Disparities in Periodontal Disease Occurrence in a Hispanic Population with Type 2 Diabetes: The LLIPDS Study

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Abstract

Objectives: Assessment of relevant social and behavioral factors can help understand their relationship with periodontal disease (PD) occurrence in individuals with type 2 diabetes (T2D).

Study Design: This is a cross-sectional work stemming from the study titled "Lipid lowering agents use in periodontitis and diabetes study" (LLIPDS).

Methods: In this study, 260 participants with T2D underwent a dental examination and completed an interview. Probing pocket depth (PPD) was measured at six sites per tooth, excluding the 3rd molars. Moderate/severe PD was defined as having a high (2nd and 3rd tertiles) percent of tooth sites with PPD ≥ 4 mm. A multivariate logistic regression model was used to assess the association between social-behavioral factors and the occurrence of PD.

Results: Moderate/severe PD cases (n = 155, 62%) were more likely to be younger, male, less educated, former smokers, and visited their dentists less frequently compared to no/mild PD cases. Age, gender, educational level, alcohol and smoking status, dental flossing and brushing habits, BMI and dental visits were incorporated in the model. Male gender (OR: 2.04, 95%CI: 1.15 - 3.62), lower educational level (OR: 1.99, 95%CI: 1.10 - 3.59) and less frequent dental visits (OR: 2.13, 95%CI: 1.13 - 4.01) were independently associated with increased PD occurrence.

Conclusion: Male gender, lower educational level and lower frequency of dental visits are social and behavioral factors that may contribute to the disparities in the occurrence of moderate/severe PD in Hispanic individuals with T2D.

Practical Implications: Results can be used to provide health education to T2D individuals, especially men, regarding the importance of dental visits in the outcomes of PD.

Keywords: Periodontal Disease; Type 2 Diabetes; Social Behavioral Factors; Oral Hygiene; Cross-Sectional Study, Public Health

Introduction

Type 2 Diabetes (T2D) is a chronic condition that affects glucose metabolism, which results from compromised insulin utilization along with insufficient compensatory insulin production [1]. From a National Health Interview Survey (NHIS) administered to 33,028 U.S. adults 18 years or older in 2016, the prevalence of T2D was 8.58%, which represented 21 million affected individuals [2]. The prevalence of T2D in Puerto Rico is even higher, with a mean unadjusted estimate of 14.3% for all counties [3]. Periodontal Disease (PD) is a chronic oral

infectious and inflammatory disease, which ultimately leads to the destruction of the tissues that support the teeth [4]. Based on the third National Health and Nutrition Examination Survey (NHANES III, 1988 - 1994), approximately 50% of dentate American adults aged ≥ 30 years had gingivitis on at least 3 teeth [5]. Chronic periodontitis, an irreversible form of PD with periodontal attachment and alveolar bone loss, is common as well, but is mostly observed in adults [6].

Based on the recent 2012 periodontitis case definitions provided by the Centers for Disease Control and Prevention in partnership with the American Academy of Periodontology (CDC-AAP definitions), 42.2% dentate U.S. adults aged 30 to 79 years in 2009 - 2014 were affected by periodontitis, of which 7.8% represented severe and 34.4% non-severe (i.e. mild or moderate) forms of the disease [7]. According to a study conducted in the San Juan area in Puerto Rico that examined elders aged 70 - 97, the prevalence of moderate and severe periodontitis (CDC-AAP) was 44.5% compared to 20.7% in the NHANES 1999 - 2004 survey among 75 years and older [8]. Individuals with T2D are more likely to have PD when compared to the general population [9,10]. Furthermore, PD may also affect diabetes control, as there is evidence for an interrelationship between the two diseases: PD worsens glycemic control while its proper management can improve it [11]. The coexistence of these conditions can eventually lead to the loss of tooth attachment and the alveolar bone, which leads to tooth loss [12].

The International Diabetes Federation has released new clinical guidelines that emphasize the importance of periodontal health for individuals with diabetes that include recommendations to have dental check-ups at least once a year [13]. In a multi-center cross-sectional study conducted in Amsterdam, Netherlands, approximately 24% of the 764 enrolled patients with T2D reported not to visit a dentist regularly. Moreover, nearly 70% of the enrolled patients reported to have experienced periodontitis, and 19% of the patients with T2D had impaired oral and general health-related quality of life [14].

To maintain periodontal health in individuals with T2D, it is important to identify the factors associated with periodontitis in this population. To the best of our knowledge, no other study has assessed socio-demographic and/or behavioral factors, that may be associated with an increased occurrence of severe PD among individuals with T2D in a Hispanic population, where this metabolic disease is highly prevalent [3].

Purpose of the Study

The purpose of this study was to assess socio-demographic, and/or behavioral risk factors, including individual's dental practices that may be related to PD among individuals with T2D. Understanding this relationship among these high-risk individuals can serve as a base for further PD control and prevention.

Methods

Study population

This cross-sectional study included 250 non-institutionalized individuals with T2D, aged 40 to 65 years, and residents of Puerto Rico who participated in the study titled "Lipid lowering agents use in periodontitis and diabetes study (LLIPDS). Participants consisted of volunteers from the general population (45%), including former participants with T2D from the San Juan Overweight Adults Longitudinal Study (SOALS); volunteers from lists of patients from the Puerto Rico Center for Diabetes (PRCD) (50%), and volunteers from the list of patients from COSSMA, a private island-wide decentralized health care organization (5%).

Among the inclusion criteria were: 1) having at least four natural teeth; 2) having a type 2 diabetes diagnosis, which was confirmed by medication(s) use or the results from fasting blood. Exclusion criteria included: 1) having any oral appliances, which might complicate the periodontal status evaluation; 2) taking steroids, anti-inflammatory drugs (except aspirin with doses of 150 mg or less), immunosup-

pressants, thiazolidinediones, glitazones or antibiotic therapy; 3) having regularly used any medication known to affect periodontal status for 2 weeks or more within 1 month prior to the clinical examination; 4) having systemic complications, or active infectious diseases within 6 months. Participants were also excluded if they 5) had been diagnosed with congenital or chronic heart diseases, endocarditis, rheumatic fever, or 6) had undergone procedures related to cardiovascular disease; or 12) had been diagnosed with cancer with active radio/immunotherapy.

The study was conducted between April 26, 2017 and March 9, 2020. Potential participants were briefed on the study's purpose and were screened based on inclusion and exclusion criteria. All potential participants were required to fast at least 9 hours prior their visit and bring written letters from their physicians, as well as laboratory results or medications labeled with their names to confirm their diabetes status. Eligibility criteria assessed at the screening session were confirmed prior to the start of the study procedures. This study was approved by the human subject ethics board of the Institutional Review Board (IRB), [approved on 03/09/2016, IRB #B0930116] and was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2013. Signed informed consent was obtained from all volunteer participants prior to performance of the study procedures.

Approximately 150 potential participants were interested in participating in the study and contacted the LLIPDS project. We also obtained a list of 134 potential participants with diabetes from SOALS and 100 volunteers from the PRCTRC data registry, who were contacted for screening. Due to the repeated individuals, we were able to contact approximately 1,520 potential participants out of nearly 2,590 from the lists provided by the PRCD. Late in the study, we were also able to contact 332 potential participants out of 494 from the list provided by COSSMA centers. Out of 595 screened participants, 267 were found to be eligible and completed the visit; 117 participants were eligible but did not participate in the study for different reasons (not assist after confirming, no answer for rescheduling, not interested in participating); 211 were further ineligible after additional screening for criteria. During the data management, we found 7of the participants who completed the visit to be ineligible and a total of 10 out of 260 participants were excluded due to missing values on dental visits, smoking status, alcohol status or PD status. Thus, a total of 250 participants were used in the present study (See figure 1).
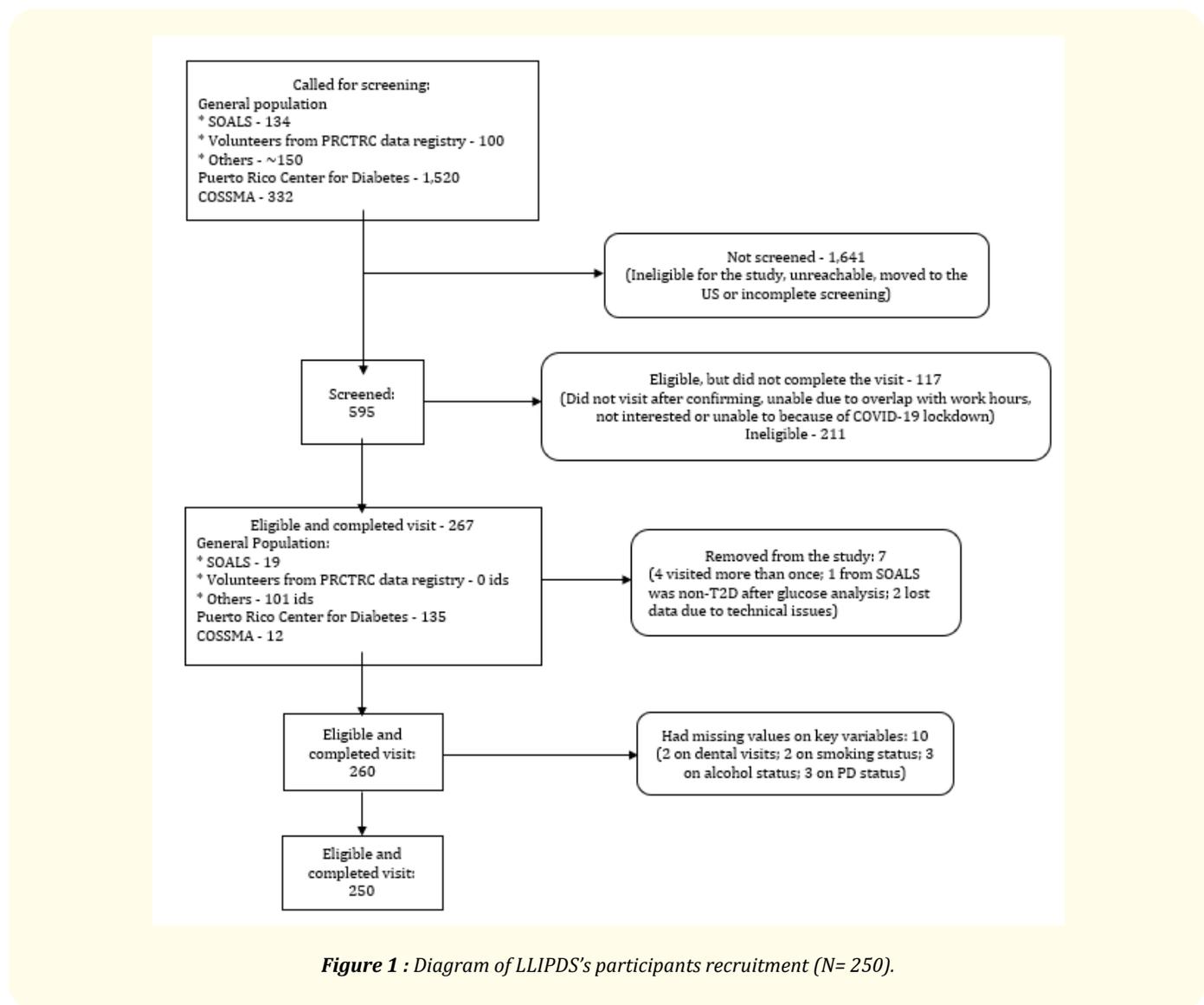

Figure 1 : Diagram of LLIPDS's participants recruitment (N= 250).

Clinical oral and dental examination

Participants underwent a thorough clinical oral and dental examination, which included assessment of soft and hard oral tissues, tooth loss count and measures of oral health hygiene and periodontal status. The measurement protocol was derived from NHANES III [15]. Periodontal probing pocket depth (PPD) was performed at the six sites per tooth for all teeth except the third molars. PPD was measured in millimeters and was rounded down if the reading fell between two probe markings [15]. The distribution of percentage of tooth sites with PPD ≥ 4 mm [16] across the sample was explored and skewness to the right was observed. To define PD, we dichotomized the PPD parameter as no/mild PD defined by the 1st tertile, and moderate/severe defined by the 2nd and 3rd tertiles combined.

The dental examination was performed by two dental examiners trained by the same NHANES reference examiner (Dr. Bruce Dye) in 2009 and calibrated by the same NHANES gold standard examiner and the Forsyth Institute gold standard examiner (Dr. Hatice Hasturk). Both dental examiners' measurement of PPD achieved more than 96% agreement with the reference gold standard examiners. The PPD of a total of 80 participants performed by the first dental examiner was compared with the PPD of a total of 170 participants performed by the second dental examiner. There was no significant difference in outcome measurement, percentage of tooth sites with PPD > = 4 mm, between the two dental examiners (p = 0.342).

Social and behavioral factors

Interview-based questionnaire: A well trained and qualified interviewer administered an interview-based questionnaire to the participants. The questionnaire collected information on socio-demographics [age, gender and educational level (≤ 12 years, > 12 years)], general health status, medical and/or dental health care visits (< 1 time within the last year, ≥ 1 time within the last year), medication usage or treatments, lifestyle practices such as smoking (never, former, current) and alcohol (abstainer, former, current) habits and oral hygiene routines [dental flossing (< 1 time a day, ≥ time 1 a day) and tooth brushing habits (< 2 times a day, ≥ 2 times a day)], and address information.

Anthropometric measurements

Weight and height recorded to the nearest 0.5 kg and 0.1 cm, respectively [17], were measured three times following the NHANES III Anthropometric standard procedures [15] and the average of the two measures was used. Body mass index (BMI) was calculated as weight (kilograms) divided by the height (meters) squared (kg/m^2). All the collected data was safely stored in a Redcap database [18,19].

Statistical analysis

The general characteristics of the study population by periodontal status (no/mild vs. moderate/severe PD). were described using the mean (standard deviation) or frequency (percent) of the variables of interest: age, gender, education, BMI, smoking status, alcohol status, frequency of dental visits, and tooth brushing and flossing habits. The independent association between different socio-demographic and behavioral factors (used as predictors) and the occurrence of PD (used as outcome) was assessed via a multivariable logistic regression model. A significance level of p < 0.05 was established. All statistical analyses were carried out using Stata for Macintosh version 13.

Results

Table 1 presents the distribution of the socio-demographic and behavioral factors by periodontal status. Participants with T2D who had moderate/severe PD were more likely to be male (52.26% vs. 32.63%, p = 0.002), less educated (41.29% vs. 25.26%, p = 0.010) and had less frequently visited their dentists (36.77% vs. 23.16%, p = 0.025) compared to participants with T2D who had no/mild PD. Although not statistically significant, participants with T2D who had moderate/severe PD also tended to be younger (25.16% vs. 18.95%,

p = 0.256), current (12.26% vs. 10.53%, p = 0.078) or former smokers (29.68% vs. 17.89%, p = 0.078), current drinkers (45.81% vs. 38.95%, p = 0.368), and overweight (26.14% vs. 24.21%, p = 0.562) as compared to participants with T2D who had no/mild PD.

Characteristics	No/Mild PD N (%)	Moderate/Severe PD N (%)	P-value
Age			
40 - 49	18 (18.95%)	39 (25.16%)	0.256
50 - 65	77 (81.05%)	116 (74.84%)	
Gender			
Female	64 (67.37%)	74 (47.74%)	0.002
Male	31 (32.63%)	81 (52.26%)	
Educational level			
> 12 yrs.	71 (74.74%)	91 (58.71%)	0.010
<= 12 yrs.	24 (25.26%)	64 (41.29%)	
Smoking status			
Current	10 (10.53%)	19 (12.26%)	0.078
Former	17 (17.89%)	46 (29.68%)	
Never	68 (71.58%)	90 (58.06%)	
Alcohol status			
Current	37 (38.95%)	71 (45.81%)	0.368
Former	30 (31.58%)	50 (32.26%)	
Abstainer	28 (29.47%)	34 (21.94%)	
BMI			
Obese	63 (66.32%)	104 (67.97%)	0.562
Overweight	23 (24.21%)	40 (26.14%)	
Under/normal	9 (9.47%)	9 (5.88%)	
Dental visits			
At least once within the last year	73 (76.84%)	98 (63.23%)	0.025
Less than once within the last year	22 (23.16%)	57 (36.77%)	
Dental flossing habits			
At least once a day	31 (32.63%)	65 (41.94%)	0.142
Less than once a day	64 (67.37%)	90 (58.06%)	
Dental brushing habits			
At least twice a day	79 (83.16%)	129 (83.23%)	0.989
Less than twice a day	16 (16.84%)	26 (16.77%)	
Total Periodontal Disease distribution	95 (38.00%)	155 (62.00%)	

Table 1: *Distribution of social and behavioral factors by occurrence of periodontal disease (N = 250).*

Table 2 displays the multivariable logistic regression model to assess the association between socio-demographic and behavioral factors and the PD outcome. After adjusting for age, sex, educational level, smoking and alcohol status, BMI, dental visits, dental flossing, and brushing habits, male participants (OR: 2.04, 95%CI: 1.15 - 3.62), participants with lower educational level (OR: 1.99, 95%CI: 1.10 - 3.59) and participants who visited their dentist less frequently (OR: 2.13, 95%CI: 1.13 - 4.01) had increased moderate/severe PD occurrence compared to the corresponding reference group counterparts. The other predictors did not show any significant associations with PD.

Characteristics	OR (95% CI)	P-value
Age	0.99 (0.95 - 1.05)	0.961
Gender (Ref: female):		
Male	2.04 (1.15 - 3.62)	0.014
Educational level (Ref: > 12 years):		
<= 12 years	1.99 (1.10 - 3.59)	0.023
Smoking status (Ref: Never):		
Current	1.26 (0.51 - 3.09)	0.614
Former	1.69 (0.84 - 3.40)	0.143
Alcohol status (Ref: Abstainer):		
Current	1.19 (0.58 - 2.45)	0.641
Former	1.11 (0.53 - 2.31)	0.784
BMI	1.01 (0.98 - 1.03)	0.573
Dental visits (Ref: ≥ 1 within the last year):		
< 1 within the last year	2.13 (1.13 - 4.01)	0.019
Dental flossing habits (Ref: ≥ 1 a day):		
< 1 a day	0.56 (0.31 - 1.01)	0.055
Dental brushing habits (Ref: ≥ 2 a day):		
< 2 a day	0.98 (0.46 - 2.08)	0.955

***Table 2:** Estimates (OR, 95% CI) for the association between social and behavioral factors and the occurrence of moderate/severe pd from the multivariate logistic regression model (N = 250).*

Discussion

Very few studies in the literature have assessed the relationship between socio-demographic and/or behavioral factors and periodontal status among Hispanic individuals with T2D. The present study would be among the first to suggest independent associations between male gender, low educational level or low frequency of dental visits with severity of PD among Hispanic individuals with T2D.

A study by Kiedrowicz., *et al.* (2015), which compared the periodontal status of 75 patients with T2D based on glycated hemoglobin levels and other risk factors, supported our finding on male gender to be a significant risk factor for periodontal disease in patients with T2D [20].

In support of our finding on the potential role of educational level on the occurrence of PD in T2D, a recent study conducted with 2,436 patients with T2D, aged 29-93 years who went to 27 Japanese medical clinics suggested low education to be one of the important predictors of poor periodontal status in patients with T2D [21]. Likewise, a recent cross-sectional study by Yokoshuma., *et al.* (2018), conducted among 503 subjects with type 2 diabetes supported our findings on the associations between lower educational scores [22].

Though not carried out in adults and/or individuals with T2D, a retrospective study by Farsi (2010) conducted in a representative sample of 3,090 Saudi Arabian young students showed the highest occurrence of healthy periodontium (~ 24%) without complex treatment need among students who had dentist annual reminders for checkups (~ 3% students) [23]. In the present study, participants with moderate/severe PD tended to be younger (p = 0.256) and visited their dentists less frequently (p = 0.025).

Our results suggested a marginal association between lower frequency of dental flossing and a lower occurrence of moderate/severe PD (OR < 1). Although this is inconsistent with some findings, as was the case in a study that used the NHANES 2011 - 2014, where they found that a higher percentage of individuals, who flossed once a week at most, showed indications of PD as compared to those who flossed more frequently [24], other studies conducted in various general populations did not find any association between self-interdental cleaning and clinical attachment or long-term change in periodontal pocket [25]. Nonetheless, our estimate of the association might be due to the temporal limitations of a cross-sectional study and individuals might have actually been disregarding their flossing habits given that they may not suspect a possible moderate/severe PD status.

We did not find any association between factors such as age, frequency of tooth brushing, smoking or alcohol consumption and the occurrence of moderate/severe PD among individuals with T2D. However, the 2012 Korean NHANES' data suggested current smoking status as an independent risk factor for periodontitis among adults with T2D [26]. Nevertheless, similar to our findings, the same study did not find any association between age or frequency of tooth brushing and occurrence of PD among adults with T2D.

Diabetes prevalence in Puerto Rico in 2017 was 17.2% compared with 10.5% in the U.S [27]. Though the case the definitions of PD are different, the 62.00% prevalence of moderate/severe form of PD, defined by percentage of sites with PD ≥ 4 mm, in the individuals with T2D from the present study, was higher than the 44.5% prevalence in the Puerto Rican elderly population, defined by CDC-AAP definitions for moderate and severe periodontitis [8]. The identified social and behavioral risk factors, such as male gender, frequency of dental visits and educational level are modifiable risk factors for PD, which can maintain and/or improve oral and general health in this high-risk population.

In the present study, men (~ 65%) tended to visit the dentist less often than women (~ 71%), rendering them to be more prone to PD. The study by Farsi., *et al.* (2010), though not conducted in individuals with T2D, showed women sought dental services more regularly than men and that the use of dental services was associated with good periodontal health, especially if the dental visits were reminders given out by the dentists [23].

The lack of general education could be the most important factor covering these modifiable oral health behaviors, which all lead to PD outcome. Oral health education programs at any age can be implemented to effectively improve oral health [28]. A periodontal disease care program for individuals with T2D, which offered diabetes and periodontitis education and encouraged self-care habits effectively improved periodontal status and dental health-related behaviors in the population from Nishihara's (2017) study [29].

As with any cross-sectional study, there are limitations in possible recall bias and temporal issues. Selection bias might have occurred as well. The sample was drawn by convenience from individuals with T2D, where PD and tooth loss are common, in order to address the oral health-related quality of life in this high-risk population. Nonetheless, in terms of strengths, most individuals with T2D residing in the San Juan municipality attended the PRCD for their follow-up, which is where about half of the study participants were selected from (50%). Approximately 45% of the participants were recruited from the general population, and efforts were made to find potential par-

ticipants outside the San Juan municipality, including COSSMA (5%) to achieve a more balanced distribution of the study population. Comparison of the general characteristics (i.e. age, gender, education level or smoking status) of participants by recruitment source did not show any significant difference (p > 0.05). To the best of our knowledge, this is the first study assessing the associations between social and behavioral determinants of periodontal health, especially frequency of dental visits or the use of dental flossing among individuals with T2D in a Hispanic and Caribbean population. The study collected a vast range of factors, which could be related to periodontal status or other chronic health outcomes for further potential hypotheses formulations. It also involved rigorous periodontal measurements using the NHANES oral health assessment protocol, the gold standard in clinical periodontal examination.

Conclusion

Our results suggest that being male, having a lower educational level, and lower frequency of dental visits is associated with an increased occurrence of PD among Hispanic Puerto Rican adults with T2D. Understanding these relationships among individuals with T2D is fundamental for disease control and is highly relevant to address public health issues. There is a need for common general and oral health promotion strategies with behavioral interventions. Individuals with T2D should be encouraged to visit their dentists more frequently to prevent or treat PD, which helps improve their diabetes status. Said individuals should be educated on the disadvantages and complications that poor oral health care might bring to their oral health and overall quality of life. It is recommended that Hispanic individuals with T2D, especially men, be provided more rigorous education regarding the importance of dental visits and oral hygiene habits. Such intervention could ultimately improve the oral and general state of health in these high risk individuals.

Conflicts of Interest

None.

Acknowledgements

Authors' Contributions

JR contributed to study conception and design, data analysis, data interpretation, and the drafting of the manuscript. CM presented the work at the Online Congress on Diabetes and Endocrinology and contributed to the drafting of the manuscript. JLV and JV contributed to data acquisition. OMA contributed to data acquisition, data interpretation and the drafting of the manuscript. JR, CM, JLV, JV, and OMA critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of the work.

Declaration of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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