 (42.5%)	18 (34.6%)	.28
Age ≥40 years	202 (57.5%)	34 (65.4%)	
Duration on antiretroviral medication			N/A
<1 year	55 (15.7%)	N/A	
≥1 year	296 (84.3%)	N/A	
Mean (±SD) CD4 count	459.3 ± 263.3	N/A	
Alcohol consumption			.13
Abstainer	199 (56.7%)	22 (42.3%)	
1–7 drinks/week	120 (34.2%)	25 (48.1%)	
>7 drinks/week	32 (9.1%)	5 (9.6%)	
Currently smoking	158 (45.0%)	30 (57.7%)	.09
Diabetes	54 (15.4%)	11 (21.2%)	.29
Mean (±SD) BMI	28.6 ± 7.3	32.4 ± 9.6	.001
Underweight/normal	124 (35.33%)	13 (25.0%)	
Overweight	109 (31.1%)	11 (21.2%)	
Obese	118 (33.6%)	28 (53.8%)	
Periodontitis			
Prevalence	267 (76.0%)	36 (69.2%)	.29
Severe	21 (6.0%)	3 (5.8%)	.64
Moderate	139 (39.5%)	21 (40.4%)	
Mild	107 (30.5%)	12 (23.0%)	
None	84 (24.0%)	16 (30.8%)	

BMI, body mass index; N/A, not applicable; SD, standard deviation; WLWH, women living with HIV; WRH, women at risk for HIV.

TABLE 2 Odds ratios (and 95% confidence intervals) assessing the associations between BMI and periodontitis severity among WLWH and WRH (full sample). Participants with "none periodontitis" were included as reference. The multinomial logistic regression model was adjusted for study sites, race/ethnicity, education, annual household income, age, smoking, alcohol consumptions, and diabetes

	Mild periodontitis	Moderate periodontitis	Severe periodontitis
Underweight/normal (reference)	1.0	1.0	1.0
Overweight	0.70 (0.31–1.58)	0.85 (0.38–1.90)	0.30 (0.08–1.15)
Obese	1.14 (0.51–2.52)	1.02 (0.46–2.29)	0.24 (0.06–1.07)

BMI, body mass index; WLWH, women living with HIV; WRH, women at risk for HIV.

TABLE 3 Odds ratios (and 95% confidence intervals) assessing the associations between BMI and periodontitis severity in WLWH subset. Participants with "no periodontitis" were included as reference. The multinomial logistic regression model was adjusted for study sites, race/ethnicity, education, annual household income, age, smoking, alcohol consumptions, diabetes, CD4 count, and duration on ART

	Mild periodontitis	Moderate periodontitis	Severe periodontitis
Underweight/normal (reference)	1.0	1.0	1.0
Overweight	0.69 (0.32–1.49)	1.01 (0.49–2.10)	0.31 (0.07–1.27)
Obese	1.31 (0.60–2.86)	1.34 (0.62–2.87)	0.45 (0.11–1.88)

ART, antiretroviral therapy; BMI, body mass index; WLWH, women living with HIV.

small sample size which may have affected the power of the study, curbing the statistically significant association. Third, there are diverse opinions about use of BMI as an indicator for obesity. According to Kopelman, BMI may not be a good representation of obesity.[35] It does not account for overall fat distribution[35] and the validity of BMI as a measure of obesity decreases with age.[35,36] Therefore, representing abdominal obesity with waist circumference or waist-to-hip ratio in women may provide a more reliable metric of overall obesity than BMI. Finally, the study utilized a cross-sectional design that lacks temporality. Study of prevalent cases rather than incident cases can underestimate the magnitude of the association.[36]

Future studies should be conducted with a prospective design, investigating the association in a present-day population of PLWH, from a broader geographic area, and using alternative measures of obesity such as waist–hip ratio.

In conclusion, considering the complexities of the HIV disease, periodontal disease, and obesity, oral health care providers should educate and encourage patients with HIV infection to adapt a lifestyle that will foster a healthy weight and an adequate periodontal health.

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