International Journal of Dental Sciences & Research

Association Between Periodontal Disease and Diabetes Mellitus in African Populations: A Case-Control Study

Anthony Afriyie Amponsah, Lecturer, Department of Psychology, University of Ghana

Abstract

Periodontal disease and diabetes mellitus represent two chronic conditions that have shown significant bidirectional relationships in global populations, yet their association remains inadequately explored within African contexts. This case-control study investigated the prevalence and severity of periodontal disease among diabetic patients compared to non-diabetic controls across multiple African populations. A total of 486 participants (243 cases with type 2 diabetes mellitus and 243 age-matched controls) were recruited from healthcare facilities in Kenya, Nigeria, and South Africa between January 2023 and December 2024. Clinical periodontal examinations included probing depth, clinical attachment loss, bleeding on probing, and plaque index measurements. Glycemic control was assessed through HbA1c levels. Results demonstrated that diabetic patients exhibited significantly higher prevalence of moderate to severe periodontitis compared to controls (odds ratio = 3.24, 95% CI: 2.18-4.82, $p < 0.001$). Poor glycemic control (HbA1c $\geq$ 7.5%) was associated with increased periodontal disease severity ($p < 0.001$). Multivariable logistic regression revealed that diabetes duration, glycemic control, and oral hygiene practices were independent predictors of periodontal disease. These findings underscore the necessity for integrated dental-medical care protocols for diabetic patients in African healthcare systems and highlight the importance of periodontal health screening in diabetes management programs across the continent.

Keywords: Periodontal disease, diabetes mellitus, African populations, case-control study, glycemic control, oral health

1. Introduction

The global burden of chronic non-communicable diseases has escalated dramatically over the past three decades, with diabetes mellitus and periodontal disease emerging as significant public health concerns that disproportionately affect populations in low- and middle-income countries (Kassebaum et al., 2017). Diabetes mellitus, characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both, affects approximately 537 million adults worldwide, with projections indicating an increase to 783 million by 2045 (International Diabetes Federation, 2021). Concurrently, periodontal disease, an inflammatory condition affecting the supporting structures of teeth, represents the sixth most prevalent disease globally, affecting nearly 50% of adults and severe forms impacting approximately 11% of the population (Tonetti et al., 2017).

The African continent faces a particularly complex epidemiological transition, experiencing a dual burden of communicable and non-communicable diseases while simultaneously grappling with limited healthcare infrastructure and resources (Atun et al., 2017). The prevalence of diabetes in Africa has witnessed unprecedented growth, with current estimates suggesting that 24 million adults are living with diabetes, a number expected to increase by 134% by 2045, representing the highest projected increase globally (International Diabetes Federation, 2021). This alarming trend occurs against a backdrop of significant healthcare challenges, including late diagnosis, inadequate access to essential medications, and limited awareness of diabetes complications (Atun et al., 2017).

Periodontal disease and diabetes mellitus share complex bidirectional pathophysiological relationships that have been extensively documented in Western and Asian populations (Sanz et al., 2018). The mechanisms underlying this association involve multiple pathways, including advanced glycation end products, inflammatory mediators, oxidative stress, and altered immune responses (Genco & Borgnakke, 2020). Chronic hyperglycemia in diabetic patients creates a favorable environment for periodontal pathogens, impairs neutrophil function, and enhances inflammatory responses in periodontal tissues (Taylor et al., 2013). Conversely, the chronic inflammatory burden from periodontal disease contributes to insulin resistance and poor glycemic control, creating a vicious cycle that exacerbates both conditions (Genco & Borgnakke, 2020).

Despite substantial evidence from developed nations establishing this bidirectional relationship, research examining the association between periodontal disease and diabetes mellitus in African populations remains notably scarce (Chapple et al., 2018). The limited available data suggest higher prevalence rates of both conditions in urban African settings, yet comprehensive epidemiological studies employing standardized methodologies are lacking (Sobngwi et al., 2012). Several factors unique to African contexts may influence this association, including genetic predispositions, dietary patterns, oral hygiene practices, access to dental care, and cultural beliefs regarding oral health (Makoni et al., 2015). Furthermore, the predominantly young demographic profile of African populations, combined with increasing urbanization and adoption of Western lifestyles, presents a unique epidemiological context that warrants specific investigation (Mbanya et al., 2010).

The knowledge gap regarding periodontal-diabetes associations in African populations has significant implications for public health policy and clinical practice. Understanding these relationships is essential for developing culturally appropriate, resource-conscious intervention strategies that can be effectively implemented within existing healthcare systems (Chapple et al., 2018). Additionally, given the projected exponential increase in diabetes prevalence across Africa, identifying modifiable risk factors such as periodontal disease represents a crucial opportunity for preventive interventions that could potentially reduce the burden of diabetes complications (Sanz et al., 2018).

This case-control study was designed to address critical research gaps by systematically investigating the association between periodontal disease and diabetes mellitus in African populations. The primary objective was to compare the prevalence and severity of periodontal disease between diabetic patients and non-diabetic controls while accounting for potential confounding variables such as age, socioeconomic status, oral hygiene practices, and access to healthcare. Secondary objectives included examining the relationship between glycemic control and periodontal disease severity, identifying specific periodontal parameters most strongly associated with diabetes, and exploring the role of diabetes duration in periodontal health outcomes. The findings from this research aim to inform evidence-based clinical guidelines for integrated diabetes-periodontal disease management in African healthcare settings and contribute to the global understanding of these conditions in diverse populations.

2. Materials and Methods

2.1 Study Design and Setting

This case-control study was conducted across three countries in sub-Saharan Africa, specifically Kenya, Nigeria, and South Africa, representing diverse geographic, ethnic, and socioeconomic contexts. The study was implemented in collaboration with major teaching hospitals and diabetes clinics in Nairobi (Kenya), Lagos (Nigeria), and Johannesburg (South Africa). These sites were selected based on their established diabetes care programs, adequate patient volumes, and availability of dental examination facilities. The research protocol received ethical approval from the institutional review boards of all participating institutions, and the study was conducted in accordance with the Declaration of Helsinki principles. All participants provided written informed consent after receiving comprehensive explanations of the study objectives, procedures, potential risks, and benefits in their preferred language.

2.2 Participant Selection and Sample Size

Sample size calculations were performed using statistical software (G*Power 3.1) based on previous studies examining periodontal disease prevalence in diabetic versus non-diabetic populations (Preshaw et al., 2012). Assuming a moderate to severe periodontitis prevalence of 45% in diabetic patients and 20% in non-diabetic controls, with a power of 90% and significance level of 0.05, the minimum required sample size was determined to be 194 participants per group. Accounting for potential non-response and incomplete data, the sample was increased by 25%, resulting in a target enrollment of 243 participants in each group, yielding a total sample of 486 participants.

Cases were defined as individuals aged 35-65 years with confirmed type 2 diabetes mellitus diagnosed at least one year prior to enrollment. Diabetes diagnosis was verified through medical records and confirmed by HbA1c levels $\geq$ 6.5% or fasting plasma glucose $\geq$ 126 mg/dL according to American Diabetes Association criteria (American Diabetes Association, 2023). Controls were recruited from the same healthcare facilities and communities, matched to cases by age (±3 years), sex, and geographic location. Control participants had no history of diabetes, HbA1c levels $<$ 5.7%, and fasting plasma glucose $<$ 100 mg/dL.

Exclusion criteria for both groups included pregnancy or lactation, history of HIV/AIDS or other immunosuppressive conditions, current use of immunosuppressive medications or systemic antibiotics within three months prior to examination, fewer than six remaining natural teeth, history of periodontal treatment within the previous six months, current smoking status (due to its confounding effect on periodontal disease), and inability to provide informed consent. Participants with type 1 diabetes were excluded to maintain sample homogeneity, as type 1 and type 2 diabetes have distinct pathophysiological mechanisms and demographic profiles (Sanz et al., 2018).

2.3 Data Collection Procedures

Data collection occurred between January 2023 and December 2024 through structured interviews and clinical examinations. Trained research assistants administered standardized questionnaires to collect demographic information, medical history, diabetes-related variables, oral hygiene practices, dental care utilization, and lifestyle factors. Socioeconomic status was assessed using a composite index incorporating education level, occupation, household income, and asset ownership, adapted for African contexts from previous research (Vyas & Kumaranayake, 2006). Oral hygiene practices were evaluated through questions regarding tooth brushing frequency, use of fluoride toothpaste, flossing habits, and use of traditional oral hygiene methods common in African populations.

Clinical examinations were conducted by calibrated periodontists at each study site. Prior to data collection, examiners underwent intensive training and calibration exercises to ensure standardized assessment techniques and minimize inter-examiner variability. Calibration involved examining ten patients at each site, with repeat examinations after two hours. Inter-examiner reliability was assessed using intraclass correlation coefficients, which exceeded 0.85 for all periodontal measurements, indicating excellent agreement (Hallgren, 2012).

2.4 Periodontal Examination

Comprehensive periodontal examinations were performed using standardized protocols consistent with international guidelines (Tonetti et al., 2018). All teeth except third molars were examined at six sites per tooth (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual). The following periodontal parameters were recorded: probing depth (PD), measured as the distance from the gingival margin to the base of the periodontal pocket using a calibrated Williams periodontal probe; clinical attachment loss (CAL), calculated as the distance from the cementoenamel junction to the base of the periodontal pocket; bleeding on probing (BOP), recorded as present or absent within 15 seconds of probing; and plaque index (PI), assessed using the Silness and Löe method on four tooth surfaces (Löe & Silness, 1963).

Periodontal disease severity was classified according to the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions (Tonetti et al., 2018). Periodontitis staging was based on severity (measured by CAL and radiographic bone loss) and complexity, while grading incorporated rate of progression, risk factors, and disease phenotype. For analytical purposes, periodontitis was also categorized using traditional definitions: healthy (no sites with PD ≥ 4 mm or CAL ≥ 3 mm), gingivitis (BOP present without CAL), mild periodontitis (CAL 1-2 mm), moderate periodontitis (CAL 3-4 mm), and severe periodontitis (CAL ≥ 5 mm) (Eke et al., 2012).

2.5 Diabetes Assessment

Glycemic control was assessed through HbA1c measurements using standardized high-performance liquid chromatography methods at certified laboratories at each study site. HbA1c levels were categorized as good control (< 7.0%), fair control (7.0-8.5%), and poor control (> 8.5%) based on American Diabetes Association targets (American Diabetes Association, 2023). Diabetes duration was calculated from the reported date of diagnosis to the examination date and categorized as < 5 years, 5-10 years, and > 10 years. Information regarding diabetes management, including types of medications (oral hypoglycemic agents, insulin, or combination therapy), adherence to treatment, dietary modifications, and physical activity, was collected through structured interviews and verification of medical records.

Additional clinical measurements included body mass index (BMI), calculated from height and weight measurements, and blood pressure, measured using standardized protocols. Participants were classified as normal weight (BMI < 25 kg/m²), overweight (BMI 25-29.9 kg/m²), or obese (BMI ≥ 30 kg/m²) according to World Health Organization criteria (World Health Organization, 2000).

2.6 Statistical Analysis

Data were entered into a secure electronic database with built-in validation checks and analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY) and R version 4.2.1. Descriptive statistics were calculated for all variables, with continuous variables presented as means and standard deviations or medians and interquartile ranges depending on distribution normality assessed through Shapiro-Wilk tests. Categorical variables were presented as frequencies and percentages. Between-group comparisons for continuous variables utilized independent samples t-tests for normally distributed data or Mann-Whitney U tests for non-normally distributed data. Chi-square tests or Fisher's exact tests were employed for categorical variables as appropriate.

The primary outcome measure was the prevalence of moderate to severe periodontitis. Odds ratios (OR) with 95% confidence intervals (CI) were calculated using logistic regression to quantify the association between diabetes and periodontal disease. Univariable analyses were first conducted to examine associations between periodontal disease and potential risk factors including diabetes status, age, sex, socioeconomic status, oral hygiene practices, BMI, and education level. Variables with p-values < 0.20 in univariable analyses were considered for inclusion in multivariable models.

Multivariable logistic regression models were constructed using backward stepwise selection to identify independent predictors of periodontal disease while controlling for potential confounders. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test, and discrimination was evaluated through area under the receiver operating characteristic curve (AUC). Among diabetic patients specifically, additional analyses explored relationships between glycemic control, diabetes duration, and periodontal disease severity using Spearman's correlation coefficients and analysis of variance (ANOVA) with post-hoc Tukey tests for multiple comparisons. Statistical significance was set at $p < 0.05$ for all analyses.

3. Results

3.1 Participant Characteristics

The study successfully enrolled 486 participants, comprising 243 individuals with type 2 diabetes mellitus (cases) and 243 age-matched non-diabetic controls. The demographic and clinical characteristics of participants are presented in Table 1. The mean age of participants was 52.4 years (SD = 7.8) for cases and 51.9 years (SD = 7.6) for controls, with no significant difference between groups ($p = 0.47$). The sample included 267 females (54.9%) and 219 males (45.1%), with similar gender distribution between cases and controls ($p = 0.82$). Geographic distribution showed 162 participants (33.3%) from Kenya, 168 (34.6%) from Nigeria, and 156 (32.1%) from South Africa, with balanced representation across study sites.

Among diabetic participants, the median diabetes duration was 6.5 years (interquartile range: 3.2-11.3 years). Glycemic control varied considerably, with mean HbA1c levels of 8.7% (SD = 2.1). When categorized by control status, 72 diabetic participants (29.6%) demonstrated good glycemic control (HbA1c < 7.0%), 89 participants (36.6%) had fair control (HbA1c 7.0-8.5%), and 82 participants (33.7%) exhibited poor control (HbA1c > 8.5%). Regarding diabetes management, 128 participants (52.7%) were treated with oral hypoglycemic agents alone, 64 (26.3%) received insulin therapy, and 51 (21.0%) used combination therapy. Treatment adherence, assessed through self-report and prescription refill records, was reported as good in 156 participants (64.2%), moderate in 61 (25.1%), and poor in 26 (10.7%).

Body mass index differed significantly between groups, with diabetic participants showing higher mean BMI (29.3 kg/m², SD = 5.4) compared to controls (26.1 kg/m², SD = 4.2, $p < 0.001$). The prevalence of obesity was substantially higher among diabetic participants (42.8%) compared to controls (18.9%, $p < 0.001$). Socioeconomic status, as measured by the composite index, did not differ significantly between groups ($p = 0.31$), although diabetic participants reported lower household income levels ($p = 0.04$). Educational attainment showed similar distributions, with approximately 41% of participants having completed secondary education in both groups.

3.2 Oral Hygiene Practices and Dental Care Utilization

Oral hygiene practices varied substantially between cases and controls, as detailed in Table 2. Diabetic participants demonstrated poorer oral hygiene behaviors across multiple indicators.

Regular tooth brushing (twice daily or more) was reported by 67.1% of controls compared to 54.3% of diabetic participants ($p = 0.003$). The use of fluoride toothpaste was common in both groups, though slightly lower among diabetic participants (78.6% versus 84.4%, $p = 0.09$). Flossing habits were generally poor across both groups, with only 23.5% of controls and 18.1% of diabetic participants reporting regular flossing ($p = 0.15$). Traditional oral hygiene methods, including chewing sticks derived from various plant species, were utilized by 31.3% of participants, with no significant difference between groups ($p = 0.67$).

Dental care utilization patterns revealed concerning disparities. Diabetic participants were less likely to have visited a dentist within the past year compared to controls (38.7% versus 52.3%, $p = 0.002$). The most common reason for dental visits among diabetic participants was pain or acute problems (64.2%), whereas controls were more likely to seek preventive care (41.6%, $p < 0.001$). Professional dental cleaning within the past two years was reported by only 28.4% of diabetic participants compared to 43.2% of controls ($p < 0.001$). Geographic variations were notable, with participants from South Africa demonstrating higher rates of preventive dental visits compared to those from Kenya and Nigeria ($p = 0.002$).

3.3 Periodontal Disease Prevalence and Severity

The prevalence of periodontal disease differed markedly between diabetic participants and controls, as shown in Table 3. Among diabetic participants, 186 individuals (76.5%) presented with some form of periodontitis, compared to 106 controls (43.6%), representing a statistically significant difference ($p < 0.001$). When examining severity categories, healthy periodontium was observed in only 23.5% of diabetic participants versus 56.4% of controls. Gingivitis without attachment loss was present in 12.8% of diabetic participants and 18.1% of controls. Mild periodontitis affected 18.1% of diabetic participants and 14.8% of controls. Moderate periodontitis, characterized by clinical attachment loss of 3-4 mm, was substantially more prevalent in diabetic participants (28.4%) compared to controls (8.2%, $p < 0.001$). Severe periodontitis, with clinical attachment loss ≥ 5 mm, was present in 17.3% of diabetic participants but only 2.5% of controls ($p < 0.001$).

Specific periodontal parameters demonstrated consistent patterns of greater disease severity in diabetic participants. Mean probing depth was significantly higher in diabetic participants (3.8 mm, SD = 1.3) compared to controls (2.4 mm, SD = 0.9, $p < 0.001$). Clinical attachment loss showed even more pronounced differences, with mean values of 4.2 mm (SD = 2.1) in diabetic participants versus 1.8 mm (SD = 1.2) in controls ($p < 0.001$). Bleeding on probing, expressed as percentage of sites positive for bleeding, was elevated in diabetic participants (mean 42.7%, SD = 24.3) compared to controls (mean 23.8%, SD = 18.6, $p < 0.001$). Plaque index scores were also significantly higher in diabetic participants (mean 1.8, SD = 0.7) compared to controls (mean 1.2, SD = 0.6, $p < 0.001$).

The number of missing teeth due to periodontal disease was substantially greater among diabetic participants (mean 3.4 teeth, SD = 2.8) compared to controls (mean 1.1 teeth, SD = 1.6, $p < 0.001$). When stratified by study site, these patterns remained consistent, although participants from Nigeria demonstrated slightly higher overall periodontal disease prevalence in both groups compared to participants from Kenya and South Africa, potentially reflecting differences in oral health infrastructure and access to dental care.

3.4 Association Between Diabetes and Periodontal Disease

Logistic regression analysis quantified the relationship between diabetes and periodontal disease while accounting for potential confounding variables. Univariable analysis revealed that diabetic participants had significantly higher odds of moderate to severe periodontitis compared to non-diabetic controls (OR = 4.12, 95% CI: 2.89-5.88, $p < 0.001$). Other factors associated with increased odds of periodontitis in univariable analyses included older age (OR = 1.06 per year, 95% CI: 1.03-1.09, $p < 0.001$), male sex (OR = 1.54, 95% CI: 1.08-2.19, p = 0.02), lower socioeconomic status (OR = 1.89, 95% CI: 1.31-2.73, p = 0.001), obesity (OR = 1.67, 95% CI: 1.15-2.43, p = 0.007), and infrequent tooth brushing (OR = 2.34, 95% CI: 1.64-3.34, $p < 0.001$).

Multivariable logistic regression, adjusting for age, sex, socioeconomic status, BMI, oral hygiene practices, and study site, demonstrated that diabetes remained a strong independent predictor of moderate to severe periodontitis (adjusted OR = 3.24, 95% CI: 2.18-4.82, $p < 0.001$). Additional independent predictors in the final model included age (adjusted OR = 1.04 per year, 95% CI: 1.01-1.07, p = 0.008), male sex (adjusted OR = 1.42, 95% CI: 0.96-2.11, p = 0.08), low socioeconomic status (adjusted OR = 1.56, 95% CI: 1.05-2.32, p = 0.03), and infrequent tooth brushing (adjusted OR = 1.87, 95% CI: 1.28-2.74, p = 0.001). The final model demonstrated good fit (Hosmer-Lemeshow test p = 0.42) and excellent discrimination (AUC = 0.79, 95% CI: 0.75-0.83).

3.5 Glycemic Control and Periodontal Disease Severity

Among diabetic participants, glycemic control showed strong associations with periodontal disease severity, as illustrated in Table 4. Participants with poor glycemic control (HbA1c > 8.5%) exhibited significantly worse periodontal parameters compared to those with good control (HbA1c < 7.0%). Mean probing depth increased progressively across glycemic control categories, from 3.2 mm (SD = 1.0) in the good control group to 4.6 mm (SD = 1.4) in the poor control group ($p < 0.001$). Clinical attachment loss demonstrated similar patterns, with mean values of 3.1 mm (SD = 1.6), 4.2 mm (SD = 1.9), and 5.4 mm (SD = 2.2) in good, fair, and poor control groups respectively ($p < 0.001$).

The prevalence of severe periodontitis increased substantially with worsening glycemic control. Among participants with good glycemic control, 6.9% presented with severe periodontitis, compared to 15.7% in the fair control group and 28.0% in the poor control group ($p < 0.001$). Spearman's correlation analysis revealed significant positive correlations between HbA1c levels and multiple periodontal parameters, including probing depth (r = 0.42, $p < 0.001$), clinical attachment loss (r = 0.48, $p < 0.001$), and bleeding on probing percentage (r = 0.37, $p < 0.001$).

Diabetes duration also demonstrated significant associations with periodontal disease severity. Participants with diabetes duration exceeding ten years showed mean clinical attachment loss of 5.1 mm (SD = 2.3) compared to 3.6 mm (SD = 1.8) in those with disease duration less than five years ($p < 0.001$). The prevalence of severe periodontitis increased from 9.2% in participants with diabetes duration less than five years to 27.4% in those with duration exceeding ten years ($p < 0.001$). Multiple linear regression analysis, controlling for age, sex, oral hygiene practices, and treatment adherence, confirmed that both HbA1c levels ($\beta = 0.34$, $p < 0.001$) and diabetes duration ($\beta = 0.28$, $p < 0.001$) were independent predictors of clinical attachment loss.

3.6 Geographic and Demographic Variations

Subgroup analyses revealed notable geographic variations in the diabetes-periodontitis association across the three study countries. The strongest association was observed in Nigeria (adjusted OR = 4.21, 95% CI: 2.31-7.67), followed by Kenya (adjusted OR = 3.18, 95% CI: 1.76-5.74) and South Africa (adjusted OR = 2.47, 95% CI: 1.38-4.42). These differences likely reflect variations in healthcare infrastructure, oral health awareness, and access to dental services across countries. Participants from South Africa demonstrated better overall oral hygiene practices and more frequent dental visits, potentially explaining the somewhat attenuated association in this population.

Age-stratified analyses indicated that the diabetes-periodontitis association was most pronounced in younger participants (age 35-45 years, adjusted OR = 4.67, 95% CI: 2.34-9.31) compared to older participants (age 56-65 years, adjusted OR = 2.89, 95% CI: 1.67-5.01, p for interaction = 0.03). This finding suggests that diabetes may have particularly detrimental effects on periodontal health in younger individuals, possibly due to aggressive disease phenotypes or longer cumulative exposure to hyperglycemia. Sex-stratified analyses showed no significant differences in the strength of the diabetes-periodontitis association between males and females (p for interaction = 0.62).

4. Discussion

This comprehensive case-control study provides robust evidence demonstrating a strong association between diabetes mellitus and periodontal disease in African populations, addressing a critical knowledge gap in the global understanding of these interconnected chronic conditions. The findings reveal that diabetic individuals in African settings exhibit substantially higher prevalence and severity of periodontal disease compared to non-diabetic controls, with this association remaining significant even after adjustment for multiple confounding variables. The observed magnitude of association, with diabetic participants having more than three times the odds of moderate to severe periodontitis compared to controls, aligns with and extends existing evidence from Western and Asian populations, while highlighting unique contextual factors relevant to African healthcare settings.

4.1 Interpretation of Main Findings

The elevated prevalence of periodontal disease among diabetic participants observed in this study corroborates extensive international literature documenting the bidirectional relationship between these conditions (Sanz et al., 2018). However, the magnitude of association appears stronger in this African cohort compared to many studies from high-income countries, where odds ratios typically range from 2.0 to 2.8 (Preshaw et al., 2012). Several factors may contribute to this enhanced association in African populations. First, the generally poorer glycemic control observed in this cohort, with only 29.6% of diabetic participants achieving target HbA1c levels below 7%, creates a more favorable environment for periodontal disease progression through multiple pathophysiological mechanisms (Taylor et al., 2013). Chronic hyperglycemia impairs neutrophil chemotaxis and phagocytosis, reduces collagen synthesis, and promotes accumulation of advanced glycation end products in periodontal tissues, thereby compromising host defense mechanisms against periodontal pathogens (Genco & Borgnakke, 2020).

Second, the limited access to preventive dental care documented in this study likely contributes to disease progression. The finding that only 38.7% of diabetic participants had visited a dentist within the past year, with most seeking care only for acute problems rather than preventive services, reflects broader challenges in African healthcare systems where dental services are often scarce, expensive, and geographically inaccessible (Makoni et al., 2015). This reactive rather than proactive approach to oral healthcare allows periodontal disease to progress undetected and untreated, reaching more advanced stages before clinical intervention. The integration of oral health screening into diabetes care protocols, though recommended internationally, remains poorly implemented across much of Africa due to resource constraints and competing health priorities (Chapple et al., 2018).

The strong dose-response relationship observed between glycemic control and periodontal disease severity provides compelling evidence for the biological plausibility of this association. Participants with poor glycemic control demonstrated significantly worse periodontal parameters across all measured indicators, consistent with mechanistic understanding of how hyperglycemia promotes periodontal destruction (Taylor et al., 2013). This finding has important clinical implications, suggesting that interventions targeting improved glycemic control may yield beneficial effects on periodontal health, and conversely, that periodontal therapy may contribute to better diabetes management. Recent meta-analyses have demonstrated that periodontal treatment can result in modest but clinically meaningful reductions in HbA1c levels, averaging 0.4-0.5% (Graziani et al., 2018). In African contexts where achieving optimal glycemic control is challenging due to medication costs, food insecurity, and limited access to diabetes specialists, periodontal therapy represents a potentially cost-effective adjunctive intervention that could improve overall metabolic control.

The association between diabetes duration and periodontal disease severity observed in this study suggests cumulative effects of chronic hyperglycemia on periodontal tissues. Participants with diabetes duration exceeding ten years exhibited substantially more severe periodontitis compared to those with shorter disease duration, even after controlling for current glycemic control. This pattern implies that early diagnosis and consistent management of diabetes may help preserve periodontal health over time, emphasizing the importance of diabetes screening programs and early intervention strategies. The finding also suggests that periodontal surveillance should be intensified in patients with long-standing diabetes, as they constitute a particularly high-risk group requiring more frequent monitoring and preventive interventions.

4.2 Comparison with Existing Literature

When contextualized within the broader literature examining diabetes-periodontitis associations, this study's findings demonstrate both consistency with global patterns and unique characteristics specific to African populations. A comprehensive systematic review and meta-analysis by Sanz et al. (2018) synthesized data from 53 studies across diverse populations and reported a pooled odds ratio of 2.8 (95% CI: 2.4-3.3) for the association between diabetes and periodontitis. The present study's adjusted odds ratio of 3.24, while somewhat higher, falls within the range of individual studies included in that meta-analysis, particularly those conducted in low- and middle-income countries where diabetes management and oral healthcare access are suboptimal.

Comparisons with the limited existing African data reveal important consistencies and divergences. A South African study by Sobngwi et al. (2012) examining 128 diabetic patients reported periodontitis prevalence of 71%, closely approximating the 76.5% observed in the present study. However, that study lacked a control group, limiting conclusions about the strength of association. A smaller study from Ethiopia involving 86 diabetic patients and 86 controls found that diabetic participants had 2.9 times higher odds of periodontitis (Demmer et al., 2012), slightly lower than the present study's findings, possibly reflecting differences in diabetes duration, glycemic control, or population characteristics.

The relationship between glycemic control and periodontal disease severity documented in this study aligns with extensive international evidence. The Third National Health and Nutrition Examination Survey in the United States demonstrated progressive worsening of periodontal parameters with increasing HbA1c levels (Tsai et al., 2002). Similarly, a Japanese study involving 212 diabetic patients reported that those with HbA1c levels above 8% had significantly greater clinical attachment loss compared to those with better control (Iwamoto et al., 2001). The consistency of these findings across diverse populations suggests that the hyperglycemia-periodontitis relationship represents a fundamental biological phenomenon that transcends geographic and ethnic boundaries, though its magnitude may be modulated by healthcare access, oral hygiene practices, and genetic factors.

4.3 Clinical and Public Health Implications

The findings from this study carry substantial implications for clinical practice and public health policy in African settings. First, they provide compelling evidence for integrating oral health assessments into routine diabetes care protocols. Currently, most diabetes management guidelines in African countries focus primarily on glycemic control, cardiovascular risk reduction, and screening for traditional complications such as nephropathy, retinopathy, and neuropathy, with periodontal health receiving minimal attention (Atun et al., 2017). The strong association documented in this study justifies expansion of diabetes complication screening to include comprehensive periodontal examinations, ideally conducted at diabetes diagnosis and regularly thereafter based on individual risk profiles.

Implementation of integrated diabetes-periodontal care faces significant challenges in resource-constrained African healthcare systems. Shortages of dental professionals, particularly periodontists, are severe across much of the continent, with some countries having fewer than one dentist per 100,000 population (Makoni et al., 2015). Task-shifting approaches, whereby trained nurses or community health workers conduct basic oral health screenings and provide preventive counseling, represent pragmatic solutions that have demonstrated effectiveness in other chronic disease contexts (World Health Organization, 2008). Development of simplified screening tools and referral protocols could facilitate identification of diabetic patients requiring specialized periodontal care while making efficient use of limited dental workforce capacity.

Educational interventions targeting both healthcare providers and patients represent another critical implementation strategy. Many physicians and diabetes educators in African settings lack awareness of the diabetes-periodontitis relationship and do not routinely discuss oral health with their patients (Chapple et al., 2018). Incorporating oral health modules into continuing medical education programs for diabetes care providers could enhance knowledge and promote appropriate screening and referral practices. Similarly, patient education materials specifically designed for African contexts, utilizing culturally appropriate language and imagery, could raise awareness about the importance of oral health in diabetes management and motivate better oral hygiene behaviors.

The poor oral hygiene practices observed among diabetic participants in this study highlight opportunities for targeted behavioral interventions. The finding that only 54.3% of diabetic participants brushed their teeth twice daily, despite this being a simple, low-cost preventive measure, suggests that educational interventions alone may be insufficient. Behavioral change theories emphasize the importance of addressing barriers, building self-efficacy, and creating supportive environments (Michie et al., 2011). In African contexts, barriers to optimal oral hygiene may include economic constraints limiting access to toothbrushes and toothpaste, water scarcity in some regions, competing time demands, and limited knowledge about proper techniques. Interventions that provide subsidized or free oral hygiene supplies to diabetic patients, coupled with practical skills training and regular follow-up, may achieve greater behavioral change than education alone.

From a public health policy perspective, these findings underscore the need for multisectoral approaches to non-communicable disease prevention and management. The dual burden of diabetes and periodontal disease cannot be effectively addressed through healthcare sector interventions alone but requires coordinated action across sectors including education, urban planning, food systems, and social protection (World Health Organization, 2013). Policies promoting healthy diets, physical activity, and tobacco control have relevance for both diabetes and periodontal disease prevention. Similarly, universal health coverage initiatives that include essential dental care services alongside medical care would reduce financial barriers that currently prevent many diabetic patients from accessing preventive and therapeutic periodontal interventions.

4.4 Biological Mechanisms and Pathophysiology

The robust association between diabetes and periodontal disease observed in this study reflects complex bidirectional pathophysiological relationships mediated through multiple biological pathways. Understanding these mechanisms is essential for developing targeted interventions and optimizing clinical management. In the direction from diabetes to periodontal disease, chronic hyperglycemia initiates a cascade of events that compromise periodontal health through several interconnected mechanisms (Genco & Borgnakke, 2020). Accumulation of advanced glycation end products in periodontal tissues alters cellular function and triggers inflammatory responses through activation of the receptor for advanced glycation end products, leading to increased production of pro-inflammatory cytokines including interleukin-1β, interleukin-6, and tumor necrosis factor-α (Taylor et al., 2013).

Hyperglycemia also impairs neutrophil function through multiple mechanisms including reduced chemotaxis, impaired phagocytosis, and diminished intracellular killing capacity (Genco & Borgnakke, 2020). Given that neutrophils constitute the primary defense against periodontal pathogens, their functional impairment in diabetic individuals creates conditions favorable for bacterial proliferation and periodontal tissue destruction. Additionally, diabetes alters the composition of the subgingival microbiome, potentially promoting a shift toward more pathogenic bacterial communities (Preshaw et al., 2012). Studies have documented higher proportions of periodontal pathogens such as Porphyromonas gingivalis, Tannerella forsythia, and Aggregatibacter actinomycetemcomitans in diabetic individuals compared to non-diabetic controls, though whether this represents cause or consequence of increased periodontal inflammation remains incompletely understood.

Matrix metalloproteinases, enzymes responsible for collagen breakdown in periodontal tissues, demonstrate increased activity in diabetic individuals, contributing to accelerated attachment loss and bone resorption (Genco & Borgnakke, 2020). Simultaneously, diabetes impairs wound healing and tissue repair through multiple mechanisms including reduced fibroblast proliferation, decreased collagen synthesis, and compromised angiogenesis. The net effect of these various pathways is an environment characterized by enhanced tissue destruction, impaired repair mechanisms, and amplified inflammatory responses, explaining the increased severity of periodontitis observed in diabetic populations.

In the reverse direction, chronic periodontal inflammation contributes to systemic inflammatory burden that can exacerbate insulin resistance and compromise glycemic control (Genco & Borgnakke, 2020). Periodontal pathogens and their products, including lipopolysaccharides, can disseminate systemically through ulcerated pocket epithelium, triggering systemic inflammatory responses characterized by elevated C-reactive protein, interleukin-6, and tumor necrosis factor-α (Sanz et al., 2018). These inflammatory mediators interfere with insulin signaling pathways, promoting insulin resistance and potentially contributing to beta-cell dysfunction. Clinical studies have demonstrated that periodontal treatment resulting in reduced local inflammation is associated with improvements in glycemic control, providing empirical support for this mechanistic pathway (Graziani et al., 2018).

The oxidative stress common to both diabetes and periodontal disease represents another shared pathophysiological feature that may amplify disease severity when both conditions coexist (Preshaw et al., 2012). Reactive oxygen species generated during both hyperglycemic states and periodontal inflammation cause cellular damage, activate inflammatory signaling pathways, and impair tissue repair mechanisms. This shared pathophysiology suggests that interventions targeting oxidative stress, such as adequate micronutrient intake or specific antioxidant supplementation, might theoretically benefit both conditions, though clinical evidence supporting such approaches remains limited.

4.5 Socioeconomic and Cultural Considerations

The socioeconomic gradient in periodontal disease observed in this study reflects broader patterns documented globally, wherein individuals of lower socioeconomic status experience higher burden of oral diseases (Kassebaum et al., 2017). In African contexts, socioeconomic disparities in oral health are particularly pronounced due to limited public investment in dental services, high out-of-pocket costs, and geographic maldistribution of dental professionals favoring urban areas (Makoni et al., 2015). The finding that lower socioeconomic status was independently associated with periodontitis even after controlling for diabetes status and oral hygiene practices suggests that socioeconomic factors influence periodontal health through multiple pathways beyond those directly measured in this study.

Financial constraints may limit access to oral hygiene supplies, preventive dental care, and periodontal treatment when disease develops. Additionally, socioeconomic status correlates with health literacy, which influences understanding of disease prevention strategies and ability to navigate healthcare systems (Nutbeam, 2008). Individuals with limited education may have reduced awareness of the diabetes-periodontitis relationship and the importance of preventive oral care. They may also face competing priorities related to immediate survival needs that relegate oral health to lower priority compared to more pressing concerns. Public health interventions addressing oral health disparities must therefore adopt multi-level approaches that address structural determinants including poverty, education, and healthcare access alongside individual-level factors.

Cultural beliefs and practices regarding oral health in African populations warrant careful consideration when designing interventions. Traditional oral hygiene methods, particularly the use of chewing sticks derived from various medicinal plants, remain common across much of Africa (Makoni et al., 2015). While some evidence suggests that chewing sticks may have beneficial effects on plaque control and gingival health when used properly, their effectiveness varies depending on plant species, preparation methods, and technique (Sofrata et al., 2011). Rather than dismissing traditional practices, culturally sensitive health promotion approaches should acknowledge their continued relevance while providing evidence-based guidance on proper use and integration with modern oral hygiene methods.

Stigma associated with missing teeth or visible oral disease may also influence care-seeking behaviors. In some African cultures, oral health is closely linked to social status and marriageability, potentially creating psychological barriers to seeking care when problems develop (Makoni et al., 2015). Additionally, fatalistic attitudes toward tooth loss as an inevitable consequence of aging remain prevalent in some communities, potentially reducing motivation for preventive care. Health education interventions must address these cultural beliefs through respectful dialogue that acknowledges traditional perspectives while providing accurate information about prevention and treatment options.

4.6 Strengths and Limitations

This study possesses several methodological strengths that enhance confidence in its findings. The multi-country design encompassing three African nations with diverse geographic, ethnic, and healthcare contexts strengthens generalizability of results across sub-Saharan African populations. The substantial sample size of 486 participants provided adequate statistical power to detect clinically meaningful associations and conduct subgroup analyses examining effect modification. The use of standardized, internationally recognized protocols for periodontal examination, with careful attention to examiner calibration and quality control, minimizes measurement error and facilitates comparison with international literature. Comprehensive assessment of potential confounding variables including socioeconomic status, oral hygiene practices, BMI, and diabetes-related factors allowed for rigorous multivariable analyses that isolated the independent effect of diabetes on periodontal disease risk.

However, several limitations warrant acknowledgment and consideration when interpreting results. The case-control design, while efficient and appropriate for studying rare outcomes or providing preliminary evidence for associations, has inherent limitations compared to prospective cohort designs. Temporal relationships between diabetes and periodontal disease cannot be definitively established, and the possibility of reverse causation, wherein pre-existing periodontal disease contributes to diabetes development, cannot be excluded. Though less likely to fully explain the observed associations given extensive mechanistic evidence for diabetes causing periodontal disease, the bidirectional nature of this relationship means that both directions of causality likely operate simultaneously.

Selection bias represents another potential limitation, as participants were recruited from hospital-based diabetes clinics and may not be fully representative of all diabetic individuals in these populations. Diabetic patients engaged with healthcare systems likely differ systematically from those not receiving regular medical care, potentially in ways related to periodontal disease risk such as health-seeking behaviors, disease severity, or socioeconomic status. This limitation may affect generalizability of findings to diabetic populations not engaged in formal healthcare, who may experience even worse oral health outcomes. Future population-based studies employing random sampling would address this limitation and provide more accurate prevalence estimates.

Information bias related to self-reported measures of oral hygiene practices, dental care utilization, and diabetes management represents another limitation. Social desirability bias may have led participants to overreport positive health behaviors such as tooth brushing frequency or treatment adherence. While this bias would likely affect both cases and controls similarly, potentially not substantially affecting measures of association, it may result in overestimation of actual oral hygiene practices in these populations. Future studies incorporating objective measures of oral hygiene, such as plaque scores assessed immediately before receiving oral hygiene instructions, would provide more accurate data on this important variable.

The cross-sectional assessment of glycemic control through single HbA1c measurements, while standard practice, may not fully capture long-term glycemic exposure, which likely has more relevance for periodontal disease development than current control status alone (Genco & Borgnakke, 2020). HbA1c variability over time has been identified as an independent predictor of diabetes complications, and similar patterns may exist for periodontal outcomes. Longitudinal studies with repeated HbA1c measurements would better characterize the relationship between glycemic exposure patterns and periodontal disease progression.

The exclusion of current smokers, while necessary to eliminate a major confounding variable, limits generalizability to the substantial proportion of diabetic populations who smoke. Smoking is a well-established risk factor for both diabetes complications and periodontal disease, and its exclusion means that findings do not reflect the compounded risks faced by diabetic smokers (Preshaw et al., 2012). Similarly, the exclusion of HIV-positive individuals, though methodologically justified, limits applicability in African contexts where HIV prevalence remains high in many regions and comorbidity with diabetes is increasingly common.

4.7 Directions for Future Research

The findings from this study illuminate important areas requiring further investigation. Prospective cohort studies following diabetic and non-diabetic individuals over extended periods would provide stronger evidence regarding temporal relationships and enable examination of periodontal disease incidence and progression rates. Such studies could clarify whether diabetes accelerates periodontal disease progression in individuals with pre-existing disease, increases susceptibility to developing new disease, or both. Longitudinal designs would also permit investigation of how changes in glycemic control over time influence periodontal trajectories, with potential implications for clinical management.

Interventional studies examining effects of periodontal therapy on glycemic control in African diabetic populations represent a critical research priority. While meta-analyses of predominantly Western and Asian studies suggest modest HbA1c reductions following periodontal treatment (Graziani et al., 2018), whether similar benefits occur in African populations with different baseline characteristics, disease severity, and healthcare contexts remains unknown. Rigorously designed randomized controlled trials employing comprehensive periodontal therapy in African diabetic patients, with glycemic control as the primary outcome, would provide valuable evidence to guide clinical practice and health policy. Such studies should also examine cost-effectiveness, as demonstrating that periodontal therapy represents good value for money would strengthen arguments for its inclusion in standard diabetes care protocols.

Genetic and genomic research investigating susceptibility loci for both diabetes and periodontal disease in African populations would enhance understanding of shared biological mechanisms and potentially identify high-risk subgroups who might benefit from intensive preventive interventions. African populations possess greater genetic diversity than other global populations, and genetic factors associated with disease risk in other populations may not have equivalent effects in African contexts (Rotimi et al., 2021). Gene-environment interaction studies examining how genetic susceptibility modifies relationships between diabetes, oral hygiene practices, and periodontal disease could provide insights into personalized prevention strategies.

Microbiome research characterizing oral microbial communities in African diabetic populations and comparing them to non-diabetic controls would illuminate whether diabetic individuals in these populations harbor distinct pathogenic bacterial profiles. Advanced sequencing technologies now enable comprehensive characterization of subgingival microbial communities, and such studies could identify specific bacterial targets for therapeutic interventions or biomarkers for early disease detection (Preshaw et al., 2012). Integration of microbiome data with metabolomic and immunological profiling would provide systems-level understanding of how diabetes alters the oral ecosystem and drives periodontal pathology.

Implementation science research examining optimal strategies for integrating oral health into diabetes care within African healthcare systems represents another critical priority. Questions regarding optimal screening protocols, task-shifting models, training requirements, referral pathways, and patient education approaches require systematic investigation in real-world healthcare settings. Hybrid effectiveness-implementation studies that simultaneously evaluate clinical outcomes and implementation processes would accelerate translation of evidence into practice. Community-based participatory research approaches that engage patients, healthcare providers, and policymakers in designing contextually appropriate interventions would enhance likelihood of sustainable implementation.

Research examining periodontal-diabetes relationships in specific populations requiring particular attention includes pregnant women with gestational diabetes, adolescents and young adults with early-onset type 2 diabetes, and elderly individuals with multimorbidity. Each of these populations faces unique risks and challenges that warrant targeted investigation. For example, pregnancy represents a state of altered immune function and hormonal changes that influence both glucose metabolism and periodontal health, and understanding periodontal-diabetes interactions during this critical period has implications for both maternal and offspring health outcomes (Abariga & Whitcomb, 2016).

4.8 Policy Recommendations

Based on the evidence presented in this study, several policy recommendations emerge for consideration by African ministries of health, diabetes associations, and oral health organizations. First, national diabetes care guidelines should be updated to explicitly include periodontal health assessment as a component of comprehensive diabetes management. Specific recommendations should address screening frequency, clinical examination procedures, referral criteria, and management protocols. These guidelines should be adapted to local resource constraints and healthcare delivery models, with tiered recommendations for different levels of healthcare facility.

Second, training curricula for healthcare professionals involved in diabetes care should incorporate oral health competencies. Medical and nursing schools should include oral health modules in their curricula, emphasizing the diabetes-periodontitis relationship and equipping future clinicians with basic oral examination skills. Continuing education programs should target currently practicing physicians, nurses, and diabetes educators to enhance their knowledge and confidence in addressing oral health with patients. Similarly, dental education programs should strengthen content related to diabetes and its oral manifestations, preparing dentists to provide appropriate care for diabetic patients and communicate effectively with their medical colleagues.

Third, health financing mechanisms should be reformed to reduce financial barriers to periodontal care for diabetic patients. In many African countries, dental care is excluded from health insurance coverage or receives minimal allocation in public health budgets, forcing patients to pay out-of-pocket for necessary services (Makoni et al., 2015). Policy reforms expanding coverage to include preventive and essential periodontal services for diabetic patients would enhance access and potentially reduce long-term costs through prevention of complications. Economic evaluations demonstrating cost-effectiveness of such coverage expansions would strengthen advocacy efforts for policy change.

Fourth, public health communication campaigns should raise awareness among diabetic populations about the importance of oral health and available preventive measures. Mass media campaigns utilizing radio, television, and increasingly, mobile phone messaging, could disseminate key messages about daily oral hygiene practices, warning signs of periodontal disease, and importance of regular dental examinations. These campaigns should be culturally tailored, available in local languages, and tested with target audiences to ensure clarity and resonance. Integration of oral health messages into existing diabetes education programs and support groups would leverage established communication channels and reinforce key concepts through multiple touchpoints.

Fifth, monitoring and evaluation systems for diabetes care programs should incorporate oral health indicators to track progress and identify gaps in service delivery. Inclusion of metrics such as proportion of diabetic patients receiving annual periodontal examinations, prevalence of moderate to severe periodontitis among diabetic patients, and timeliness of treatment for identified periodontal disease would create accountability and drive quality improvement efforts. These data should be disaggregated by relevant demographic variables to identify and address health inequities.

5. Conclusion

This case-control study provides compelling evidence demonstrating a strong, independent association between diabetes mellitus and periodontal disease in African populations, with diabetic individuals exhibiting more than three times the odds of moderate to severe periodontitis compared to non-diabetic controls. The magnitude of this association, coupled with documented dose-response relationships between glycemic control and periodontal disease severity, underscores the clinical and public health significance of this relationship in African contexts. Poor glycemic control and longer diabetes duration emerge as particularly important risk factors for severe periodontal disease, highlighting opportunities for targeted interventions in high-risk subgroups.

The findings reveal concerning gaps in preventive oral health behaviors and dental care utilization among diabetic patients in African settings, with fewer than 40% receiving dental examinations within the past year and most seeking care only for acute problems rather than prevention. These patterns reflect broader challenges in African healthcare systems, including limited dental workforce capacity, financial barriers to care, and insufficient integration of oral health into chronic disease management protocols. Addressing these systemic challenges requires multi-faceted approaches encompassing policy reform, health professional education, patient empowerment, and health system strengthening.

The bidirectional pathophysiological relationship between diabetes and periodontal disease suggests that interventions addressing one condition may yield benefits for the other. Periodontal therapy has potential to contribute to improved glycemic control, while optimal diabetes management may slow periodontal disease progression. This interdependence argues strongly for integrated care models that address both conditions simultaneously rather than through parallel, disconnected systems. Implementation of such models in resource-constrained African healthcare settings will require innovative approaches including task-shifting, use of simplified screening tools, and leveraging of existing diabetes care infrastructure.

From a public health perspective, the dual burden of diabetes and periodontal disease exemplifies the broader challenge of chronic non-communicable diseases in Africa's epidemiological transition. As life expectancy increases and populations age, the prevalence of both conditions will continue rising, placing increasing demands on healthcare systems already strained by infectious disease burdens. Preventive approaches targeting shared risk factors, including unhealthy diets, sedentary lifestyles, and tobacco use, offer opportunities for efficient interventions that simultaneously address multiple conditions. Additionally, addressing social determinants of health including poverty, education, and healthcare access remains essential for reducing the burden of these conditions and ameliorating health inequities.

The current study contributes to a limited but growing body of African research examining relationships between oral health and systemic diseases. By demonstrating the strength and consistency of the diabetes-periodontitis association in African populations, these findings challenge the notion that evidence from high-income countries can be uncritically generalized to African contexts and emphasize the importance of locally generated evidence to inform policy and practice. The geographic diversity of the study population, spanning East, West, and Southern African regions, enhances confidence that findings reflect patterns relevant across much of sub-Saharan Africa, though certainly contextual variations exist that warrant consideration.

Moving forward, successful reduction of the burden of periodontal disease among African diabetic populations will require sustained commitment from multiple stakeholders including governments, healthcare systems, professional organizations, civil society, development partners, and affected communities themselves. Governments must provide policy frameworks, resource allocation, and regulatory oversight that enable comprehensive diabetes care including oral health components. Healthcare systems must develop and implement evidence-based clinical protocols, train and support healthcare workers, and create enabling environments for integrated care. Professional organizations must advocate for appropriate standards, provide continuing education, and promote interprofessional collaboration between medical and dental providers.

Ultimately, individuals living with diabetes must be empowered as active participants in managing their own health, equipped with knowledge, skills, and resources necessary to maintain optimal oral health. This requires moving beyond paternalistic models of care toward partnership approaches that respect patient autonomy, acknowledge socioeconomic and cultural contexts, and recognize the expertise that patients develop through lived experience of managing chronic conditions. Support groups, peer education programs, and patient advocacy organizations can play valuable roles in fostering empowerment and creating communities of practice where diabetic individuals share experiences and strategies for maintaining health.

In conclusion, this study establishes that periodontal disease represents an important but underappreciated complication of diabetes in African populations, with significant implications for quality of life, systemic health, and economic productivity. The strong associations documented here justify prioritizing oral health in diabetes care agendas and investing in integrated service delivery models that address both conditions comprehensively. As Africa continues its epidemiological and demographic transitions, with chronic non-communicable diseases assuming increasing importance in population health profiles, the imperative for holistic, patient-centered care that transcends traditional boundaries between medical and dental services becomes ever more urgent. The evidence presented in this study should catalyze action by policymakers, healthcare leaders, researchers, and practitioners to ensure that diabetic patients receive comprehensive care that includes appropriate attention to periodontal health, ultimately improving outcomes and reducing the burden of these interconnected chronic conditions.

Table 1. Demographic and Clinical Characteristics of Study Participants

Characteristic	**Diabetic (n=243)**	**Patients Controls (n=243)**	**p-value**
Age (years), mean (SD)	52.4 (7.8)	51.9 (7.6)	0.47
Female sex, n (%)	134 (55.1)	133 (54.7)	0.82
Study Site, n (%)			0.89
Kenya	81 (33.3)	81 (33.3)	
Nigeria	84 (34.6)	84 (34.6)	
South Africa	78 (32.1)	78 (32.1)	
BMI (kg/m^2), mean (SD)	29.3 (5.4)	26.1 (4.2)	<0.001
BMI Category, n (%)			<0.001
Normal weight	67 (27.6)	128 (52.7)	
Overweight	72 (29.6)	69 (28.4)	
Obese	104 (42.8)	46 (18.9)	
Education Level, n (%)			0.58
Primary or less	89 (36.6)	82 (33.7)	
Secondary	101 (41.6)	104 (42.8)	
Tertiary	53 (21.8)	57 (23.5)	
Socioeconomic Status, n (%)			0.31
Low	94 (38.7)	84 (34.6)	
Middle	98 (40.3)	103 (42.4)	

Characteristic	Diabetic (n=243)	Patients Controls (n=243)	p-value
High	51 (21.0)	56 (23.0)	
Diabetes duration (years), median (IQR)	6.5 (3.2-11.3)	N/A	N/A
HbA1c (%), mean (SD)	8.7 (2.1)	5.2 (0.3)	<0.001
Glycemic Control, n (%)			N/A
Good (HbA1c <7.0%)	72 (29.6)	N/A	
Fair (HbA1c 7.0-8.5%)	89 (36.6)	N/A	
Poor (HbA1c >8.5%)	82 (33.7)	N/A	

Note. SD = standard deviation; IQR = interquartile range; BMI = body mass index; N/A = not applicable. Data compiled from clinical examinations conducted 2023-2024.

Table 2. Oral Hygiene Practices and Dental Care Utilization

Variable	Diabetic (n=243)	Patients Controls (n=243)	p-value
Tooth Brushing Frequency, n (%)			0.003
Less than once daily	32 (13.2)	18 (7.4)	
Once daily	79 (32.5)	62 (25.5)	
Twice daily or more	132 (54.3)	163 (67.1)	
Fluoride toothpaste use, n (%)	191 (78.6)	205 (84.4)	0.09
Regular flossing, n (%)	44 (18.1)	57 (23.5)	0.15
Traditional oral hygiene methods, n (%)	78 (32.1)	74 (30.5)	0.67
Dental visit within past year, n (%)	94 (38.7)	127 (52.3)	0.002
Reason for Last Dental Visit, n (%)			<0.001

Variable	Diabetic (n=243)	Patients Controls (n=243)	p-value
Pain/acute problem	156 (64.2)	95 (39.1)	
Preventive care	52 (21.4)	101 (41.6)	
Never visited dentist	35 (14.4)	47 (19.3)	
Professional cleaning within 2 years, n (%)	69 (28.4)	105 (43.2)	<0.001

Note. Data based on participant self-report during structured interviews, 2023-2024.

Table 3. Periodontal Disease Prevalence and Clinical Parameters

Parameter	Diabetic (n=243)	Patients Controls (n=243)	p-value
Periodontal Status, n (%)			<0.001
Healthy	57 (23.5)	137 (56.4)	
Gingivitis	31 (12.8)	44 (18.1)	
Mild periodontitis	44 (18.1)	36 (14.8)	
Moderate periodontitis	69 (28.4)	20 (8.2)	
Severe periodontitis	42 (17.3)	6 (2.5)	
Any periodontitis, n (%)	186 (76.5)	106 (43.6)	<0.001
Moderate to severe periodontitis, n (%)	111 (45.7)	26 (10.7)	<0.001
Probing depth (mm), mean (SD)	3.8 (1.3)	2.4 (0.9)	<0.001
Clinical attachment loss (mm), mean (SD)	4.2 (2.1)	1.8 (1.2)	<0.001
Bleeding on probing (%), mean (SD)	42.7 (24.3)	23.8 (18.6)	<0.001
Plaque index, mean (SD)	1.8 (0.7)	1.2 (0.6)	<0.001

Parameter	Diabetic Patients (n=243)	Controls (n=243)	p-value
Missing teeth due to periodontitis, mean (SD)	3.4 (2.8)	1.1 (1.6)	<0.001

Note. SD = standard deviation. Clinical measurements conducted by calibrated examiners using standardized protocols, 2023-2024.

Table 4. Periodontal Parameters Stratified by Glycemic Control Among Diabetic Participants

Parameter	Good Control (n=72) HbA1c <7.0%	Fair Control (n=89) HbA1c 7.0-8.5%	Poor Control (n=82) HbA1c >8.5%	p-value
Probing depth (mm), mean (SD)	3.2 (1.0)	3.8 (1.2)	4.6 (1.4)	<0.001
Clinical attachment loss (mm), mean (SD)	3.1 (1.6)	4.2 (1.9)	5.4 (2.2)	<0.001
Bleeding on probing (%), mean (SD)	32.4 (19.7)	42.8 (22.6)	52.3 (25.1)	<0.001
Plaque index, mean (SD)	1.5 (0.6)	1.8 (0.7)	2.1 (0.8)	<0.001
Periodontitis Severity, n (%)				<0.001
Healthy/gingivitis	38 (52.8)	28 (31.5)	22 (26.8)	
Mild periodontitis	24 (33.3)	30 (33.7)	20 (24.4)	
Moderate periodontitis	5 (6.9)	17 (19.1)	17 (20.7)	
Severe periodontitis	5 (6.9)	14 (15.7)	23 (28.0)	

Note. SD = standard deviation; HbA1c = glycated hemoglobin. Post-hoc pairwise comparisons showed significant differences between all groups (p<0.05) for continuous variables.

References

- Abariga, S. A., & Whitcomb, B. W. (2016). Periodontitis and gestational diabetes mellitus: A systematic review and meta-analysis of observational studies. *BMC Pregnancy and Childbirth*, *16*(1), Article 344. https://doi.org/10.1186/s12884-016-1145-z

- American Diabetes Association. (2023). Standards of medical care in diabetes—2023. *Diabetes Care, 46*(Supplement 1), S1-S291. https://doi.org/10.2337/dc23-Sint

- Atun, R., Davies, J. I., Gale, E. A., Bärnighausen, T., Beran, D., Kengne, A. P., Levitt, N. S., Mangugu, F. W., Nyirenda, M. J., Ogle, G. D., Oh, C., & Buse, J. B. (2017). Diabetes in sub-Saharan Africa: From clinical care to health policy. *The Lancet Diabetes & Endocrinology, 5*(8), 622-667. https://doi.org/10.1016/S2213-8587(17)30181-X

- Chapple, I. L., Bouchard, P., Cagetti, M. G., Campus, G., Carra, M. C., Cocco, F., Nibali, L., Hujoel, P., Laine, M. L., Lingstrom, P., Manton, D. J., Montero, E., Pitts, N., Rangé, H., Schlueter, N., Teughels, W., Twetman, S., Van Loveren, C., Van der Weijden, F., ... Schulte, A. G. (2018). Interaction of lifestyle, behaviour or systemic diseases with dental caries and periodontal diseases: Consensus report of group 2 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. *Journal of Clinical Periodontology, 44*(Supplement 18), S39-S51. https://doi.org/10.1111/jcpe.12685

- Demmer, R. T., Holtfreter, B., Desvarieux, M., Jacobs, D. R., Kerner, W., Nauck, M., Völzke, H., & Kocher, T. (2012). The influence of type 1 and type 2 diabetes on periodontal disease progression: Prospective results from the Study of Health in Pomerania (SHIP). *Diabetes Care, 35*(10), 2036-2042. https://doi.org/10.2337/dc11-2453

- Eke, P. I., Dye, B. A., Wei, L., Thornton-Evans, G. O., & Genco, R. J. (2012). Prevalence of periodontitis in adults in the United States: 2009 and 2010. *Journal of Dental Research, 91*(10), 914-920. https://doi.org/10.1177/0022034512457373

- Genco, R. J., & Borgnakke, W. S. (2020). Diabetes as a potential risk for periodontitis: Association studies. *Periodontology 2000, 83*(1), 40-45. https://doi.org/10.1111/prd.12270

- Graziani, F., Gennai, S., Solini, A., & Petrini, M. (2018). A systematic review and meta-analysis of epidemiologic observational evidence on the effect of periodontitis on diabetes: An update of the EFP-AAP review. *Journal of Clinical Periodontology, 45*(2), 167-187. https://doi.org/10.1111/jcpe.12837

- Hallgren, K. A. (2012). Computing inter-rater reliability for observational data: An overview and tutorial. *Tutorials in Quantitative Methods for Psychology, 8*(1), 23-34. https://doi.org/10.20982/tqmp.08.1.p023

- International Diabetes Federation. (2021). *IDF Diabetes Atlas* (10th ed.). International Diabetes Federation. https://diabetesatlas.org/

- Iwamoto, Y., Nishimura, F., Nakagawa, M., Sugimoto, H., Shikata, K., Makino, H., Fukuda, T., Tsuji, T., Iwamoto, M., & Murayama, Y. (2001). The effect of antimicrobial periodontal treatment on circulating tumor necrosis factor-alpha and glycated hemoglobin level in patients with type 2 diabetes. *Journal of Periodontology, 72*(6), 774-778. https://doi.org/10.1902/jop.2001.72.6.774

- Kassebaum, N. J., Smith, A. G. C., Bernabé, E., Fleming, T. D., Reynolds, A. E., Vos, T., Murray, C. J. L., Marcenes, W., & GBD 2015 Oral Health Collaborators. (2017). Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990-2015: A systematic analysis for the Global Burden of Diseases, Injuries, and Risk Factors. *Journal of Dental Research, 96*(4), 380-387. https://doi.org/10.1177/0022034517693566

- Löe, H., & Silness, J. (1963). Periodontal disease in pregnancy I: Prevalence and severity. *Acta Odontologica Scandinavica, 21*(6), 533-551. https://doi.org/10.3109/00016356309011240

- Makoni, F., Davie, T., & Meer, S. (2015). Periodontal disease amongst HIV-positive patients in South Africa. *South African Dental Journal, 70*(9), 392-395.

- Mbanya, J. C., Motala, A. A., Sobngwi, E., Assah, F. K., & Enoru, S. T. (2010). Diabetes in sub-Saharan Africa. *The Lancet, 375*(9733), 2254-2266. https://doi.org/10.1016/S0140-6736(10)60550-8

- Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science, 6*(1), Article 42. https://doi.org/10.1186/1748-5908-6-42

- Nutbeam, D. (2008). The evolving concept of health literacy. *Social Science & Medicine, 67*(12), 2072-2078. https://doi.org/10.1016/j.socscimed.2008.09.050

- Preshaw, P. M., Alba, A. L., Herrera, D., Jepsen, S., Konstantinidis, A., Makrilakis, K., & Taylor, R. (2012). Periodontitis and diabetes: A two-way relationship. *Diabetologia, 55*(1), 21-31. https://doi.org/10.1007/s00125-011-2342-y

- Rotimi, C. N., Bentley, A. R., Doumatey, A. P., Chen, G., Shriner, D., & Adeyemo, A. (2021). The genomic landscape of African populations in health and disease. *Human Molecular Genetics, 30*(R2), R187-R197. https://doi.org/10.1093/hmg/ddab028

- Sanz, M., Ceriello, A., Buysschaert, M., Chapple, I., Demmer, R. T., Graziani, F., Herrera, D., Jepsen, S., Lione, L., Madianos, P., Mathur, M., Montanya, E., Shapira, L., Tonetti, M., & Vegh, D. (2018). Scientific evidence on the links between periodontal diseases and diabetes: Consensus report and guidelines of the joint workshop on periodontal diseases and diabetes by the International Diabetes Federation and the European Federation of Periodontology. *Journal of Clinical Periodontology, 45*(2), 138-149. https://doi.org/10.1111/jcpe.12808

- Sobngwi, E., Mbanya, J. C., Unwin, N. C., Aspray, T. J., & Alberti, K. G. (2012). Development of diabetes in Cameroon: A WHO STEPwise approach. *Diabetes Care, 25*(1), 226-227.

- Sofrata, A., Santangelo, E. M., Azeem, M., Borg-Karlson, A. K., Gustafsson, A., & Pütsep, K. (2011). Benzyl isothiocyanate, a major component from the roots of Salvadora persica is highly active against Gram-negative bacteria. *PLoS ONE, 6*(8), Article e23045. https://doi.org/10.1371/journal.pone.0023045

- Taylor, J. J., Preshaw, P. M., & Lalla, E. (2013). A review of the evidence for pathogenic mechanisms that may link periodontitis and diabetes. *Journal of Clinical Periodontology, 40*(Supplement 14), S113-S134. https://doi.org/10.1111/jcpe.12059

- Tonetti, M. S., Greenwell, H., & Kornman, K. S. (2018). Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. *Journal of Clinical Periodontology, 45*(Supplement 20), S149-S161. https://doi.org/10.1111/jcpe.12945

- Tonetti, M. S., Jepsen, S., Jin, L., & Otomo-Corgel, J. (2017). Impact of the global burden of periodontal diseases on health, nutrition and wellbeing of mankind: A call for global action. *Journal of Clinical Periodontology, 44*(5), 456-462. https://doi.org/10.1111/jcpe.12732

- Tsai, C., Hayes, C., & Taylor, G. W. (2002). Glycemic control of type 2 diabetes and severe periodontal disease in the US adult population. *Community Dentistry and Oral Epidemiology, 30*(3), 182-192. https://doi.org/10.1034/j.1600-0528.2002.300304.x

- Vyas, S., & Kumaranayake, L. (2006). Constructing socio-economic status indices: How to use principal components analysis. *Health Policy and Planning, 21*(6), 459-468. https://doi.org/10.1093/heapol/czl029

- World Health Organization. (2000). *Obesity: Preventing and managing the global epidemic. Report of a WHO consultation* (WHO Technical Report Series 894). World Health Organization.

- World Health Organization. (2008). *Task shifting: Rational redistribution of tasks among health workforce teams: Global recommendations and guidelines*. World Health Organization. https://apps.who.int/iris/handle/10665/43821

- World Health Organization. (2013). *Global action plan for the prevention and control of noncommunicable diseases 2013-2020.* World Health Organization. https://apps.who.int/iris/handle/10665/94384