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The association of periodontal disease and cardiovascular disease risk: Results from the Hispanic Community Health Study / Study of Latinos

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Abstract

Background—Current evidence suggests that periodontal disease (PD) is associated with a significant increased risk of atherosclerotic cardiovascular disease (CVD) independent of known confounders. PD is a chronic oral disease with significant variation in prevalence demonstrated among Hispanic/Latino subgroups. The purpose of this study was to investigate the associations between PD and CVD risk and variations with sex, age, and Hispanic/Latino background.

Methods—The sample included 7,379 participants aged 30–74 years, from the Hispanic Community Health Study/Study of Latinos (2008 to 2011). We assessed CVD risk by the Framingham 10-year general CVD risk score (FGRS). PD severity classification was based upon

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Conflicts of Interest

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calibrated measurements of gingival recession and probing depth. Multivariable sequential linear models for complex sample design assessed FGRS by PD severity, Hispanic/Latino background, and covariates.

Results—The prevalence of moderate and severe PD combined was 46%. For women and men with severe PD, the combined prevalence of moderate and high CVD risk was 44% and 85%, respectively. The FGRS observed for women (5.1% (95% CI: 4.1%, 6.0%), $p < 0.001$) and men 10.8% (95% CI (9.2%, 12.3%), $p < 0.001$) with severe PD were 56% and 134% greater than those without PD, respectively. Dominican women and men with moderate or severe PD, aged 60–69 years, exhibited the greatest CVD risks (FGRS = 15.1%, 95% CI (7.8%, 22.5%)) and (FGRS = 40.2%, 95% CI (30.2%, 50.3%)), respectively.

Conclusions—Moderate and severe PD were associated with significant CVD risk with marked sex disparity and heterogeneity by Hispanic/Latino background.

Keywords

periodontal diseases; cardiovascular diseases; risk factor(s); Hispanic Americans; epidemiology; cross-sectional studies

Introduction

Current evidence suggests that periodontal disease (PD) is associated with a significant increase in the risk of atherosclerotic cardiovascular disease (CVD) that is independent of known confounders.^{1–3} Periodontal disease (PD) is a prevalent chronic inflammatory disease of the oral cavity involving the gingiva, connective tissue, and alveolar bone supporting the teeth.⁴ Connective tissue and alveolar bone destruction due to PD results from inflammatory and host responses to pathologic oral bacteria and bacterial byproducts. The soft and hard tissue destruction due to PD is cumulative and can lead to tooth loss. Plausible biologic mechanisms linking PD to CVD involve both direct and indirect mechanisms.^{3, 5} Direct mechanisms include PD-induced bacteremia and the role of periodontal bacterial pathogens in vascular infection.^{6, 7} Indirect mechanisms are based upon the association of PD with systemic inflammation, a predictor of cardiovascular events,^{8, 9} and molecular mimicry, wherein, an immune cross-reactivity response to periodontopathic bacterial components are thought to cause endothelial damage related to atherosclerotic vascular disease.^{10, 11}

The Framingham 10-year general CVD risk score (FGRS) is a sex-specific, validated assessment of general CVD risk that predicts the risk of developing “any and all initial atherosclerotic CVD events” defined by a composite of outcomes that include coronary death, myocardial infarction, ischemic stroke, hemorrhagic stroke, transient ischemic attack, peripheral artery disease, and heart failure.¹² PD is known to be independently associated with these CVD outcomes predicted by the FGRS.^{13–15} The CVD risk factors used in computing the FGRS, including age, diabetes, smoking, total cholesterol, and HDL, are also independently associated with PD.^{16–18} The associations of PD with both the Framingham outcomes and risk factors suggest that PD may be a reasonable determinant to inform CVD risk.

PD affects nearly one-half of the U.S. adult population¹⁹ and Mexican Americans exhibit the highest prevalence compared to non-Hispanic whites and non-Hispanic Blacks.¹⁹ Jiménez et al.,²⁰ and Sanders et al.²¹ have recently demonstrated significant variation in PD prevalence among Hispanic/Latino subgroups. These studies reported that the lowest prevalence of moderate and severe PD combined was found among Dominicans and the highest prevalence among Cubans.^{20, 21}

Previous research exploring association between PD and CVD among the Hispanic/Latino population has predominantly involved studies among Mexican Americans alone^{19, 22} or among “Hispanics” defined as a homogeneous group.²³ As such, knowledge of the relationship between PD and CVD risk, and whether the association varies by Hispanic/Latino background groups remains incomplete. Given the high prevalence of PD and CVD, their respective morbidities, and the substantial impact on public health resources,^{24, 25} it is important to understand these associations among Hispanics/Latinos. Therefore, the objectives of this study were to investigate the associations between PD and CVD risk and whether these associations vary by sex, age, and Hispanic/Latino background groups.

Methods

Study design, setting, and participants

The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a longitudinal, multi-center, population-based, prospective cohort study designed to examine the prevalence of multiple chronic health conditions, disease risk, and protective factors among U.S. Hispanics/Latinos. HCHS/SOL study design and cohort selection have been previously described.^{26, 27} In short, a stratified two-stage area probability sampling design was used to select households in census tracts districts adjoining the four U.S. field centers (Chicago, Miami, Bronx, San Diego). The present study is based upon cross-sectional study data from the baseline examinations that occurred between 2008 and 2011, wherein 16,415 self-identified Hispanic/Latino individuals aged 18–74 years were recruited from field centers, that represent diverse regions of the U.S., each with high concentrations of specific Hispanic/Latino national/regional backgrounds.²⁸

HCHS/SOL sampling weights were adjusted for nonresponse to allow generalization to non-institutionalized Hispanic/Latino adults residing in the four community areas sampled and calibrated to the 2010 U.S. Census by age, sex, and Hispanic/Latino background.²⁷ Our analyses included all individuals between the ages of 30–74 years who completed the baseline examinations and the periodontal examination (n=14,048; 86%), had laboratory-based values necessary to calculate the FGRS (n=13,326; 81%), and complete values for all covariates (n=10,428; 64%). Those with prevalent CVD, defined by the Framingham Heart Study¹² (n=3,049; 19%), were excluded. The final analytic sample included 7,379 (45%) participants.

The HCHS/SOL was conducted under the oversight and approval of the Institutional Review Boards (IRB) at the following participating institutions that served as the regional field centers: Albert Einstein College of Medicine/Montefiore Medical Center; Feinberg School of Medicine, Northwestern University; University of Miami; San Diego State University;

and the HCHS/SOL Coordinating Center at the University of North Carolina. All participants provided written informed consent prior to data collection.

CVD Risk Assessment - Framingham 10-year general CVD risk score (FGRS)

CVD risk was assessed by the **FGRS**, the dependent variable in our study. FGRS is a continuous variable based upon the Framingham Study criterion that includes laboratory-based lipid values.¹² The FGRS follows the Framingham Heart Study definition that predicts the 10-year risk of general CVD as a composite of *Coronary Heart Disease* (including: coronary death, myocardial infarction, coronary insufficiency, and angina), *Cerebrovascular Events* (including: ischemic stroke, hemorrhagic stroke, and transient ischemic attack), *Peripheral Artery Disease* (intermittent claudication), and *Heart Failure*.¹² Categorization of FGRS into **CVD risk groups** followed the scheme of D'Agostino et al.,²⁹ (i.e., low CVD risk 0% to ≤ 6%; moderate CVD risk > 6% to ≤ 20%; and high CVD risk > 20%).

Periodontal examination and periodontal disease severity

Certified dental examiners assigned among the four field centers, accompanied by a trained data recorder, conducted the periodontal examinations. One reference examiner, who had participated in the National Health and Nutrition Examination Survey, calibrated the periodontal measurements and probing techniques each of the three years of the baseline examinations. The mean interclass correlation coefficient, percent agreement, and Kappa statistic (κ) for periodontal probing depth measures accurate to ± 1 mm, were 0.95 (range: 0.90–0.96), 95.8 (range: 92.1–96.7), and 0.94 (range: 0.88–0.96), respectively, across all examiners and the reference examiner. Similarly, for clinical attachment level measures accurate to ± 1 mm, the interclass correlation coefficient, percent agreement, and Kappa statistic (κ) were 0.86 (range: 0.56–0.93), 92.8 (range: 84.3–98.2), and 0.84 (range: 0.88–0.96), respectively, across all examiners and the reference examiner.

Gingival recession and periodontal probing depth were measured at six sites per tooth (distal-facial, midfacial, mesial-facial, mesial-lingual, midlingual, and distal-lingual) on all fully erupted permanent teeth, excluding third molars. The measurements were used to calculate the clinical attachment level, a measure that indicates the magnitude of connective tissue destruction. Periodontal probing depth and clinical attachment level measurements were used to define PD severity as normal (no PD), mild, moderate, or severe, based upon the most recent grading guidelines of the Centers for Disease Control and Prevention and the American Academy of Periodontology.¹⁹ Study participants who were edentulous or who required antibiotic prophylaxis prior to the periodontal examination were excluded.

Interviews - Baseline Clinical Examinations – Laboratory Assays

Participants self-described as of Dominican, Central American, Cuban, Mexican, Puerto Rican, South American, or more than one heritage/other. Demographic characteristics, smoking status (never, former, or current), and time since last dentist visit (< 1 year, 1 to ≤ 5 years, > 5 years) were self-reported. Acculturation was measured by nativity status (U.S. born or foreign born), language preference (Spanish or English), and for foreign-born participants, the length of time residing in U.S. (<10, 10 to 19, and ≥ 20 years). Body mass index (BMI) was calculated by direct measurement of height to the nearest 1.0 cm and body

weight to the nearest 0.1 kg. BMI was categorized using National Heart, Lung, and Blood Institute (NHLBI/NIH) guidelines: underweight or normal ($<18.5 - 24.9 \text{ kg/m}^2$); overweight ($25.0 - 29.9 \text{ kg/m}^2$); and obese ($\geq 30 \text{ kg/m}^2$).³⁰ Waist and hip circumference were measured to the nearest 1.0 cm, and sex-specific at-risk waist-hip ratio was dichotomized at values ≥ 0.85 for women and ≥ 0.90 for men.³¹ Blood pressure was recorded as the average of three seated measurements. Hypertension was defined according to NHLBI criteria,³² as a systolic blood pressure of 140 mm Hg or above, or a diastolic blood pressure of 90 mm Hg or above, or currently taking medication to lower blood pressure.

All blood specimens were analyzed at the University of Minnesota Medical Center-Fairview (Minneapolis, MN) using standardized laboratory procedures and equipment.³³ Blood assays included white blood cell count (WBC) (count $\times 10^3$ cells/ μL), high-sensitivity C-reactive protein (hs-CRP) (mg/L), total cholesterol (mg/dL), high-density lipoprotein (HDL) (mg/dL), and triglycerides (mg/dL). Standard reference ranges for blood assays: WBC ($4.5 - 10.0 \times 10^3$ cells/ μL); hs-CRP risk cutoffs (low risk $< 1.0 \text{ mg/L}$; intermediate risk $1.0 - 3.0 \text{ mg/L}$; high risk $> 3.0 \text{ mg/L}$); total cholesterol (target $< 200 \text{ mg/dL}$); HDL (target $> 60 \text{ mg/dL}$); triglycerides (normal $< 150 \text{ mg/dL}$; borderline high $150 - 199 \text{ mg/dL}$; high $> 200 \text{ mg/dL}$).^{34, 35} The classification of diabetes condition (non-diabetic, pre-diabetic, diabetic) followed the American Diabetes Association definition based upon serum assays and a self-report of diabetes.³⁶

Statistical Analysis

Analyses used survey methods for complex sampling designs with appropriate strata, primary sampling unit, and sampling weights. The analyses were conducted using statistical software for complex sampling designs.^{††} Univariate analyses provided summary statistics of overall population characteristics and cross-tabulation of population characteristics with CVD risk groups stratified by sex. A series of multivariable linear regression models assessed the degree to which covariate blocks accounted for the variance and impacted the strength of association of PD with FGRS. The covariate blocks were entered sequentially into successive models in a hierarchical fashion. The first block entered represented Hispanic/Latino background (Model 1), followed by acculturation (Model 2), next were socioeconomic factors and utilization of oral health care services (Model 3), and the fully adjusted model included known CVD risk factors (Model 4). Throughout we used the estimated least square mean FGRS to describe the magnitude of CVD risk. Lastly, stratification of the multivariable analyses was performed by domain analysis for sex, age, and Hispanic/Latino background groups, in order to permit valid estimation of sample variance. P-values were not adjusted for multiple comparisons.

Results

Table 1 presents the overall descriptive statistics, as well as the unadjusted estimated population characteristics stratified by sex and CVD risk groups. The study population was primarily less than 50 years of age (71%), almost equally distributed by sex, and

^{††}SAS 9.4 software (SAS Institute, Cary, NC) and SUDAAN software Release 11.0.1 (RTI International, Research Triangle Park, NC).

predominantly of Mexican background (42%). The majority of the individuals were foreign born (85%) and preferred speaking Spanish (82%), but had lived in the U.S. 10 years or longer (71%). More than half of the study population had no more than a high school education and almost three-quarters reported an annual income of \$40,000 or less.

The estimated prevalence of moderate and severe PD combined was 46%. The mean WBC was within recognized reference levels, but the mean hs-CRP was above the risk threshold. More than 81% of the target population was overweight or obese and 78% exhibited sex-specific waist to hip ratios at or above “at-risk” thresholds. Mean total cholesterol was borderline high, while the mean HDL cholesterol was normal. Just over half of the study population was pre-diabetic or diabetic, almost two-thirds were lifetime non-smokers, and the mean untreated systolic blood pressure was within a normal range. The combined prevalence of moderate and high CVD risk among men (54%) was more than double the risk among women (26%). For women and men with moderate PD, the combined prevalence of moderate and high CVD risk was 35% and 62%, and for those with severe PD, 44% and 85%, respectively. Additionally, the prevalence of CVD risk outcomes varied markedly by many of the population characteristics observed. For example, for both women and men the unadjusted prevalence of high CVD risk was highest among those who were the oldest, least educated, and those with the lowest incomes. This greater prevalence of high CVD risk was also observed among those who were foreign born, preferred to speak Spanish, had the longest U.S. residency, were diabetic, and current smokers.

Table 2a and 2b report sequential modeling of the association of PD severity with FGRS for women and men, respectively. After controlling for Hispanic/Latino background groups (Model 1), moderate and severe PD each were significantly associated with FGRS, with the model explaining 7.0% ($R^2 = 0.07$, $F_{[12, 634]} = 14.15$, $p < 0.001$) of the variance in FGRS for women and 10.0% ($R^2 = 0.10$, $F_{[12, 634]} = 18.22$, $p < .001$) for men. The FGRS for women with moderate, (6.6%, 95% CI (5.9%, 7.2%), $p < 0.001$), and severe, (7.3%, 95% CI (6.4%, 8.2%), $p < 0.001$), PD were nearly one-half the FGRS for men with moderate, (11.4% 95% CI (10.5%, 12.3%), $p < .001$), and severe, (15.8% 95% CI (14.5%, 17.2%) $p < 0.001$), PD. Each successive regression model (Models 2, 3, and 4) explained significant increases in the variance of FGRS associated with moderate or severe PD for women and men. Although the FGRS for moderate and severe PD for each sex was somewhat attenuated in the successive models, all remained statistically significant. The FGRS estimates in the fully adjusted Model 4 for women with moderate and severe PD were 4.7% (95% CI (4.1%, 5.4%), $p < 0.001$) and 5.1% (95% CI: 4.1%, 6.0%), $p < 0.001$), which were 46% and 56% greater, respectively, compared to women with no PD. The FGRS estimates for men with moderate and severe PD were 7.3% (95% CI (6.2%, 8.3%), $p < 0.001$) and 10.8% (95% CI (9.2%, 12.3%), $p < 0.001$), which were 58% and 134% greater, respectively, compared to men with no PD (Figure 1).

FGRS for both women and men in the fully adjusted Model 4 was significantly impacted by acculturation (Table 2a and 2b). For women, the estimated FGRS attributed to being U.S. born versus foreign-born was 3.1% (95% CI (2.3%, 3.9%)) vs. 5.1% (95% CI (4.6%, 5.7%)), a 39% difference ($p < 0.001$). Among foreign-born women, the FGRS increased as the duration of U.S. residency increased, with differences significant only for those residing in

the U.S. < 10 years (3.2%, 95% CI (2.4%, 3.9%)) compared to those with ≥ 20 years of residency (5.8%, 95% CI (5.4%, 6.3%), $p < 0.001$). Similarly, the FGRS for women preferring to speak English was 26% less than those who preferred speaking Spanish (3.5%, 95% CI (2.8%, 4.2%)) vs. (4.7%, 95% CI (4.1%, 5.3%), $p < 0.01$). Likewise, for men, the FGRS attributed to being U.S. born (4.1% 95% CI (2.7%, 5.6%)), was 57% less than being foreign-born (9.5% 95% CI (8.5%, 10.5%), $p < 0.001$). Among foreign-born men, the estimated FGRS also increased with increasing duration of U.S. residency from 3.7% (95% CI (2.4%, 5.0%)) for those residing in the U.S. < 10 years (referent) to 5.7% (95% CI (4.4%, 7.1%), $p < 0.001$) and 11.0% (95% CI (10.1%, 12.0%), $p < 0.001$) for those with 10 to < 20 years and ≥ 20 years of residency, respectively. Additionally, the FGRS for men preferring to speak English was 29% less than those who preferred speaking Spanish, (5.6%, 95% CI (4.3%, 7.0%)) vs. (8.0%, 95% CI (7.0%, 8.9%), $p < 0.001$), respectively. Lastly, the FGRS was also significantly greater for women and men with less than a high school education versus more education, those with more frequent dental visits versus less frequent, and those with sex specific “at-risk” waist-hip ratios versus those not at-risk.

For the fully adjusted model (Model 4), Table 3 and supplementary Figure 1 in the online *Journal of Periodontology* report the age-stratified differences in estimated FGRS by sex, across Hispanic/Latino background groups and the age- and sex-stratified FGRS for Hispanic/Latino background groups. Our analyses focused on those with moderate or severe PD, because normal periodontal health and mild PD were not significantly associated with FGRS. After adjusting for Hispanic/Latino background groups and covariates, there was a significant sex disparity in FGRS. Women exhibited significantly lower FGRS than men at each age stratum ($p < 0.001$). The differences in FGRS by sex across all Hispanic/Latino background groups ranged from 2.2% ($\Delta \text{FGRS}_{(\text{Men-Women})} = 2.2\%$, 95% CI (1.8%, 2.6%), $p < 0.001$) between ages 30–39 years to 14.3% ($\Delta \text{FGRS}_{(\text{Men-Women})} = 14.3\%$, 95% CI (11.5%, 17.1%), $p < 0.001$) between ages 60–69 years. Significant heterogeneity in FGRS by Hispanic/Latino background was observed for women at each age stratum, except ages 50–59 years, while significant differences for men were only observed between the ages of 60–69 years. The greatest CVD risks, for both women and men occurred between the ages of 60–69 years. For this age group, Dominican women and men each exhibited the largest FGRS (15.1%, 95% CI (7.8%, 22.5%) and 40.2%, 95% CI (30.2%, 50.3%), respectively). The smallest FGRS for those aged 60–69 years occurred for South American women (6.2%, 95% CI (1.4%, 11.0%)) and Central American men (23.2%, 95% CI (14.9%, 31.5%)). Although we found significant heterogeneity in FGRS by Hispanic/Latino background for both men and women with moderate or severe PD, Hispanic/Latino background was not a statistically significant moderator of the PD/FGRS association.

Supplementary Table 1 in the online *Journal of Periodontology* presents the significant differences in FGRS by Hispanic/Latino background groups, stratified by age and sex. The greatest differences in FGRS among Hispanic/Latino background groups occurred for both women and men aged 60–69 years. For this age group, the greatest differences observed in FGRS for women was between Dominicans and South Americans ($\Delta \text{FGRS}_{(\text{Dominican-South American})} = 8.9\%$, 95% CI (2.3%, 15.6%), $p = 0.009$) and for men, between Dominicans and Central Americans ($\Delta \text{FGRS}_{(\text{Dominican-Central American})} = 17.1\%$,

95% CI (8.2%, 26.0%), $p < 0.001$), respectively. The smallest observed difference for women was between Mexicans and South Americans ($\Delta \text{FGRS}_{(\text{Mexican-South American})} = 5.4\%$, 95% CI (0.5%, 10.3%), $p = 0.033$), and for men, between South Americans and Central Americans ($\Delta \text{FGRS}_{(\text{South American-Central American})} = 7.2\%$, 95% CI (0.1%, 14.4%), $p = 0.048$).

Discussion

D'Agostino et al.,²⁹ stated that the purpose of the FGRS “was to formulate a single multivariable risk assessment tool that would enable physicians to identify high-risk candidates for any and all initial atherosclerotic CVD events using measurements readily available at the clinic or office.” Our study extends this concept by providing dentists with supporting information to consider in the primary screening of Hispanic/Latino patients to similarly identify high-risk candidates, based upon routine PD examinations and health history. While current evidence does not support a causal relationship between PD and CVD,^{1–3} Tonetti et al.² suggest that dentists refer periodontal patients exhibiting other CVD risk factors for a physical examination if they have not been to a physician within the past 12 months. For physicians, our study informs the impact that PD status may have on CVD risk assessment for Hispanic/Latino patients.

Our study represents one of the first attempts to characterize the association between PD and CVD risk, assessed by FGRS, in a Hispanic/Latino population. The 10-year unadjusted prevalence of CVD risk outcomes for Hispanics/Latinos in this population-based, cross-sectional study varied markedly by PD severity, age, sex, Hispanic/Latino background, measures of acculturation, and socioeconomic status.

We found a significant association between moderate and severe PD and FGRS for both women and men. Our results are consistent with previous studies that have demonstrated independent associations of PD with individual CVD outcomes (e.g. myocardial infarction),^{14, 15} and with studies that have used proxies for either PD and/or CVD outcomes.^{37, 38} However, there appear to be no previous studies that have directly examined the PD-FGRS association. One study of obese patients by Pires et al.³⁹ reported higher Framingham scores for the prediction of coronary artery disease, for obese patients with PD compared to obese patients without PD. Their results were analogous to ours despite different operational definitions for PD and CVD risk than used in the present study.

Positive associations between moderate and severe PD and FGRS were found for men and women in sequential models controlling for Hispanic/Latino background, acculturation, sociodemographic factors, utilization of oral health care services, and known CVD risk factors. Our findings parallel those from studies in diverse populations (i.e., not exclusively Hispanic/Latino) linking PD to a significant increase in the risk of CVD independent of established CVD risk factors.^{1–3} Among Hispanic/Latino individuals with moderate or severe PD, measures of acculturation significantly impacted FGRS. Among foreign-born Hispanic/Latino women and men, the FGRS increased as the duration of U.S. residency increased. Yet, the FGRS of those residing in the U.S. less than 10 years was similar to those born in the U.S. This suggests that the significantly larger FGRS observed among Hispanic/

Latino immigrants residing in the U.S. 20 years or more was apparently not due to an initial CVD risk disparity. Similar observations describing the impact of acculturation on CVD and diabetes prevalence were reported by Daviglius et al.,⁴⁰ and Schneiderman et al.⁴¹

A secondary aim of this study was to examine whether the associations varied by sex and Hispanic/Latino background groups. Among individuals with moderate or severe PD, we found a significant sex disparity, whereby men exhibited greater FGRS at each age stratum (Table 3 and Figure 1). The differences by sex in FGRS across Hispanic/Latino background groups increased from 2.2% to 14.3% between 30–39 and 60–69 years of age. Our findings are consistent with Salinas et al.,⁴² who reported greater FGRS among Mexican men compared to women. Further, our findings parallel previous results from the HCHS/SOL that demonstrated greater prevalence of moderate and severe PD, and major CVD risk factors, among men compared to women.^{21, 40}

Among women and men with moderate or severe PD, we found marked heterogeneity in FGRS associated with Hispanic/Latino background. The heterogeneity in FGRS increased with age and was most pronounced for women and observed for men only between the ages of 60–69 years. For this age group, Dominican women and men each exhibited the largest FGRS's (15.1% and 40.2%, respectively). Moreover, in this age group, the magnitude of the FGRS observed for women and men of each Hispanic/Latino background constituted moderate and severe CVD risk. Clearly, for those with moderate or severe PD, the association of Hispanic/Latino background with CVD risk is complex and multifactorial. Many studies from the HCHS/SOL describe Hispanic/Latino background heterogeneity in recognized CVD risk factors, such as hypertension,⁴³ diabetes mellitus,^{41, 44} obesity,⁴⁴ smoking,^{44, 45} hypercholesterolemia,⁴⁴ dietary fat and red meat intake,⁴⁶ and electrocardiographic abnormalities.⁴⁷ Such findings underscore the complex interaction between Hispanic/Latino background and the clinical manifestation of CVD imposed by burden of multiple risk factors.

The strengths of our study include the large well-defined sample with reliable and valid measures of the FGRS and PD status that permitted objective analyses of the associations we examined. The probability sampling design permitted analyses across Hispanic/Latino background groups in a manner that minimized sampling bias. Limitations include the fact that covariates describing sociodemographic characteristics, smoking status, and utilization of oral health services relied upon self-report data that was potentially subject to differential recall. Also, the cross-sectional nature of the HCHS/SOL baseline data precludes statements of causation and temporality. An additional limitation is the absence of a validation study showing that the Framingham 10-year general CVD risk score has similar properties in Hispanic/Latino populations as in the original Framingham cohort; however, other studies^{42, 48, 49} have used the FGRS in Hispanic/Latino populations. The longitudinal data that will be available in the HCHS/SOL will provide important information towards this end.

Conclusion

This study presents the first findings of the association of PD severity and FGRS in a Hispanic/Latino population. Our results indicated that the Hispanic/Latino population is a

heterogeneous population with a varying, but significant, burden of CVD risk that is associated with PD. For those with moderate or severe PD, our study demonstrates a significant sex disparity in FGRS. Furthermore, among women and men with moderate or severe PD we found heterogeneity in FGRS associated with Hispanic/Latino background that increased across age strata. Future research exploring the impact of PD on systemic inflammatory biomarkers may provide insight into the indirect physiologic mechanisms underlying our findings. Most importantly, longitudinal research, through the addition of ongoing oral health examinations in studies like the HCHS/SOL, is required to enable next-step examination of causal relationships between PD and systemic disease burdens facing the Hispanic/Latino population, and support the development and testing of culturally appropriate preventive interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Findings

Moderate and severe periodontal disease were associated with significant cardiovascular disease risk with marked sex disparity and heterogeneity by Hispanic/Latino background.

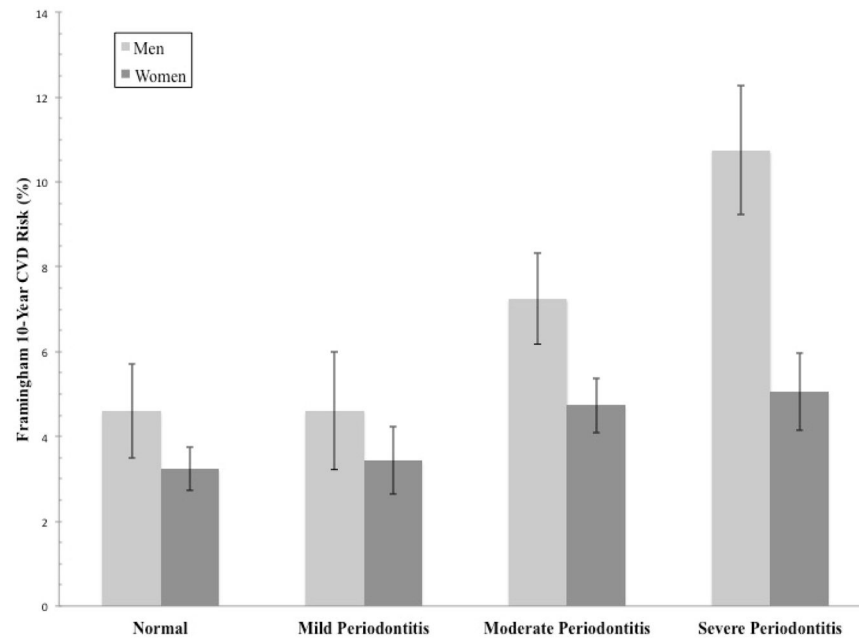


Figure 1.

Estimated least square mean Framingham 10-year General CVD Risk Score (CVD risk) and 95% CI from Model 4, adjusting for Hispanic/Latino background groups, acculturation, sociodemographic factors and utilization of dental services, and CVD risk factors. Pairwise contrasts in CVD risk for men and women, respectively, between all levels of periodontitis, except normal and mild periodontitis, were statistically significant ($p < 0.01$).

Table 1

Estimated population characteristics by CVD Risk Groups* (low, moderate, high) in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), United States 2008–2011 (N = 7379)†.

Characteristic	Total (N = 7379)		Women (N = 4382)			Men (N = 2997)		
	Col. Percent (95% CI)		Row Percent (95% CI)			Row Percent (95% CI)		
	Mean (SE)		Low CVD Risk (n = 2969)	Mod. CVD Risk (n = 1201)	High CVD Risk (n = 212)	Low CVD Risk (n = 992)	Mod. CVD Risk (n = 1440)	High CVD Risk (n = 565)
Gender								
Female	51.9 (50.2, 53.6)		74.3 (72.1, 76.5)	21.5 (19.5, 23.5)	4.2 (3.5, 5.0)	...	...	...
Male	48.1 (46.4, 49.8)		...	...	...	45.6 (43.1, 48.0)	41.0 (38.7, 43.3)	13.4 (12.0, 14.8)
Age								
18 – 29 years‡	...		...	...	...	...	...	...
30 – 39 years	38.4 (36.4, 40.5)		99.3 (98.9, 99.8)	0.7 (0.2, 1.1)	0.0 (0.0, 0.0)	84.7 (81.2, 88.1)	15.2 (11.8, 18.7)	0.1 (0.0, 0.2)
40 – 49 years	33.0 (31.4, 34.6)		86.4 (83.7, 89.1)	13.4 (10.7, 16.0)	0.3 (0.0, 0.5)	36.5 (32.0, 40.9)	59.0 (54.5, 63.6)	4.5 (3.0, 6.0)
50 – 59 years	17.9 (16.7, 19.1)		42.3 (38.1, 46.4)	51.3 (47.0, 55.7)	6.4 (4.6, 8.2)	3.0 (1.6, 4.4)	70.4 (66.4, 74.5)	26.5 (22.6, 30.5)
60 – 69 years	8.6 (7.6, 9.5)		9.2 (5.3, 13.0)	70.0 (63.3, 76.7)	20.8 (15.4, 26.3)	0.0 (0.0, 0.0)	28.6 (22.5, 34.7)	71.4 (65.3, 77.5)
70 – 74 years	2.1 (1.6, 2.7)		0.0 (0.0, 0.0)	56.1 (41.9, 70.4)	43.9 (29.6, 58.1)	0.0 (0.0, 0.0)	22.5 (5.5, 39.5)	77.5 (60.5, 94.5)
Education								
< High School	30.4 (28.5, 32.2)		68.6 (65.1, 72.2)	25.0 (21.9, 28.1)	6.4 (4.9, 7.9)	42.1 (37.4, 46.8)	38.8 (34.8, 42.8)	19.1 (16.1, 22.0)
High School or Equivalent	27.9 (26.2, 29.6)		79.8 (76.4, 83.2)	16.9 (13.7, 20.1)	3.3 (2.0, 4.6)	50.8 (46.2, 55.3)	39.9 (35.5, 44.4)	9.3 (7.1, 11.5)
> High School or Equivalent	41.8 (39.3, 44.2)		75.0 (71.4, 78.5)	21.8 (18.3, 25.2)	3.3 (1.9, 4.6)	44.4 (40.2, 48.5)	43.3 (39.5, 47.2)	12.3 (10.3, 14.3)
Household Income								
< \$10,000	11.3 (10.1, 12.6)		65.1 (58.6, 71.7)	28.9 (22.2, 35.6)	6.0 (3.7, 8.2)	39.5 (31.8, 47.2)	37.4 (30.6, 44.1)	23.1 (16.9, 29.4)
\$10,001 – 20,000	29.1 (27.1, 31.2)		74.2 (70.8, 77.7)	21.3 (18.1, 24.4)	4.5 (3.1, 5.9)	44.3 (39.6, 49.0)	40.9 (36.5, 45.4)	14.7 (11.8, 17.7)
\$20,001 – 40,000	32.3 (30.6, 34.1)		77.8 (74.1, 81.6)	18.9 (15.4, 22.3)	3.3 (1.9, 4.8)	49.2 (44.6, 53.7)	38.4 (34.2, 42.6)	12.4 (10.1, 14.8)
\$40,001 – 75,000	14.4 (13.0, 15.8)		78.6 (73.0, 84.2)	19.0 (13.5, 24.6)	2.3 (1.0, 3.7)	42.9 (36.7, 49.0)	48.7 (42.5, 54.9)	8.4 (5.3, 11.6)
> \$75,000	6.3 (4.3, 8.3)		87.9 (81.7, 94.1)	10.1 (4.7, 15.6)	2.0 (0.0, 4.3)	46.3 (34.0, 58.7)	44.6 (34.4, 54.8)	9.0 (4.0, 14.1)
Missing	6.5 (5.6, 7.4)		61.9 (55.8, 68.0)	30.0 (24.6, 35.4)	8.1 (4.8, 11.4)	47.4 (35.4, 59.4)	33.4 (22.5, 44.4)	19.1 (10.8, 27.5)

Characteristic	Total (N = 7379)		Women (N = 4382)			Men (N = 2997)		
	Col. Percent (95% CI)		Row Percent (95% CI)			Row Percent (95% CI)		
	Mean (SE)		Low CVD Risk (n =2969)	Mod. CVD Risk (n = 1201)	High CVD Risk (n = 212)	Low CVD Risk (n = 992)	Mod. CVD Risk (n = 1440)	High CVD Risk (n = 565)
Marital Status								
Single	22.9 (21.0, 24.8)		78.4 (73.7, 83.1)	18.6 (13.9, 23.3)	3.1 (1.9, 4.2)	60.4 (55.1, 65.6)	32.2 (27.0, 37.4)	7.4 (5.1, 9.8)
Married or living with a partner	60.1 (57.8, 62.4)		80.5 (78.2, 82.7)	16.6 (14.5, 18.7)	3.0 (2.1, 3.9)	42.8 (39.4, 46.1)	43.3 (40.2, 46.3)	14.0 (12.2, 15.7)
Separated, divorced, or widow(er)	17.0 (15.6, 18.3)		54.4 (49.4, 59.3)	36.9 (32.2, 41.6)	8.7 (6.1, 11.3)	30.5 (24.7, 36.3)	46.6 (40.3, 53.0)	22.9 (17.9, 27.9)
Hispanic Background								
Dominican	8.2 (6.8, 9.7)		78.6 (72.2, 84.9)	17.6 (12.1, 23.1)	3.8 (1.7, 5.9)	48.8 (39.3, 58.3)	39.7 (31.8, 47.5)	11.5 (6.8, 16.3)
Central American	7.4 (6.2, 8.6)		76.6 (72.2, 81.0)	18.0 (14.4, 21.7)	5.3 (2.9, 7.8)	48.8 (41.6, 56.1)	40.6 (33.4, 47.7)	10.6 (7.4, 13.8)
Cuban	21.2 (17.6, 24.8)		63.1 (58.0, 68.3)	28.7 (24.0, 33.5)	8.1 (5.5, 10.8)	36.8 (32.2, 41.4)	42.9 (38.6, 47.3)	20.3 (16.8, 23.8)
Mexican	42.1 (38.3, 45.9)		80.8 (78.4, 83.3)	16.9 (14.7, 19.0)	2.3 (1.5, 3.1)	49.5 (45.4, 53.7)	40.0 (36.1, 43.8)	10.5 (8.6, 12.3)
Puerto Rican	12.6 (11.0, 14.1)		61.9 (53.7, 70.0)	31.9 (23.3, 40.5)	6.2 (3.5, 8.9)	40.6 (33.0, 48.2)	46.0 (38.4, 53.6)	13.4 (10.1, 16.7)
South American	5.6 (4.8, 6.4)		71.2 (64.2, 78.2)	25.6 (18.8, 32.5)	3.1 (1.0, 5.3)	53.1 (45.1, 61.1)	35.9 (28.5, 43.2)	11.0 (7.1, 14.9)
More than one heritage / Other	2.9 (2.2, 3.7)		78.9 (66.8, 91.0)	19.1 (7.6, 30.5)	2.1 (0.0, 5.4)	57.7 (42.0, 73.4)	29.0 (15.5, 42.4)	13.3 (4.2, 22.5)
U.S. Born								
No	85.2 (83.5, 86.9)		72.5 (70.2, 74.8)	23.0 (20.9, 25.1)	4.5 (3.7, 5.4)	42.7 (40.0, 45.4)	42.1 (39.6, 44.7)	15.1 (13.6, 16.7)
Yes	14.8 (13.1, 16.5)		85.8 (81.9, 89.8)	11.8 (8.3, 15.3)	2.4 (0.3, 4.4)	60.1 (53.3, 66.9)	35.2 (28.8, 41.6)	4.7 (2.9, 6.6)
Years lived in the U.S.								
< 10	28.9 (26.5, 31.2)		80.0 (76.9, 83.0)	16.3 (13.6, 19.0)	3.7 (2.3, 5.2)	56.5 (52.2, 60.7)	34.1 (29.9, 38.3)	9.4 (7.0, 11.8)
10 to < 20	26.2 (24.5, 27.9)		81.6 (78.7, 84.6)	15.2 (12.6, 17.8)	3.2 (2.0, 4.4)	49.2 (43.8, 54.7)	39.5 (34.4, 44.6)	11.3 (8.5, 14.0)
≥ 20	44.9 (42.4, 47.5)		65.7 (61.7, 69.8)	29.0 (25.2, 32.7)	5.3 (4.0, 6.5)	37.2 (33.4, 40.9)	45.9 (42.4, 49.3)	17.0 (14.9, 19.1)
Language Preference								
Spanish	82.4 (82.4, 82.4)		73.4 (71.3, 75.5)	21.9 (20.1, 23.7)	4.6 (3.7, 5.5)	43.8 (41.0, 46.5)	41.0 (38.4, 43.6)	15.2 (13.6, 16.9)
English	17.6 (17.6, 17.6)		78.6 (71.1, 86.2)	19.1 (11.7, 26.6)	2.3 (0.6, 3.9)	53.3 (46.8, 59.8)	41.1 (34.9, 47.2)	5.6 (3.6, 7.6)

Characteristic	Total	Women			Men		
		Row Percent (95% CI), Mean (SE)			Row Percent (95% CI), Mean (SE)		
		Low Risk	Mod. CVD Risk	High CVD Risk	Low CVD Risk	Mod. CVD Risk	High CVD Risk
Field Center Site Location							
Bronx, NY	22.5 (19.6, 25.3)	75.7 (70.0, 81.4)	20.9 (15.4, 26.4)	3.4 (2.3, 4.5)	48.7 (43.2, 54.3)	39.6 (34.6, 44.7)	11.7 (9.1, 14.3)
Chicago, IL	15.8 (13.7, 18.0)	81.4 (78.4, 84.5)	16.1 (13.4, 18.7)	2.5 (0.9, 4.1)	49.7 (44.9, 54.5)	38.5 (34.1, 42.9)	11.8 (9.6, 14.0)
Miami, FL	31.4 (26.9, 35.9)	65.7 (61.7, 69.8)	27.1 (23.6, 30.5)	7.2 (5.2, 9.1)	39.9 (36.2, 43.6)	41.6 (37.7, 45.6)	18.4 (15.8, 21.1)
San Diego, CA	30.3 (25.9, 34.7)	77.9 (74.6, 81.2)	19.2 (16.2, 22.1)	2.9 (1.8, 4.1)	47.3 (42.2, 52.5)	42.7 (38.1, 47.3)	10.0 (7.8, 12.2)
Periodontitis Severity (CDC/AAP)[§]							
Normal	44.2 (42.3, 46.1)	81.0 (77.9, 84.1)	16.2 (13.3, 19.1)	2.8 (1.8, 3.8)	61.4 (57.5, 65.2)	30.6 (27.0, 34.2)	8.0 (6.2, 9.9)
Mild Periodontitis	9.8 (8.7, 10.8)	81.4 (77.1, 85.8)	15.0 (11.1, 19.0)	3.6 (1.4, 5.7)	58.3 (49.4, 67.3)	37.9 (29.4, 46.4)	3.8 (1.9, 5.6)
Moderate Periodontitis	35.9 (34.2, 37.7)	65.0 (61.4, 68.7)	28.6 (25.3, 32.0)	6.3 (4.7, 8.0)	38.5 (34.7, 42.2)	45.0 (41.2, 48.8)	16.5 (14.0, 19.1)
Severe Periodontitis	10.1 (9.1, 11.0)	56.1 (49.4, 62.9)	37.4 (30.7, 44.2)	6.5 (3.5, 9.4)	15.0 (10.9, 19.2)	59.3 (53.4, 65.1)	25.7 (21.2, 30.2)
Framingham Risk Score (%)	7.7 (0.2)	2.3 (0.0)	10.5 (0.2)	29.2 (0.8)	3.4 (0.1)	11.0 (0.2)	32.4 (0.7)
White Blood Cells (x10³/μL)	6.5 (0.0)	6.7 (0.1)	6.5 (0.1)	7.1 (0.2)	6.3 (0.1)	6.4 (0.1)	6.5 (0.1)
hs C-Reactive Protein (mg/L)[¶]	3.9 (0.2)	4.6 (0.4)	4.9 (0.3)	6.7 (1.3)	2.6 (0.2)	3.1 (0.2)	3.4 (0.3)
Cholesterol							
HDL (mg/dL)	48.7 (0.2)	52.9 (0.4)	51.5 (0.5)	48.8 (0.8)	45.8 (0.4)	43.9 (0.5)	42.5 (0.6)
Total (mg/dL)	202.7 (0.8)	191.0 (0.9)	223.1 (1.8)	244.3 (4.8)	196.5 (2.2)	211.9 (1.7)	216.3 (2.1)
Triglycerides (mg/dL)[#]	142.7 (1.8)	111.5 (1.7)	155.2 (3.5)	202.2 (13.3)	136.2 (4.3)	176.6 (5.2)	205.3 (8.5)
Diabetes Status							
Non-diabetic	45.5 (43.7, 47.3)	88.3 (85.8, 90.9)	11.0 (8.4, 13.5)	0.7 (0.3, 1.2)	62.0 (58.4, 65.7)	32.3 (28.9, 35.6)	5.7 (4.2, 7.2)
Pre-diabetic	41.5 (39.9, 43.2)	69.3 (65.8, 72.8)	26.9 (23.6, 30.2)	3.8 (2.5, 5.1)	39.5 (35.8, 43.2)	47.7 (44.1, 51.3)	12.8 (10.7, 14.8)
Diabetic	13.0 (11.9, 14.1)	36.9 (31.2, 42.6)	44.5 (39.1, 49.8)	18.6 (14.7, 22.5)	12.4 (8.2, 16.6)	46.6 (40.1, 53.2)	40.9 (34.9, 47.0)
BMI (kg/m²)							
Underweight/Normal (<18.5 – 24.9)	18.3 (17.1, 19.6)	83.6 (80.4, 86.8)	13.8 (10.9, 16.6)	2.7 (1.2, 4.1)	52.1 (46.8, 57.4)	33.5 (28.6, 38.4)	14.4 (10.9, 17.9)
Overweight (25.0–29.9)	42.3 (40.4, 44.2)	72.9 (69.8, 75.9)	23.2 (20.4, 25.9)	4.0 (2.7, 5.2)	45.9 (42.1, 49.7)	40.7 (37.2, 44.3)	13.3 (11.2, 15.5)
Obese (≥ 30)	39.4 (37.3, 41.4)	71.3 (67.4, 75.1)	23.5 (19.9, 27.1)	5.2 (3.9, 6.5)	41.9 (37.7, 46.2)	45.0 (40.9, 49.1)	13.1 (10.8, 15.4)
Sex Specific Waist-Hip Ratio^{**}							
Not at Risk	22.0 (20.6, 23.5)	82.6 (78.4, 86.8)	16.2 (12.1, 20.4)	1.2 (0.4, 1.9)	65.0 (59.5, 70.5)	27.9 (22.7, 33.0)	7.1 (4.7, 9.6)
At risk	78.0 (76.5, 79.4)	71.5 (68.9, 74.2)	23.2 (20.9, 25.5)	5.3 (4.3, 6.3)	41.0 (38.3, 43.7)	44.1 (41.5, 46.6)	14.9 (13.3, 16.5)

Characteristic	Total	Women			Men		
		Row Percent (95% CI), Mean (SE)			Row Percent (95% CI), Mean (SE)		
		Low Risk	Mod. CVD Risk	High CVD Risk	Low CVD Risk	Mod. CVD Risk	High CVD Risk
Systolic Blood Pressure (mm HG)	Col. Percent (95% CI)						
	Mean (SE)						
Not treated	118.3 (0.3)	110.9 (0.4)	131.4 (0.8)	151.9 (2.9)	117.5 (0.5)	124.8 (0.6)	138.7 (1.1)
Treated	131.3 (0.7)	115.7 (1.4)	131.1 (0.9)	147.2 (2.0)	122.2 (4.9)	127.9 (1.1)	138.2 (1.4)
Cigarette Use							
Never	61.0 (59.0, 62.9)	77.0 (74.5, 79.5)	19.3 (17.0, 21.6)	3.7 (2.8, 4.6)	58.0 (54.4, 61.6)	33.8 (30.6, 37.0)	8.2 (6.6, 9.8)
Former	19.5 (18.0, 21.0)	68.8 (63.9, 73.8)	26.7 (22.2, 31.2)	4.4 (2.1, 6.8)	39.2 (34.3, 44.0)	43.2 (38.6, 47.9)	17.6 (14.3, 20.9)
Current	19.5 (17.9, 21.2)	66.4 (59.6, 73.2)	26.9 (21.1, 32.7)	6.7 (4.0, 9.3)	26.7 (21.8, 31.7)	53.4 (48.2, 58.6)	19.9 (16.3, 23.4)
Dentist Visits (time since last visit)							
< 1Yr	50.4 (48.4, 52.3)	72.5 (69.7, 75.3)	22.6 (19.9, 25.2)	4.9 (3.8, 6.1)	44.7 (40.9, 48.4)	40.4 (37.1, 43.7)	15.0 (12.7, 17.2)
1Yr to ≤ 5Yrs	34.6 (32.9, 36.4)	76.1 (72.1, 80.0)	20.3 (16.7, 24.0)	3.6 (2.4, 4.8)	47.1 (42.9, 51.3)	42.2 (38.0, 46.5)	10.6 (8.5, 12.8)
> 5Yrs / Never	15.0 (13.7, 16.4)	77.2 (72.5, 82.0)	19.8 (15.2, 24.5)	2.9 (1.4, 4.5)	44.9 (39.2, 50.7)	40.3 (35.0, 45.7)	14.7 (11.5, 18.0)

* Framingham 10-Year General CVD Risk Score cutoffs for CVD risk groups: Low CVD risk (0% to ≤ 6%); Moderate CVD Risk (> 6% to ≤ 20%); High CVD risk > 20%.

[†] Unweighted sample size (N).

[‡] The Framingham Study criteria apply only to individuals aged 30–74 years.

[§] Periodontal disease severity grading guidelines established by the Centers for Disease Control and Prevention (CDC) and the American Academy of Periodontology (AAP).¹⁹

^{||} WBC- White blood cell count (x10³ cells/μL); White blood cells reference range: 4.5 – 10.0 (x10³cells/μL); Alert values: < 2 or > 25 (x10³cells/μL).

[¶] hs-CRP risk cutoffs: Low risk < 1.0 mg/L; Intermediate risk 1.0–3.0 mg/L; High risk > 3.0 mg/L.

[#] Triglyceride cutoffs: Normal < 150mg/dL; Borderline high 150–199 mg/dL; High > 200 mg/dL.

^{**} Sex specific Waist-Hip ratio is dichotomized at values ≥ 0.85 for women and values ≥ 0.90 for men, WHO, 2008.³¹

Table 2a

Framingham 10-Year General CVD Risk Score (FGRS) for women regressed upon periodontal disease severity and exposures in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) ($N_{\text{women}} = 4382$)[†], United States 2008–2011.

Covariates	Model 1		Model 2		Model 3		Model 4	
	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS
Periodontitis Severity (ref: Normal)								
Mild Periodontitis	p < 0.001\$	4.33 (3.90, 4.76)	p < 0.001\$	2.54 (2.09, 3.00)	p < 0.001\$	3.05 (2.53, 3.57)	p < 0.001\$	3.24 (2.73, 3.75)
Moderate Periodontitis	0.00 (0.00)	4.81 (3.94, 5.69)	0.00 (0.00)	2.81 (1.93, 3.69)	0.00 (0.00)	3.21 (2.33, 4.09)	0.00 (0.00)	3.44 (2.64, 4.24)
Severe Periodontitis	0.02 (0.00) ***	6.55 (5.93, 7.17)	0.02 (0.00) ***	4.42 (3.70, 5.14)	0.02 (0.00) ***	4.75 (4.04, 5.47)	0.01 (0.00) ***	4.73 (4.09, 5.38)
Hispanic Background (ref: Mexican)								
Dominican	0.03 (0.00) ***	7.32 (6.41, 8.24)	0.02 (0.00) ***	5.02 (4.04, 6.00)	0.02 (0.00) ***	5.13 (4.19, 6.06)	0.02 (0.00) ***	5.05 (4.14, 5.96)
Central American	p < 0.001\$	4.44 (3.96, 4.92)	p < 0.001\$	2.26 (1.59, 2.93)	p < 0.001\$	2.47 (1.79, 3.16)	p < 0.001\$	2.27 (1.63, 2.91)
Cuban	0.01 (0.01) *	5.86 (4.91, 6.82)	0.01 (0.01) *	3.60 (2.63, 4.56)	0.01 (0.01) *	3.94 (2.88, 4.99)	0.02 (0.01) ***	4.60 (3.55, 5.65)
Puerto Rican	0.01 (0.00)	5.27 (4.43, 6.11)	0.01 (0.00)	3.01 (2.12, 3.89)	0.01 (0.00) *	3.46 (2.57, 4.35)	0.01 (0.00) **	3.47 (2.62, 4.31)
South American	0.02 (0.01) **	6.79 (5.69, 7.89)	0.03 (0.01) ***	5.02 (3.96, 6.07)	0.03 (0.01) ***	5.43 (4.37, 6.49)	0.03 (0.01) ***	5.58 (4.57, 6.58)
More than one heritage / Other	0.03 (0.01) ***	7.88 (6.84, 8.92)	0.04 (0.01) ***	5.89 (4.94, 6.84)	0.04 (0.01) ***	5.98 (5.07, 6.89)	0.04 (0.00) ***	5.90 (5.04, 6.77)
U.S. Born (ref: foreign-born)								
Yes	0.01 (0.01) *	5.46 (4.60, 6.31)	0.01 (0.00) *	3.50 (2.59, 4.41)	0.01 (0.00) **	3.86 (2.92, 4.81)	0.02 (0.00) ***	4.01 (3.12, 4.89)
Years lived in the U.S. (ref: < 10 yrs.)								
10 to < 20 yrs.	0.00 (0.01)	4.57 (3.15, 5.99)	0.00 (0.01)	2.62 (1.04, 4.20)	0.01 (0.01)	3.10 (1.68, 4.52)	0.01 (0.01)	2.98 (1.37, 4.59)
≥ 20 yrs.	p < 0.001\$	5.20 (4.64, 5.76)	p < 0.001\$	5.20 (4.64, 5.76)	p < 0.001\$	5.27 (4.74, 5.80)	p < 0.001\$	5.14 (4.57, 5.70)
Language Preference (ref: English)								
Spanish	-0.03 (0.01) ***	2.20 (1.34, 3.05)	-0.03 (0.01) ***	2.20 (1.34, 3.05)	-0.02 (0.00) ***	2.80 (1.96, 3.64)	-0.02 (0.00) ***	3.09 (2.31, 3.88)
Education (ref: < High School)								
High School or Equivalent	p < 0.001\$	2.33 (1.53, 3.12)	p < 0.001\$	2.33 (1.53, 3.12)	p < 0.001\$	2.84 (2.05, 3.64)	p < 0.001\$	3.15 (2.40, 3.90)
> High School or Equivalent	0.01 (0.00)	2.88 (2.21, 3.55)	0.01 (0.00)	2.88 (2.21, 3.55)	0.00 (0.00)	3.29 (2.56, 4.02)	0.00 (0.00)	3.38 (2.72, 4.04)
Household Income (ref: < \$10,000)								
< \$10,000	0.04 (0.00) ***	5.89 (5.43, 6.34)	0.04 (0.00) ***	5.89 (5.43, 6.34)	0.03 (0.00) ***	5.97 (5.52, 6.43)	0.03 (0.00) ***	5.82 (5.36, 6.27)
\$10,000 to < \$20,000	p < 0.001\$	2.89 (2.12, 3.65)	p < 0.001\$	2.89 (2.12, 3.65)	p = 0.007\$	3.46 (2.73, 4.19)	p = 0.005\$	3.51 (2.80, 4.22)
> \$20,000	0.02 (0.00) **	4.51 (3.89, 5.13)	0.01 (0.00) *	4.51 (3.89, 5.13)	0.01 (0.00) *	4.61 (3.98, 5.24)	0.01 (0.00) **	4.72 (4.12, 5.32)
< High School	p < 0.001\$	5.02 (4.28, 5.76)	p < 0.001\$	5.02 (4.28, 5.76)	p < 0.001\$	5.02 (4.28, 5.76)	p = 0.002\$	4.94 (4.25, 5.63)
High School or Equivalent	-0.02 (0.00) **	3.50 (2.80, 4.19)	-0.02 (0.00) **	3.50 (2.80, 4.19)	-0.02 (0.00) **	3.59 (2.99, 4.19)	-0.01 (0.00) **	3.69 (3.03, 4.35)
> High School or Equivalent	-0.01 (0.00) **	3.59 (2.99, 4.19)	-0.01 (0.00) **	3.59 (2.99, 4.19)	-0.01 (0.00) **	3.59 (2.99, 4.19)	-0.01 (0.00) **	3.72 (3.16, 4.28)
Household Income (ref: < \$10,000)								
< \$10,000	p = 0.058\$	4.37 (3.60, 5.13)	p = 0.058\$	4.37 (3.60, 5.13)	p = 0.058\$	4.37 (3.60, 5.13)	p = 0.378\$	4.12 (3.40, 4.85)

Covariates	Model 1		Model 2		Model 3		Model 4	
	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS
\$10,001 – 20,000			0.00 (0.00)	3.91 (3.28, 4.54)	0.00 (0.00)	3.90 (3.27, 4.53)	0.00 (0.00)	3.90 (3.27, 4.53)
\$20,001 – 40,000			0.00 (0.00)	3.95 (3.26, 4.64)	0.00 (0.00)	3.95 (3.29, 4.62)	0.00 (0.00)	3.95 (3.29, 4.62)
\$40,001 – 75,000			–0.01 (0.00)	3.76 (2.91, 4.61)	–0.01 (0.00)	3.92 (3.11, 4.73)	0.00 (0.00)	3.92 (3.11, 4.73)
> \$75,000			–0.01 (0.01)	3.14 (2.21, 4.07)	–0.01 (0.01)	3.79 (2.81, 4.78)	0.00 (0.01)	3.79 (2.81, 4.78)
Missing			0.01 (0.01)	5.08 (4.06, 6.10)	0.01 (0.01)	5.01 (4.05, 5.97)	0.01 (0.01)	5.01 (4.05, 5.97)
Marital Status (ref: Single)			p < 0.001 [§]	2.67 (2.04, 3.31)	p < 0.001 [§]	2.85 (2.23, 3.46)	p < 0.001 [§]	2.85 (2.23, 3.46)
Married or living with a partner			0.01 (0.00) *	3.42 (2.83, 4.00)	0.01 (0.00) *	3.43 (2.87, 3.99)	0.01 (0.00) *	3.43 (2.87, 3.99)
Separated, divorced, or widow(er)			0.03 (0.00) ***	6.01 (5.15, 6.87)	0.03 (0.00) ***	6.07 (5.30, 6.85)	0.03 (0.00) ***	6.07 (5.30, 6.85)
Time since last dental visit (ref: < 1 yr.)			p < 0.001 [§]	4.73 (4.12, 5.34)	p < 0.001 [§]	4.77 (4.21, 5.32)	p < 0.001 [§]	4.77 (4.21, 5.32)
1Yr to ≤ 5 yrs.			–0.01 (0.00) **	3.89 (3.29, 4.50)	–0.01 (0.00) **	3.93 (3.35, 4.52)	–0.01 (0.00) **	3.93 (3.35, 4.52)
> 5 yrs. / Never			–0.01 (0.00) **	3.48 (2.76, 4.19)	–0.01 (0.00) **	3.65 (2.99, 4.31)	–0.01 (0.00) ***	3.65 (2.99, 4.31)
BMI (ref: Underweight / Normal)			p = 0.098 [§]		p = 0.098 [§]	3.73 (3.06, 4.40)	p = 0.098 [§]	3.73 (3.06, 4.40)
Overweight (25.0–29.9)					0.01 (0.00)	4.34 (3.74, 4.94)	0.01 (0.00)	4.34 (3.74, 4.94)
Obese (≥ 30)					0.01 (0.00)	4.28 (3.70, 4.85)	0.01 (0.00)	4.28 (3.70, 4.85)
Triglycerides (x10^{–3} mg/dL)					0.23 (0.03) ***	p < 0.001 [§]		p < 0.001 [§]
Waist-Hip Ratio Risk (ref: Not at risk)					p < 0.001 [§]	3.50 (2.91, 4.08)	p < 0.001 [§]	3.50 (2.91, 4.08)
At risk					0.01 (0.00) ***	4.73 (4.16, 5.31)	0.01 (0.00) ***	4.73 (4.16, 5.31)
Intercept	0.04 (0.00) **		0.01 (0.01)		0.02 (0.01) **	---	–0.02 (0.01) **	---
	Model 1		Model 2		Model 3		Model 4	
R² (ΔR², √ΔR²)	0.07 ***		0.12 (0.05, 0.22) ***		0.17 (0.05, 0.22) ***		0.26 (0.09, 0.30) ***	
F-Value	14.15		25.50		19.35		25.23	

* < 0.05,

** < 0.01,

*** < 0.001.

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[†]Unweighted Sample size (N).
[‡]Unstandardized linear regression coefficient (SE).
[§]p-Value for test of model effects.
^{||}FGRS - Least square mean Framingham 10-year general CVD risk score estimate, (95% CI).
Model 1 includes Hispanic/Latino background groups and adjusts for field center site location.
Model 2 adds adjustments for acculturation (nativity, years lived in the U.S., and language preference).
Model 3 adds adjustments for sociodemographic characteristics (education, income, marital status) and utilization of dental services.
Model 4 adds adjustments for CVD risk factors (BMI (kg/m²), triglycerides (mg/dL), waist-to-hip ratio, dichotomized for women at values ≥ 0.85, WHO, 2008).³¹

Table 2b

Framingham 10-Year General CVD Risk Score (FGRS) for men regressed upon periodontal disease severity and exposures in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) ($N_{\text{men}} = 2997$)[†], United States 2008–2011.

Covariates	Model 1		Model 2		Model 3		Model 4	
	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS
Periodontitis Severity (ref: Normal)								
Mild Periodontitis	p < 0.001\$	7.46 (6.81, 8.11)	p < 0.001\$	4.26 (3.51, 5.02)	p < 0.001\$	5.08 (4.00, 6.15)	p < 0.001\$	4.59 (3.49, 5.70)
Moderate Periodontitis	0.00 (0.01)	7.29 (6.12, 8.45)	-0.01 (0.01)	3.62 (2.33, 4.91)	-0.01 (0.01)	4.51 (3.02, 6.00)	0.00 (0.01)	4.60 (3.22, 5.98)
Severe Periodontitis	0.04 (0.01) ***	11.43 (10.54, 12.31)	0.03 (0.00) ***	7.44 (6.53, 8.36)	0.03 (0.00) ***	8.03 (6.99, 9.07)	0.03 (0.00) ***	7.25 (6.18, 8.33)
	0.08 (0.01) ***	15.82 (14.45, 17.18)	0.07 (0.01) ***	11.22 (9.84, 12.61)	0.06 (0.01) ***	11.42 (9.92, 12.92)	0.06 (0.01) ***	10.75 (9.23, 12.26)
Hispanic Background (ref: Mexican)								
Dominican	p = 0.083\$	9.76 (8.89, 10.64)	p < 0.001\$	5.29 (4.24, 6.34)	p < 0.001\$	5.94 (4.74, 7.13)	p < 0.001\$	5.34 (4.10, 6.58)
Central American	0.01 (0.01)	11.05 (9.17, 12.92)	0.02 (0.01)	6.99 (5.14, 8.84)	0.02 (0.01)	7.47 (5.56, 9.39)	0.02 (0.01) *	7.37 (5.45, 9.29)
Cuban	0.00 (0.01)	9.60 (8.38, 10.82)	0.00 (0.01)	5.00 (3.65, 6.35)	0.00 (0.01)	5.79 (4.22, 7.36)	0.00 (0.01)	4.87 (3.29, 6.46)
Puerto Rican	0.02 (0.01)	12.25 (10.46, 14.04)	0.03 (0.01) **	8.63 (6.83, 10.43)	0.03 (0.01) **	9.18 (7.27, 11.09)	0.03 (0.01) **	8.70 (6.77, 10.64)
South American	0.01 (0.01)	11.14 (9.92, 12.36)	0.03 (0.01) **	8.02 (6.79, 9.25)	0.03 (0.01) **	8.63 (7.32, 9.93)	0.03 (0.01) **	8.30 (7.00, 9.61)
More than one heritage / Other	0.00 (0.01)	9.87 (8.64, 11.09)	0.00 (0.01)	5.71 (4.25, 7.17)	0.01 (0.01)	6.46 (4.83, 8.10)	0.01 (0.01)	5.88 (4.24, 7.52)
	0.00 (0.01)	9.81 (7.27, 12.36)	0.02 (0.01)	6.83 (4.39, 9.27)	0.01 (0.01)	7.35 (4.78, 9.91)	0.02 (0.01)	7.11 (4.56, 9.67)
U.S. Born (ref: foreign-born)								
Yes			p < 0.001\$	9.42 (8.62, 10.22)	p < 0.001\$	9.70 (8.72, 10.68)	p < 0.001\$	9.46 (8.47, 10.45)
			-0.06 (0.01) ***	3.86 (2.66, 5.06)	-0.05 (0.01) ***	4.81 (3.39, 6.24)	-0.05 (0.01) ***	4.13 (2.69, 5.58)
Years lived in the U.S. (ref: < 10 yrs.)								
10 to < 20 yrs.			p < 0.001\$	3.50 (2.40, 4.60)	p < 0.001\$	4.05 (2.74, 5.37)	p < 0.001\$	3.65 (2.35, 4.95)
≥ 20 yrs.			0.02 (0.01) **	5.40 (4.21, 6.58)	0.02 (0.01) ***	6.24 (4.87, 7.61)	0.02 (0.01) ***	5.72 (4.35, 7.10)
			0.08 (0.01) ***	11.02 (10.25, 11.79)	0.07 (0.01) ***	11.48 (10.57, 12.40)	0.07 (0.01) ***	11.02 (10.05, 11.99)
Language Preference (ref: English)								
Spanish			p < 0.001\$	4.95 (3.79, 6.11)	p < 0.001\$	6.01 (4.64, 7.38)	p < 0.001\$	5.64 (4.26, 7.03)
			0.03 (0.01) ***	8.33 (7.54, 9.11)	0.03 (0.01) **	8.51 (7.53, 9.49)	0.02 (0.01) ***	7.95 (6.98, 8.93)
Education (ref: < High School)								
			p < 0.001\$		p < 0.001\$	8.15 (6.88, 9.43)	p < 0.001\$	7.59 (6.31, 8.87)

	Model 1		Model 2		Model 3		Model 4	
Covariates	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS	B (SE) [‡]	FGRS
High School or Equivalent								
> High School or Equivalent					-0.02 (0.01) ***	5.99 (4.79, 7.19)	-0.02 (0.01) ***	5.71 (4.50, 6.93)
Household Income (ref: < \$10,000)					-0.01 (0.01)	7.64 (6.65, 8.63)	-0.01 (0.01)	7.09 (6.09, 8.08)
\$10,001 – 20,000					p = 0.003\$	9.26 (7.40, 11.12)	p = 0.022\$	8.40 (6.48, 10.32)
\$20,001 – 40,000					-0.02 (0.01)	7.31 (6.31, 8.31)	-0.02 (0.01)	6.71 (5.68, 7.74)
\$40,001 – 75,000					-0.03 (0.01) **	6.47 (5.44, 7.49)	-0.02 (0.01) **	5.91 (4.90, 6.91)
> \$75,000					-0.03 (0.01) **	6.04 (4.83, 7.25)	-0.03 (0.01) **	5.73 (4.53, 6.92)
Missing					-0.03 (0.01) **	5.79 (3.94, 7.64)	-0.03 (0.01) *	5.85 (4.02, 7.68)
Marital Status (ref: Single)					-0.01 (0.01)	8.69 (6.48, 10.90)	0.00 (0.01)	8.20 (6.05, 10.34)
Married or living with a partner					p < 0.001\$	5.25 (4.28, 6.23)	p < 0.001\$	5.02 (4.00, 6.05)
Separated, divorced, or widow(er)					0.02 (0.01) ***	7.68 (6.58, 8.78)	0.02 (0.01) ***	7.01 (5.90, 8.12)
Time since last dental visit (ref: < 1 yr)					0.04 (0.01) ***	8.84 (7.19, 10.49)	0.03 (0.01) ***	8.36 (6.72, 9.99)
1 Yr to ≤ 5 yrs.					p = 0.048\$	8.03 (6.92, 9.14)	p = 0.050\$	7.55 (6.45, 8.64)
> 5 yrs. / Never					-0.01 (0.00) *	7.05 (5.91, 8.20)	-0.01 (0.00) *	6.59 (5.44, 7.75)
BMI (ref: Underweight / Normal)					-0.01 (0.01) *	6.69 (5.41, 7.97)	-0.01 (0.01) *	6.25 (4.93, 7.58)
Overweight (25.0–29.9)					p = 0.180\$		p = 0.180\$	7.30 (5.93, 8.66)
Obese (≥ 30)					0.00 (0.01)		0.00 (0.01)	6.91 (5.73, 8.09)
Triglycerides (x10 ⁻³ mg/dL)					-0.01 (0.01)		-0.01 (0.01)	6.19 (5.01, 7.36)
Waist-Hip Ratio Risk (ref: Not at risk)					0.18 (0.02) ***		0.18 (0.02) ***	p < 0.001\$
At risk					p < 0.001\$		p < 0.001\$	5.49 (4.27, 6.70)
Intercept	0.07 (0.00) ***		0.01 (0.01) **		0.04 (0.01) **		0.03 (0.00) ***	8.11 (7.09, 9.13)
							0.00 (0.01)	---
	Model 1		Model 2		Model 3		Model 4	

	Model 1	Model 2	Model 3	Model 4
Covariates	B (SE) [‡]	B (SE) [‡]	B (SE) [‡]	B (SE) [‡]
	FGRS	FGRS	FGRS	FGRS
$R^2 (\Delta R^2, \sqrt{\Delta R^2})$	0.10 ***	0.18 (0.08, 0.28) ***	0.21 (0.03, 0.17) ***	0.26 (0.05, 0.23) ***
F-Value	18.22	22.67	22.29	23.26

* < 0.05,

** < 0.01,

*** < 0.001.

[‡] Unweighted Sample size (N).

[‡] Unstandardized linear regression coefficient (SE).

[§] p-Value for test of model effects.

//FGRS - Least square mean Framingham 10-year general CVD risk score estimate, (95% CI).

Model 1 includes Hispanic/Latino background groups and adjusts for field center site location.

Model 2 adds adjustments for acculturation (nativity, years lived in the U.S., and language preference).

Model 3 adds adjustments for sociodemographic characteristics (education, income, marital status) and utilization of dental services.

Model 4 adds adjustments for CVD risk factors (BMI (kg/m²), triglycerides (mg/dL), waist-to-hip ratio, dichotomized for men at values ≥ 0.90, WHO, 2008).³¹

Table 3

Heterogeneity in Framingham 10-Year General CVD Risk Score (FGRS)[†] predicted by Hispanic/Latino background, stratified by sex and age, and FGRS[‡] differences by sex, stratified by age among participants with moderate or severe PD; FGRS[‡] (95% CI), United States 2008–2011 (N = 7379)[‡].

Gender	Age (yr.) [§]	Mexican	Central American	Cuban	Dominican	Puerto Rican	South American	>1 / Other	Overall
Female	30 – 39	1.2 (0.8, 1.6)	1.8 (1.2, 2.3)	2.0 (1.4, 2.6)	1.2 (0.3, 2.0)	2.5 (1.1, 3.8)	1.4 (0.8, 1.9)	2.0 (1.2, 2.7)	1.9 (3.6, 4.6) ***
	40 – 49 *	3.5 (2.6, 4.4)	4.6 (3.3, 5.9)	4.8 (3.5, 6.0)	4.8 (3.1, 6.4)	4.7 (3.7, 5.6)	4.3 (2.8, 5.7)	4.5 (3.1, 5.9)	4.4 (3.5, 5.3) ***
	50 – 59	6.6 (4.8, 8.4)	7.1 (4.9, 9.4)	8.8 (6.6, 11.0)	9.5 (5.6, 13.3)	8.0 (6.0, 10.0)	7.6 (4.5, 10.8)	7.9 (5.1, 10.6)	9.0 (7.2, 10.7) ***
	60 – 69 *	11.6 (6.8, 16.4)	12.9 (6.8, 18.9)	12.2 (7.2, 17.2)	15.1 (7.8, 22.5)	8.7 (3.4, 13.9)	6.2 (1.4, 11.0)	8.4 (3.4, 13.3)	13.1 (7.7, 18.5) ***
Male	30 – 39	3.3 (2.4, 4.3)	3.7 (2.8, 4.6)	4.0 (2.9, 5.2)	4.1 (2.5, 5.8)	4.9 (3.4, 6.4)	3.4 (1.9, 4.8)	5.0 (3.7, 6.2)	4.1 (3.6, 4.6) ***
	40 – 49	9.4 (7.7, 11.1)	8.3 (6.0, 10.7)	10.1 (8.2, 12.1)	8.2 (5.9, 10.6)	8.6 (7.3, 9.9)	9.2 (6.4, 11.9)	8.2 (5.5, 10.8)	8.9 (7.9, 9.8) ***
	50 – 59	18.9 (15.9, 21.9)	15.5 (11.6, 19.5)	17.5 (13.2, 21.9)	23.0 (17.5, 28.4)	19.5 (16.3, 22.6)	16.9 (12.6, 21.2)	23.3 (16.0, 30.6)	17.9 (16.1, 19.6) ***
	60 – 69 **	27.8 (21.0, 34.5)	23.2 (14.9, 31.5)	33.9 (25.7, 42.2)	40.2 (30.2, 50.3)	32.0 (24.0, 39.9)	30.4 (21.6, 39.1)	35.2 (24.7, 45.7)	27.4 (22.2, 32.6) ***
Age (yr.)		30 – 39		40 – 49		50 – 59		60 – 69	
Male vs. Female Δ FGRS [‡] (95% CI)		2.2 (1.8, 2.6) ***		4.5 (3.9, 5.2) ***		8.9 (7.7, 10.0) ***		14.3 (11.5, 17.1) ***	

* p < 0.05;

** p < 0.01,

*** p < 0.001

[†] FGRS - Least square mean Framingham 10-year general CVD risk score estimate, (95% CI); Least square means were not estimable at age ≥ 70 yrs. due to small cell sizes.

[‡] Unweighted Sample size (N).

[§] Tests of model effects for Hispanic/Latino background.

^{||} Tests of model effects for gender, across Hispanic/Latino Background groups.

[¶] Difference in Least square mean FGRS according to sex; Contrast (95% CI).

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Covariates: field center site location, acculturation (nativity, years lived in the U.S., and language preference), sociodemographic characteristics (education, income, marital status) and utilization of dental services, and CVD risk factors (BMI (kg/m²), triglycerides (mg/dL), waist-to-hip ratio, dichotomized for women at values ≥ 0.85 and for men at values ≥ 0.90 , WHO, 2008).³¹