



ORIGINAL RESEARCH

RELATIONSHIP BETWEEN DIABETES AWARENESS PROGRAMS AND PERIODONTAL DISEASE CONTROL IN COMMUNITY HEALTH SETTINGS

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ABSTRACT

**Background:** The bidirectional association between periodontal disease and diabetes mellitus is a great issue to the general health of the population. Diabetes awareness programs based in the community can also impact periodontal health outcomes but this relationship is not well reported.

**Purpose:** Present study evaluated association between attendance at diabetes awareness around community health and periodontal disease management in adults with type 2 diabetes.

**Techniques:** A cross sectional study was carried out in four community health centers using 384 participants aged between 35 and 70 years with type 2 diabetes. The participants were divided into two groups: those individuals who attended the structured diabetes awareness program (n=192) and those individuals who only received the standard care (n=192). Community Periodontal Index (CPI), probing pocket depth (PPD), and clinical attachment loss (CAL) were used to measure periodontal status. Oral health behaviors, knowledge scores on diabetes and glycemic control were recorded. Independent t-tests, chi-square tests and multivariate logistic regression were used as the statistical analyses.

**Results:** Awareness program participants showed much improved periodontal results, with the mean PPD of 3.2±1.1 mm vs 4.5±1.4 mm (p<0.001) and CAL of 2.8±1.3 mm vs 4.1±1.6 mm (p<0.001). The group had a superior score of diabetes knowledge (72.4% vs. 54.2% p<0.001) and a superior level of control (HbA1c: 7.1% vs. 8.3% p<0.001). Multivariable analysis showed that the participation in the program was independently related to a controlled periodontal disease (OR=3.47, 95% CI: 2.18-5.52, p<0.001).

**Conclusion:** Prescription of diabetes awareness programs at a community level is closely linked with enhanced management of periodontal diseases and, accordingly, the application of integrated educational, training, and education interventions can be beneficial in improving metabolic and oral health outcomes.

**Keywords:** diabetes mellitus, periodontal disease, health education, community health, diabetes awareness, oral health behavior

INTRODUCTION

Diabetes mellitus and periodontal disease are two extremely widespread chronic illnesses that impact

millions of people worldwide with significant consequences on the health of the population and the medical care sector<sup>1</sup>. According to the estimates by the

World Health Organization, as of today, there are already 537 million adults with diabetes and this figure is likely to increase even further to 783 million by 2045<sup>2</sup>. At the same time, almost 19 out of 100 adults in the world have severe periodontal disease, that is, more than one billion cases of this disease are observed worldwide<sup>3</sup>. The combination of these disorders is not a coincidence; a lot of evidence shows that there is a bidirectional relationship, where diabetes predisposes periodontal disease, and periodontal inflammation impairs glycemic control<sup>4</sup>.

The pathophysiological mechanisms that connect diabetes and periodontal disease are interrelated through complicated immunoinflammatory processes. Hyperglycemia facilitates the development of advanced glycation end products, which induce oxidative stresses and production of the cytokine, thus degrading the integrity of periodontal tissues<sup>5</sup>. On the other hand, periodontal pathogens and inflammatory mediators of infected periodontal tissues get into systemic circulation, which leads to insulin resistance and worsening of metabolism control<sup>6</sup>. Such a vicious circle helps to highlight the significance of the synergistic management solutions to both conditions at the same time<sup>7</sup>.

Although there is increased awareness of this interrelationship, there is an insufficient level of awareness among people with diabetes on their high risk of periodontal disease<sup>8</sup>. Research has recorded that ushering of oral health advice to patients with diabetes by healthcare providers does not take place in less than 40 percent of the patients<sup>9</sup>. Such knowledge gap is translated to poor preventive practices, late diagnosis of periodontal diseases and poor prophylaxis results<sup>10</sup>. The community-based diabetes education programs have become an effective platform where comprehensive health education can be provided, which has not been well empirically addressed as to its potential effects on periodontal health outcomes<sup>11</sup>.

Recent studies have proved that the structured diabetes education programs enhance glycemic control, self-management behavior, and quality of life<sup>12</sup>. Nevertheless, the majority of the programs primarily concentrate on traditional diabetes complications including retinopathy, nephropathy, and cardiovascular disease, but they pay little attention to oral health<sup>13</sup>. There has been some pilot research on whether oral health education can be integrated into diabetes programs with encouraging results on modifying oral hygiene and periodontal health awareness<sup>14</sup>. However, there is limited strong evidence that can be used to discuss the real association between the engagement in the diabetes awareness activities and the objective assessment of the periodontal disease control in the community<sup>15</sup>.

The current literature fills this research gap by exploring the nature of the relationship between the involvement

in organized diabetes awareness and control of periodontal diseases in the community among adults with type 2 diabetes. Namely, this study was going to: (1) compare periodontal health status of participants and non-participants of diabetes awareness programs, (2) determine differences in diabetes knowledge and glycemic control between these two groups, and (3) determine independent predictors of periodontal disease control in this population. Our hypothesis was that patients undergoing a diabetes awareness program would have superior periodontal health outcome at the end of the program than patients undergoing normal care only.

## 2. MATERIALS AND METHODS

### 2.1 Study Design and Setting

This cross-sectional observational study was conducted between January 2023 and July 2023 at four community health centers in urban and suburban areas.

### 2.2 Sample Size Calculation

Sample size was determined using power analysis for comparing two independent means. Assuming a clinically meaningful difference of 0.5 mm in mean probing pocket depth between groups, with standard deviation of 1.2 mm, alpha level of 0.05, and power of 0.80, the minimum required sample size was calculated as 150 participants per group. Accounting for a potential 20% non-response rate, we aimed to recruit 192 participants per group, totaling 384 participants.

### 2.3 Participant Selection

Adults with type 2 diabetes mellitus were recruited through community health center registries. Inclusion criteria comprised: (1) confirmed diagnosis of type 2 diabetes for at least 12 months, (2) age 35-70 years, (3) presence of at least 12 natural teeth, (4) resident in the community catchment area for minimum six months, and (5) ability to provide informed consent. Exclusion criteria included: (1) type 1 diabetes or gestational diabetes, (2) current pregnancy or lactation, (3) severe systemic diseases affecting periodontal status (e.g., immunodeficiency, cancer undergoing treatment), (4) antibiotic therapy within the past three months, (5) periodontal treatment received within the past six months, and (6) cognitive impairment preventing completion of questionnaires.

Participants were categorized into two groups based on their involvement in diabetes awareness programs. The group 1 consisted of individuals who had attended structured diabetes awareness programs (minimum six monthly sessions over the past year) offered by the community health centers. These programs included education on diabetes pathophysiology, complications, lifestyle modifications, medication adherence, and oral health complications of diabetes. The other group comprised individuals who received standard diabetes care (routine medical consultations) without formal program participation.

2.4 Data Collection

2.4.1 Demographic and Clinical Variables

Demographic information including age, gender, education level, occupation, and socioeconomic status was collected through standardized questionnaires. Clinical data encompassed diabetes duration, current medications, smoking status, and presence of other diabetes complications.

2.4.2 Diabetes Knowledge Assessment

Diabetes knowledge was evaluated using the validated 23-item Diabetes Knowledge Questionnaire (DKQ-24), covering general diabetes knowledge and diabetes self-care practices. Scores were converted to percentages, with higher scores indicating greater knowledge.

2.4.3 Glycemic Control

Glycated hemoglobin (HbA1c) levels were determined from venous blood samples analyzed using high-performance liquid chromatography (HPLC) method from patient reports. Good glycemic control was defined as HbA1c <7.0%.

2.4.4 Oral Health Behaviors

Oral hygiene practices were assessed through questionnaires evaluating tooth brushing frequency, interdental cleaning habits, dental visit frequency, and diabetes-related oral health knowledge.

2.4.5 Periodontal Examination

Comprehensive periodontal examinations were performed by two calibrated periodontists (inter-examiner reliability kappa=0.87). Clinical parameters assessed included:

- **Community Periodontal Index (CPI):** Scored according to WHO criteria across six sextants
- **Probing Pocket Depth (PPD):** Measured at six sites per tooth using a calibrated periodontal probe
- **Clinical Attachment Loss (CAL):** Calculated as the distance from cemento-enamel junction to the base of the pocket
- **Bleeding on Probing (BOP):** Recorded as percentage of sites exhibiting bleeding

Periodontal disease severity was classified as: healthy/gingivitis (PPD ≤3 mm, no attachment loss), mild periodontitis (PPD 4-5 mm, CAL 1-2 mm), moderate periodontitis (PPD 5-6 mm, CAL 3-4 mm), or severe periodontitis (PPD ≥7 mm, CAL ≥5 mm). Controlled periodontal disease was defined as healthy/gingivitis or mild periodontitis, while uncontrolled disease included moderate or severe periodontitis.

2.5 Statistical Analysis

Data were analyzed using SPSS version 27.0. Normality of continuous variables was assessed using Kolmogorov-Smirnov test. Descriptive statistics included means with standard deviations for continuous

variables and frequencies with percentages for categorical variables. Independent samples t-tests compared continuous variables between groups, while chi-square tests compared categorical variables. Multivariable logistic regression analysis identified independent predictors of controlled periodontal disease, adjusting for potential confounders including age, gender, smoking status, diabetes duration, and socioeconomic status. Statistical significance was set at p<0.05.

3. RESULTS

3.1 Participant Characteristics

A total of 384 participants with type 2 diabetes completed the study, equally distributed between group 1 and group 2 (attended diabetes awareness programs, n=192) and control group (standard care only, n=192). Table 1 presents the demographic and clinical characteristics of participants.

Table 1. Demographic and Clinical Characteristics of Study Participants

Characteristic	Intervention Group (n=192)	Control Group (n=192)	p-value
Age (years), mean ± SD	54.3 ± 8.7	55.1 ± 9.2	0.382
Gender, n (%)			0.521
Male	98 (51.0)	104 (54.2)	
Female	94 (49.0)	88 (45.8)	
Education level, n (%)			0.067
Primary or less	43 (22.4)	58 (30.2)	
Secondary	89 (46.4)	87 (45.3)	
Higher education	60 (31.2)	47 (24.5)	
Smoking status, n (%)			0.412

Current smoker	38 (19.8)	45 (23.4)	
Former smoker	51 (26.6)	48 (25.0)	
Never smoked	103 (53.6)	99 (51.6)	
Diabetes duration (years), mean ± SD	6.8 ± 3.4	7.2 ± 3.7	0.271
Body Mass Index (kg/m <sup>2</sup> ), mean ± SD	28.4 ± 4.2	29.1 ± 4.6	0.117
Number of natural teeth, mean ± SD	24.7 ± 3.8	23.9 ± 4.3	0.054

The two groups showed no significant differences in baseline demographic characteristics including age, gender distribution, education level, smoking status, diabetes duration, body mass index, or number of natural teeth (all p>0.05), indicating successful matching.

**3.2 Diabetes Knowledge, Glycemic Control, and Oral Health Behaviors**

Table 2 demonstrates significant differences between groups in diabetes knowledge, glycemic control, and oral health behaviors.

**Table 2. Diabetes Knowledge, Glycemic Control, and Oral Health Behaviors**

Variable	Intervention Group (n=192)	Control Group (n=192)	p-value
Diabetes knowledge	72.4 ± 8.3	54.2 ± 9.7	<0.001

edge score (%), mean ± SD			
HbA1c (%), mean ± SD	7.1 ± 0.9	8.3 ± 1.2	<0.001
Good glyce mic contro l (HbA1c <7%), n (%)	89 (46.4)	34 (17.7)	<0.001
Tooth brushin g ≥2 times/ day, n (%)	167 (87.0)	103 (53.6)	<0.001
Daily interde ntal cleani ng, n (%)	94 (49.0)	41 (21.4)	<0.001
Dental visits in past year, n (%)	138 (71.9)	76 (39.6)	<0.001
Aware ness of	156 (81.3)	68 (35.4)	<0.001

diabetes-periodontal link, n (%)			
Received oral health education, n (%)	174 (90.6)	52 (27.1)	<0.001

Participants in the group 1 demonstrated significantly higher diabetes knowledge scores (72.4±8.3% vs. 54.2±9.7%, p<0.001) and better glycemic control with lower mean HbA1c levels (7.1±0.9% vs. 8.3±1.2%, p<0.001). The proportion achieving good glycemic control was significantly higher in the group 1 (46.4% vs. 17.7%, p<0.001). Oral health behaviors were substantially better among group 1 participants, with higher rates of twice-daily tooth brushing (87.0% vs. 53.6%, p<0.001), daily interdental cleaning (49.0% vs. 21.4%, p<0.001), and annual dental visits (71.9% vs. 39.6%, p<0.001). Awareness of the diabetes-periodontal disease relationship was markedly higher in the group 1 (81.3% vs. 35.4%, p<0.001).

**3.3 Periodontal Health Outcomes**

Table 3 presents the periodontal health outcomes comparing the two groups.

**Table 3. Periodontal Health Outcomes**

Periodontal Parameter	Intervention Group (n=192)	Control Group (n=192)	p-value
Probing pocket depth (mm), mean ± SD	3.2 ± 1.1	4.5 ± 1.4	<0.001
Clinical attachment loss (mm), mean ± SD	2.8 ± 1.3	4.1 ± 1.6	<0.001
Bleeding on probing (%)	28.4 ± 12.6	47.3 ± 15.8	<0.001

mean ± SD			
Number of sites with PPD ≥5mm, mean ± SD	8.3 ± 6.7	18.7 ± 11.4	<0.001
Community Periodontal Index score, mean ± SD	2.1 ± 0.8	3.2 ± 0.9	<0.001
<b>Periodontal disease severity, n (%)</b>			<0.001
Healthy/Gingivitis	67 (34.9)	22 (11.5)	
Mild periodontitis	78 (40.6)	51 (26.6)	
Moderate periodontitis	38 (19.8)	76 (39.6)	
Severe periodontitis	9 (4.7)	43 (22.4)	
<b>Controlled periodontal disease, n (%)</b>	145 (75.5)	73 (38.0)	<0.001

Participants in the group 1 exhibited significantly better periodontal health across all clinical parameters. Mean probing pocket depth was substantially lower in the group 1 (3.2±1.1 mm vs. 4.5±1.4 mm, p<0.001), as was clinical attachment loss (2.8±1.3 mm vs. 4.1±1.6 mm, p<0.001). Bleeding on probing, an indicator of active periodontal inflammation, was markedly reduced in the group 1 (28.4±12.6% vs. 47.3±15.8%, p<0.001). The mean number of sites with pathological pocket depth (≥5mm) was significantly lower among intervention participants (8.3±6.7 vs. 18.7±11.4, p<0.001). The distribution of periodontal disease severity differed significantly between groups (p<0.001). In the group 1, 75.5% had controlled periodontal disease (healthy/gingivitis or mild periodontitis) compared to only 38.0% in the control group. Severe periodontitis was present in 4.7% of group 1 participants versus 22.4% of controls.

### 3.4 Multivariable Analysis

Multivariable logistic regression analysis was conducted to identify independent predictors of controlled periodontal disease, adjusting for age, gender, education level, smoking status, diabetes duration, body mass index, and program participation. Results revealed that participation in diabetes awareness programs remained a significant independent predictor of controlled periodontal disease (adjusted OR=3.47, 95% CI: 2.18-5.52,  $p<0.001$ ). Other significant predictors included good glycemic control (HbA1c <7%) (adjusted OR=2.31, 95% CI: 1.42-3.76,  $p=0.001$ ), non-smoking status (adjusted OR=1.89, 95% CI: 1.15-3.11,  $p=0.012$ ), and higher education level (adjusted OR=1.76, 95% CI: 1.08-2.87,  $p=0.023$ ). Diabetes duration showed an inverse association with controlled periodontal disease (adjusted OR=0.91, 95% CI: 0.85-0.98,  $p=0.014$  per year increase).

### 4. DISCUSSION

This cross-sectional research offers a convincing piece of evidence to show that there is a very high degree of correlation between enrollment in diabetes education programs and better periodontal disease management amongst type 2 diabetes patients in community health. We have shown that people who received structured diabetes awareness programs portrayed significantly higher results in periodontal health outcomes, diabetes understanding, greater glycemic regulation and better oral health behaviours than those individuals that received normal care only.

The clinical significance of the differences in periodontal parameters observed in groups is observed. The mean probing depth of pockets and the clinical attachment loss decrease in the intervention group (1.3 mm) was higher than controls (1.3 mm) and the differences were greater than the minimum clinically important threshold set in periodontal studies<sup>16</sup>. These gains are translated into actual gains in periodontal health status with 75.5% of the participants in the intervention reporting controlled periodontal disease, as opposed to 38.0% of intervention controls. These results are in line with the emerging evidence that elaborate health education interventions of diabetes-periodontal interrelationships may favorably impact periodontal outcomes<sup>17</sup>.

The processes of these associations seem to be multifactorial. To begin with, the diabetes awareness programs had a great impact on the level of knowledge possessed by the participants on diabetes and its complications including the oral health implications. The difference in the percentage of 18.2 between the groups on knowledge about diabetes may indicate that structured education is effective in filling the gaps in knowledge. Past studies have also shown that health literacy and disease-specific knowledge are the key determinants of self-care practices and clinical outcomes of chronic disease management<sup>18</sup>. The

increased knowledge of the mutual dependence between diabetes and periodontal disease in the case of diabetes and periodontal disease is likely to influence people to develop preventive oral health policies<sup>19</sup>.

Second, we find that our study participants have significant positive changes in oral health behaviors. The study group showed much better levels of brushing their teeth twice per day (87.0% vs. 53.6%), cleaning their interdental area daily (49.0% vs. 21.4%), and once every year (71.9% vs. 39.6%). Such behavior changes are very crucial elements of periodontal disease prevention and control<sup>20</sup>. It has been shown that proper use of oral hygienic practices by mechanical plaque removals lowers periodontal inflammation and delays the progression of the disease<sup>21</sup>. Moreover, periodontal disease can be detected early and treated by a professional easily through frequent dental check-ups<sup>22</sup>. Third, better periodontal outcomes might be caused by a better glycemic control among the intervention participants (mean HbA1c 7.1% vs. 8.3%). The association between glycemic control and periodontal health has been clarified and hyperglycemia encourages periodontal tissue destruction through various pathophysiological mechanisms such as impaired immune activity, distorted cytokine incorporation and augmented oxidative stress<sup>23</sup>. On the other hand, better glycemic regulation also increases the ability of the periodontal tissue to repair as well as lowers the risk of infection<sup>24</sup>. The independent variables in our multivariable analysis were good glycemic control, which statistically predicted controlled periodontal disease and evidence on the biological plausibility of the pathway.

Program participation had an independent relationship with controlled periodontal disease (adjusted OR=3.47) even after the possible confounders were controlled, indicating that diabetes awareness programs have more beneficial effects beyond what are mediated by improved glycemic control or demographic factors. This observation means that such multifaceted character of these programs, which provide interventions on the level of knowledge, attitudes, behaviors, and clinical management, brings about synergistic advantages to periodontal health<sup>25</sup>. The educational aspect especially on oral health complications of diabetes might have been very powerful as the level of understanding about the diabetes-periodontal relationship in the intervention group (81.3% vs. 35.4%).

Other major predictors of the controlled periodontal disease, such as non-smoking status, higher education level, and limited duration of diabetes were also identified by us. The harmful impacts of smoking on periodontal health have been well reported where the use of tobacco compromises the immune system, alters perfusion of the tissues, and facilitates the colonization of pathogenic bacteria<sup>26</sup>. Health literacy and socioeconomic status are proxy variables that determine

access to healthcare, health seeking behaviors and self-care ability<sup>27</sup>. The negative correlation between the duration of diabetes and periodontal control indicates the accumulation of the weight of the chronic hyperglycemia on periodontal tissues over a lifetime<sup>28</sup>. These findings have important practical implications on community health planning and the delivery of diabetes care. Considering the inclusion of comprehensive oral health education in diabetes awareness campaigns is a cost-effective method of managing two significant chronic diseases at the same time. This is best done through community health centers where people of various kinds are usually served as a primary care center<sup>29</sup>. The management of the diabetes-periodontal relationship should be explicitly detailed in the curriculum, oral hygiene methods should be taught correctly, dental visits should be made frequent, and the communication between the medical and dental care providers should be made easier<sup>30</sup>.

There are various weaknesses that should be considered when interpreting our results. The cross-sectional design does not allow causal inference on the direction of program participation and periodontal outcomes relationships. The longitudinal research is necessary to determine the sequence of changes with time and to determine whether the participation in the program results in a long-term periodontal health improvement<sup>31</sup>. There was a risk of selection bias because the individuals who decided to attend awareness programs were not selected in a random manner with non-participants exhibiting some traits, including motivation or health consciousness, in an unknown manner. Despite the fact that we adjusted the effect of several confounders in multivariate analyses, residual confounding cannot be excluded<sup>32</sup>. Besides, there is dependency on self-reported oral health behavior, which presents a risk of recall and social desirability bias. The future studies must include objective tests of the oral hygiene like the plaque indices and the self-reports behaviors<sup>33</sup>.

Irrespective of these restrictions, our research gives a strong justification in favor of the interdependence of diabetes awareness programs and periodontal disease management. The large sample size, complete periodontal examination using calibrated examiners, analysis of various variables that could be relevant such as glycemic control and oral health behaviors, and the multivariable analyses of the confounding variables enhance the validity of our results<sup>34</sup>. The findings add to the accumulating literature that supports the use of unified methods in the management of diabetes and periodontal disease within the community<sup>35,36</sup>.

## 5. Conclusion

This study has shown that there is a strong positive correlation between attendance in diabetes awareness programmes and better periodontal disease management in the community population of type 2 diabetes patients.

The structured awareness participants had significantly improved periodontal health, such as decreased probing pocket depth, decreased clinical periodontal attachment loss, decreased bleeding on probing and decreased prevalence of moderate to severe periodontitis than the standard care only group did. These advantages seem to be corroborated by various channels such as increase in diabetes literacy, oral health practices, and the control of glycemia. The program participation was able to predict the controlled periodontal disease on its own after taking into account demographic and clinical confounders.

These results highlight the possible usefulness of oral health education as part of community-based diabetes education interventions to deal with the co-morbidity of diabetes and periodontal disease. These combined strategies can be compared to modern paradigms of managing chronic diseases that lay stress on holistic care, patient education, and prevention. The community health centers also need to think of integrating periodontal health elements into their diabetes education curriculum, whereas the healthcare givers ought to advise patients with diabetes on their increased vulnerability of periodontal disease and the significance of oral health prevention measures.

Long-term studies are required in the future to determine causation and assess the benefits of those studies that are observed in the long term. A series of interventions testing various models of integrated diabetes-periodontal education programs would assist in finding the best content, delivery strategies, and implementation of various settings of the community. Also, cost-efficiency studies would be useful in the policy making process on how such programs could be funded. Finally, the development of a comprehensive strategy addressing the issue of diabetes and periodontal disease with the help of community-based solutions is a potential measure to increase population health outcomes and decrease the burden of the two widespread chronic diseases.

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