ORIGINAL ARTICLE

Effect of diabetes mellitus as a modifier with periodontitis severity and oral health–related quality of life in older adults: a cross-sectional study

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ABSTRACT

Introduction: The main complication of diabetes mellitus (DM) in the oral cavity is periodontitis. Periodontitis is one of the conditions that affects quality of life because it causes psychological discomfort, stress, interpersonal relationship problems, and difficulties in daily activities. The objective of this study was to analyze the effect of diabetes mellitus as a modifier with periodontitis severity and oral health–related quality of life in older adults. **Methods**: This study used a cross-sectional design, which can provide preliminary evidence of potential causal relationships. The subjects were 302 elderly individuals aged ≥ 60 years who still had at least 6 teeth representing 6 regions. The study variables were periodontitis severity, Oral Health-Related Quality of Life (OHRQoL), and diabetes mellitus (DM). Periodontitis was diagnosed using the classification from the American Association of Periodontology (AAP) and the European Federation of Periodontology (EFP) in 2018, using the Clinical Attachment Loss (CAL) indicator. The Geriatric Oral Health Assessment Index (GOHAI) was used to measure OHRQoL. DM status was diagnosed using HbA1c levels. Data analysis was performed using multiple linear regression with a significance level of 0.05. **Results**: The majority of participants had severe periodontitis (73.8%) followed by moderate periodontitis (22.2%) and mild periodontitis (4%). The results of multiple linear regression analysis showed an interaction between uncontrolled DM and periodontitis on OHRQoL (Adj.β = -11, p=0.05). **Conclusions**: Diabetes mellitus acts as a modifier on the relationship between periodontitis severity and OHRQoL. The more severe the periodontitis, the lower the OHRQoL. Uncontrolled DM influences the direct relationship between periodontitis severity and OHRQoL. The relationship between periodontitis severity and OHRQoL is stronger and more pronounced in individuals with uncontrolled DM.

KEYWORDS

Elderly, periodontitis, diabetes mellitus, oral health-related quality of life, effect modification

INTRODUCTION

The prevalence of oral diseases in the elderly aged 65 and above has shown a significant increase, and the burden of disease is concentrated on dental caries, periodontal disease and tooth loss. Oral health issues in older persons (aged ≥ 65), including inflammatory or non-inflammatory disorders,

such as dental caries, periodontal disease, tooth loss, oral cancer, dry mouth, and dysphagia, demonstrate multidirectional links with systemic health.[1] Type 2 diabetes mellitus accounts for the majority of diabetics worldwide. The main complication of diabetes mellitus (DM) in the oral cavity is periodontitis.[2]

Periodontal inflammation is most commonly triggered by bacteria present in excessive accumulations of dental plaque (biofilm) on tooth surfaces.[3] Diabetes mellitus and periodontitis have a bidirectional relationship. Hyperglycemia in patients with DM increases Advanced Glycation End products (AGEs), which bind to AGE receptors on the periodontal tissue endothelium and cause oxidative stress, resulting in impaired delivery of nutrients and oxygen. Anaerobic gram-negative bacteria which are commensal bacteria in periodontal pockets become more pathogenic resulting in periodontitis. On the other hand, inflammatory mediators released due to periodontitis, such as Tumor Necrotizing Factors-Alpha (TNF-α), Inter Leukin-6 (IL-6) and Inter Leukin-1 (IL-1) increase.[4]

These inflammatory mediators have an important effect on lipid and glucose metabolism, acting as insulin antagonists, thereby increasing blood sugar levels and exacerbating hyperglycemia in patients with DM.[4,5] Periodontitis develops through a complicated interaction between oral bacteria and the host's immune response. Imbalances in the oral microbiota, particularly the development of pathogenic bacteria such as Porphyromonas gingivalis, disrupt the normal balance of periodontal tissues. The microbial dysbiosis, combined with the host inflammatory response, leads to progressive tissue damage. Chronic inflammation associated with periodontitis has been linked to a variety of systemic disorders, including cardiovascular disease, diabetes, respiratory disease, and poor pregnancy outcomes.[6]

Oral diseases such as caries, gingivitis, and periodontitis often result from inadequate oral hygiene (OH).[7] A previous study reported that most participants demonstrated moderate knowledge and attitudes, but a significant proportion practiced inadequate hygiene.[8] Periodontitis is an infectious disease caused by periodontopathogenic bacteria in dental plaque biofilm, leading to periodontal ligament and alveolar bone damage in susceptible individuals. Hyperglycemia can affect the migration and phagocytic activity of mononuclear and PMN cells, resulting in more severe disease, and thus periodontitis in patients with DM is more progressive than those without DM.[4]

Inflammatory mediators such as Prostaglandin E2 (PGE2) or cytokines such as TNF-α and IL-1 can stimulate the production and activity of enzymes that damage gingival connective tissue and the production of osteoclasts that will resorb alveolar bone.[9] The pro-inflammatory state results in elevated levels of inflammatory mediators, including TNF-α, and oxidative stress, which impairs important biological functions. Hyperglycemia appears to be the most common cause of periodontal disease.

Chronic hyperglycemia produces increased oxidative stress in the periodontal tissues as well as raised levels of inflammatory mediators. These mediators eventually contribute to the breakdown of the crestal alveolar bone, causing periodontitis. Periodontal treatment improves both infection management and overall health, resulting in better blood glucose control for patients with type 2 diabetes.[10] The common genes imply that periodontal disease is not causally linked to diabetes, but rather that they are both consequences of analogue aberrant inflammatory pathways.[4]

Poor periodontal status impacts quality of life. Geriatric Oral Health Assessment Index (GOHAI) was used to assess the quality of life associated with oral health. The 12-item GOHAI questionnaire was designed to examine three areas of OHRQoL: physical function, pain or discomfort, and psychosocial function. It is a six-point Likert scale ranging from never, seldom, sometimes, often, very often, and always, with a score of 0 to 5. The final score ranges from 0 to 60, with a higher number indicating improved OHRQoL. The greater

GOHAI score, the better OHRQoL.[12] The total OHRQoL score which indicates the level of quality of life is influenced by the factors of periodontitis, dental caries and missing teeth.[11]

Periodontitis is one of the conditions that impact quality of life as it causes psychological discomfort, stress, interpersonal relationship problems, and difficulties in daily activities.[12] Periodontitis is different from gingivitis, because in periodontitis clinical attachment loss or CAL has occurred. Clinical attachment loss is a result of damage to the periodontal ligament and alveolar bone.[13]

A case of periodontitis is defined by an interdental clinical attachment loss of 2 mm or more at two or more non-adjacent teeth or a buccal or oral clinical attachment loss of 3 mm or more with a pocket depth of 3 mm or more for two or more teeth. CAL records the extent and severity of the periodontal lesion.The clinical attachment was lost as a result of the microbial dysbiosis, which triggered a host reaction that resulted in the loss of connective tissue fiber attachment to the teeth. It is irreparable damage to the tooth's supporting mechanism that, without any regenerative attempts, will be lost for the life of a tooth. [14,15]

The bidirectional relationship between diabetes mellitus and periodontal disease is well-documented, with poor glycemic control exacerbating periodontal inflammation, each condition can adversely influence the other. Periodontal inflammation can adversely affect glycemic control by increasing insulin resistance. Inflammatory cytokines released from periodontal tissues can interfere with insulin signaling pathways, worsening blood glucose levels and complicating diabetes management.[6]

The novelty of this study is the concept of interaction between the severity of periodontitis and DM with the HbA1c level indicator. The aim of this study was to analyze the effect of diabetes mellitus as a modifier with periodontitis severity and oral health–related quality of life in older adults.

METHODS

This study employed an observational cross-sectional design.[20] Data collection was conducted from June to September 2022 at the PROLANIS Program, in 11 community health centers/primary care clinics in Yogyakarta, with EC number KE/FK/0686/EC. Sample size calculation was performed using the formula for cross-sectional research with differences between two means, Za (1.96) and Zb (0.84) which were related to the confidence interval (95%) and power (80%) σ was the estimated standard deviation, and the minimum sample size obtained was 63.[16,17]

The minimum sample size was 63, however a total 302 elderly individuals aged 60 years and above, were included using purposive sampling techniques. Inclusion criteria were residing in Yogyakarta Province, communicative and cooperative, and willing to be a respondent (agreeing to informed consent). Exclusion criteria included participants who were ill during data collection and unable to complete the study. Periodontitis severity was assessed using clinical parameters, namely interdental CAL. Data collection was carried out by 4 dentists who had been given training in CAL measurement by a periodontist. The similarity of the perceptions of 4 dentists in making these measurements was measured using Interclass correlation coefficient, which was found to be 0.76 (p=0.01). These results explain that the perception between 4 dentists in measuring CAL was the same.

The severity of periodontitis in this study was based on the EFP/AAP/CDC 2018 classification, using the CAL parameter. The severity of periodontitis was defined by interdental CAL. Measurements were made using the WHO's CPI Probe, measured from the reference point, namely the cementoenamel junction to the bottom of the probable crevice. Periodontitis severity categories include mild periodontitis (interdental CAL 1-2 mm), moderate periodontitis

(interdental CAL > 2-4 mm) and severe periodontitis (interdental CAL>4 mm).[18]

Oral Health Related Quality of Life in this study was an assessment of a person's quality of life status based on physical, functional, pain or discomfort and psychosocial aspects related to conditions in the oral cavity, measured using the GOHAI questionnaire (adoption from Agustina et.al., 2018) which was conducted by interviewing respondents. The questionnaire consists of three domains: physical function, pain or discomfort, and psychological aspects. The questions were read out and explained with real-life examples by the surveyors to make it easier for the elderly to understand. Answers were measured with 6 Likert scale scores, namely score 5 (never), score 4 (very rarely), score 3 (sometimes), score 2 (often), score 1 (very often) and score 0 (always).[19]

The scores obtained from the 12 statement items were then summed up, resulting in a GOHAI score with a total score between 0 and 60. Diabetes mellitus was established by measuring HbA1c. HbA1c measurements were taken directly at the time of data collection, with a cut-off value between controlled and uncontrolled DM of 7%. Age, occupation and smoking as covariates were measured using questionnaires.[20,21]

These measurements were taken to minimize the effect of outcome interest. Statistical analyses included chi square tests, independent t-tests, simple linear regression and multiple linear regression, with a significance level of 0.05. All analyses were performed using STATA 18 software. Diabetes mellitus status (controlled vs. uncontrolled) and periodontitis severity were hypothesized to have an interaction effect on OHRQoL; therefore, interaction analysis was performed using multiple linear regression. The regression model was determined based on AIC, with the model showing the lowest AIC selected as the final model.

RESULTS

Among the 302 participants with periodontitis, the majority had severe periodontitis (73.8%) followed by moderate (22.2%) and mild periodontitis (4%). Most participants were female (63.2%), while the most common occupation and education levels were non-civil servants (56.6%) and elementary-high school (65.9%). Females were more prevalent in the controlled DM group than in the uncontrolled group. Civil servant employment and education of at least diploma/graduate were more common in the controlled DM group than in the uncontrolled group.

The average age of participants was older and the mean OHRQoL score was higher in the controlled DM group than in the uncontrolled (Table 1). Participants with severe periodontitis had a lower mean quality of life compared to those with moderate or mild periodontitis, while participants with uncontrolled DM status had a lower mean quality of life scores than those with controlled DM. Participants with a high level of education had a higher mean quality of life score than those who did not complete primary school (Table 2).

The severity of periodontitis had a significant association with the mean quality of life score. Participants with severe periodontitis had a lower mean score of 3.9 points than people with moderate or mild periodontitis, and participants with employment status as civil servants had a higher mean score of 10.9 than participants with employment status as housewives. Participants who had uncontrolled DM had an average quality of life score lower by 3.8 points than participants with controlled DM. The severity of periodontitis had a significant association with the mean quality of life score.

Table 1. Characteristic and DM status of respondents

Research Variables	Controlled DM	Uncontrolled DM	Total	P-value[1]
	n (%) (N=178)	n (%) (N=124)	n (%) (N=302)	
Gender				
Male	66 (37.1)	45 (36.3)	111 (36.8)	0.02
Female	112 (62.9)	79 (63.7)	191 (63.2)	
Employment				
Retired Civil Servant	31 (17.4)	8 (6.5)	39 (12.9)	
Retired Non-Civil Servant	91 (51.1)	80 (64.5)	171 (56.6)	0.010
Housewife	56 (31.5)	36 (29.0)	92 (30.5)	
Education				
College	48 (27.0)	19 (15.3)	67 (22.2)	
Elementary-Senior	115 (64.6)	84 (67.7)	199 (65.9)	0.011
No Education	15 (8.4)	21 (16.9)	36 (11.9)	
Severity of Periodontitis				
Severe	123 (69.1)	100 (80.6)	223 (73.8)	
Moderate	46 (25.8)	21 (16.9)	67 (22.2)	0.253
Mild	9 (5.1)	3 (2.4)	12 (4.0)	
OHRQoL Score	38.56±13.12	33.86±12.39	36.6±13.0	0.002

[1]chi square test or independent t test

Table 2. Bivariate analysis between OHRQoL and independent variables

Research Variables	Coefficient β	95% CI	P-value[1]
Gender			
Female	-0.17	-3.22 – 2.89	0.915
Male	Ref*		
Employment			
Retired Civil Servants	10.13	5.41 – 14.84	0.001
Retired Non Civil Servants	0.60	-2.59 – 3.79	0.713
Housewife	Ref*		
Education			
College	7.42	2.22 – 12.62	0.005
Elementary-Senior	4.01	-0.55 0 8.57	0.085
No Education	Ref*		
Severity of Periodontitis			
Severe	-3.49	-6.81 – (-0.18)	0.039
Moderate	Ref*		
Mild			

[1]Simple Linear Regression Test, *Ref=Refference

Participants who had uncontrolled DM had an average quality of life score that was 3.8 points lower than participants with controlled DM. Participants who smoked had mean OHRQoL scores approximately 6 points lower than non-smokers, and increasing age was associated with a 0.27 points decrease in mean OHRQoL score per year (Table 3).

Table 3. Multivariate analysis of dependent variables to OHRQoL

Research Variables	Model 1 Adj. β (95% CI)	Model 2 Adj. β (95% CI)	Model 3 Adj. β (95% CI)
Severity of Periodontitis			
Severe	-3.70 (-6.88-(-0.52)*	-3.65 (-6.84-(-0.47)*	-3,94 (-7,113-(-0,75)*
Moderate/Mild	Ref	Ref	Ref
Employment			
Retired Civil	11.02 (5.64-16.58)***	10.89 (6.27-15,51)***	10,93 (6,28-15,58)***
Retired Non-Civil	2.24 (-1.39-5.87)	2.22 (-0.97-5,41)	2,28 (-0,91-5,47)
Housewife	Ref	Ref	Ref
Gender			
Female	0.07 (-3.59-3.74)	-	-
Male	Ref		
Education			
College	1.79 (-3.78-7.35)	-	-
Elementary-Senior	2.53 (-1.89-6.95)		
No Education	Ref		
DM Status			
Uncontrolled	-3.68 (-6.57-(-0.78))*	-3.86 (-6.73-(-0.98))**	-3,80 (-6,69-(-0,91)*
Controlled	Ref	Ref	Ref

*p<0,05; **p<0,01; ***p<0,001,Ref=Refference, - (does'nt include in model)

Participants with uncontrolled DM and severe periodontitis had a mean quality of life score that was 11 points lower than participants with controlled DM and mild periodontitis. A significant interaction was observed between uncontrolled DM and periodontitis (Table 4).

Table 4. Interaction analysis between uncontrolled DM status and periodontitis to the oral health related quality of life (multiple linear regression test)

Research Variables	Adj β	95% CI	P-value	AIC
Uncontrolled DM and Periodontitis[1]				
1. Uncontrolled DM and severe periodontitis	-11.30	-19,17-(-	0,005	2376,28
2. Uncontrolled DM and Moderate-mild periodontitis	-3.58	3.43)	0,021	
3. Controlled DM and severe periodontitis	-5.16	-6.62-(-0.54)	0,149	
4. Controlled DM and moderate-mild periodontitis	Ref.*	-12.16-1.85		

[1]Controlled by employment, age, and smoking variables,*Ref=Refference

DISCUSSION

The average age of participants was older and the mean OHRQoL score was higher in the controlled DM group than the uncontrolled group (Table 1). Advancing age is associated with a physiological decline in organ function, resulting in an increase in the incidence of acute and chronic diseases, such as diabetes mellitus, heart disease, and stroke. Diabetes mellitus presents with macrovascular and microvascular complications, including oral manifestations such as periodontitis and xerostomia. Complications of DM, both in general and in the oral cavity, affect an individual's quality of life. These findings are consistent with previous research by Slowik et.al, which states that individuals with periodontitis have a poorer quality of life compared to individuals without periodontitis; the more severe the periodontitis, the poorer the quality of life.[22]

Occupation, education level, smoking status, periodontitis severity, and DM status are associated with OHRQoL (Table 2). Sociodemographic factors such as occupation and education level are factors related to a person's quality of life. Occupation reflects socioeconomic status, which impacts health behavior by individuals or communities. A higher level of education correlates with the level of health knowledge. Education level can support health literacy and oral health literacy skills. In addition, individuals with higher education levels often possess better coping skills. Individuals or communities with high socioeconomic status and education are better able to access promotive, preventive, curative, and rehabilitative care, thereby maintaining their quality of life.

Sociodemographic factors such as occupation affect DM status (Table 3). Gender and education were not included in models 2 and 3. Employment reflects the level of income and socioeconomic status of the community. Socioeconomic status is related to promotive and preventive health behavior and health seeking behavior. Females constituted the majority of participants with controlled DM status. Gender differences in DM status reflect differences in lifestyle, such as lack of physical activity, obesity, and an unhealthy diet. Employment is related to a person's socioeconomic status and level of knowledge.

This is in line with previous research stating that knowledge is an important factor in DM disease prevention and treatment programs in populations with high cultural diversity. Lifestyles are still the main reason for the increase in DM cases in Indonesia.[23] Severe periodontitis is a major cause of tooth loss, which affects masticatory dysfunction. Decreased masticatory efficacy is a predisposing factor for malnutrition. Tooth loss leads to malocclusion and TMJ disorders, and is directly related to reduced quality of life.[24] The elderly who experience severe tooth loss may develop masticatory problems; therefore, they tend to have limited food choices.[25]

Chronic periodontitis is associated with poorer OHRQoL compared to individuals without periodontitis, regardless of age and gender. Periodontitis has a significant impact on functional, social and psychosocial aspects.[26] The results of this study indicate that there is an interaction between uncontrolled DM and periodontitis. This shows that DM status acts as a modifying factor effect on the relationship between periodontitis severity and quality of life in the elderly. DM variables can strengthen or weaken the relationship between the two,greater periodontitis severity combined with uncontrolled DM is associated with lower quality-of-life scores. Conversely, severe periodontitis with controlled DM does not significantly affect quality of life. Individuals with chronic periodontitis reported a negative impact on quality of life.[27]

Research suggests that treating periodontitis can improve glycemic management by increasing insulin sensitivity.[21,28] Periodontal disease is more prevalent, incident, and severe among individuals with diabetes, negatively impacting quality of life. Using quality-of-life questionnaires and various clinical criteria, studies linked periodontal disease to functional limitation, pain, and psychological and physical disability, underscoring the need for integrated diabetes and periodontal health management.[29]

Susceptibility to increased severity of periodontitis in hyperglycemic conditions is partly due to neutrophil dysfunction, abnormal collagen glycosylation and cross-linking, and impaired healing.[4] Cytokine levels in the gingival sulcus fluid of patients with DM are higher than those in non-DM patients and contribute to more bone resorption and soft tissue damage. This occurs despite similar bacterial composition between DM and non-DM patients.

Alveolar bone resorption and soft tissue destruction lead to tooth loss. The effects of tooth loss include physical impairment related to the number of missing teeth, speech difficulties, appearance problems, chewing difficulties, mobility of adjacent teeth and halitosis.[1] This is supported by Hazara, who states that losing all teeth can be an emotional burden, reduce self-confidence, anxiety and depression.[30] Severe periodontitis is the main cause of tooth loss, resulting in decreased masticatory efficacy, malocclusion and TMJ disorders, and is directly related to decreased quality of life.[24]

Periodontitis is one of the conditions that impact quality of life as it causes psychological discomfort, stress, interpersonal relationship problems, and difficulties in daily activities. Individuals with periodontitis have a worse quality of life than those without the condition; increasing severity is associated with progressively poorer quality of life.[31] Diabetes has an impact on certain areas of life quality. Patients with diabetes did not only demonstrate improvements in their clinical periodontal health after treatment, but also improvements in quality of life.[32]

Based on these results (Table 4), statements from various researchers suggest that uncontrolled DM status can exacerbate periodontitis in various pathways, but do not examine potential moderating factors that influence the relationship between the two. The results of this study contribute to the understanding of the severity of periodontitis and potential moderators, namely DM status, which can affect the quality of life in the elderly. Non-probability sampling is a limitation in this study because randomized sampling is difficult to perform. A meta-analysis conducted by Homagarini et al. (2023) on 11 studies with cohort, case-control, and cross-sectional designs concluded that DM has no statistically significant relationship with quality of life. However, based on a review of these articles, DM can cause functional limitations, physical pain, and psychological discomfort. On the other hand, complications of DM such as xerostomia and periodontal problems have a negative impact on the well-being and quality of life of individuals.[33]

There is a need for policies supporting the implementation of integrated strategies in primary health care settings for patients with DM and periodontitis to improve care effectiveness, reduce risk factors, prevent complications, and

enhance quality of life in the elderly. DM significantly reduces quality of life. This highlights the intricate relationship between periodontal health and systemic illnesses. Periodontitis has a significant role in lowering quality of life among those with DM, reinforcing the need for integrated healthcare strategies that address both diabetes and periodontal disease management.

The limitation of this study is that the respondents consisted of 302 elderly PROLANIS participants, which may not fully represent the broader elderly population. The characteristics of elderly in a widespread community were unrepresented. Future research should include more representative samples to better capture the characteristics of the general elderly population.

CONCLUSION

Diabetes mellitus acts as a modifying factor in the relationship between the severity of periodontitis and OHRQoL in the elderly. The clinical implication of this study is that DM and periodontitis are conditions that can jointly worsen the quality of life, highlighting the importance of their management in improving the quality of life of the elderly. Periodontal treatment and DM treatment contribute to improved clinical outcomes in a bidirectional manner. The relationship between periodontitis severity and OHRQoL is greater and stronger in patients with uncontrolled DM. Future research should include more representative samples of the broader elderly population to capture diverse characteristics. The implication of this research is the need for policies promoting the involvement of dentists in the PROLANIS program/health center to prevent the progression of DM-related periodontitis and improve quality of life in the elderly.

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