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

Sri Utami[1]*
Hari Kusnanto[2]
Dibyo Pramono[3]
Novitasari Ratna Astuti[1]
Afina Hasnasari Heningtyas[1],
Nova Oktavia[4]
Fannisa Afrilyana Ulyanah[5]

[1]Department of Dental Public Health, Faculty of Dentistry, Universitas Muhammadiyah Yogyakarta, Indonesia
[2]Department of Family Medicine, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada Yogyakarta Indonesia
[3]Department of Dental Public Health, Faculty of Dentistry Universitas Gadjah Mada Yogyakarta Indonesia
[4]Department of Medical Record, Faculty of Pharmacy, Universitas Muhammadiyah Kuningan, Indonesia
[5]Department of Stomatognathic Function and Occlusal Reconstruction, Tokushima University, Japan.

* Correspondence:
Sri.utami@umy.ac.id

Received: 8 January 2026
Revised: 13 Februari 2026
Accepted: 20 March 2026
Published: 31 March 2026
DOI:10.24198/pjd.vol38no1.67700

p-ISSN 1979-0201
e-ISSN 2549-6212

Citation:
Utami, S, Kusnanto, H, Pramono, D, Astuti, NR, Heningtyas, AH, Oktavia, N, Ulyanah, FA. Effect of diabetes mellitus as a modifier with periodontitis severity and oral health–related quality of life in older adults: a cross-sectional study.Padjajaran J. Dent. March. 2026; 38(1): 35–44.

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 is a cross-sectional study, where this design can be used to provide the groundwork to infer preliminary evidence for a causal relationship. The subjects were 302 elderly individuals aged ≥ 60 years who still had at least 6 teeth representing 6 regions. The study variables were the severity of periodontitis, 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 that there was an interaction between uncontrolled DM and periodontitis on OHRQoL (Adj.β = -11, p=0.05). **Conclusions**: Diabetes mellitus acts as a modifier effect on the relationship between the severity of periodontitis 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 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 showed a significant increase, and the burden of disease was 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 their multidirectional links with systemic health.[1] Type 2 diabetes mellitus accounts for the majority of diabetics worldwide. The main complication of 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 conditions in DM patients increase the Advanced Glycation End product-highly oxidant compound/AGE, which then binds to AGE receptor on the periodontal tissue endothelium and causes oxidative stress, resulting in impaired distribution 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, namely as insulin antagonists, thereby increasing blood sugar levels and exacerbating hyperglycemia conditions in patients with DM.[4,5] Periodontitis develops through a complicated interaction between the oral bacteria and the host's immune response. Imbalances in the oral microbiota, particularly the development of pathogenic bacteria such as Porphyromonas gingivalis disturb the normal balance of periodontal tissues. The microbial dysbiosis, combined with the host's inflammatory response, causes 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] Previous study stated that the majority of participants had 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, in susceptible individuals causing damage to the periodontal ligament and alveolar bone. Hyperglycemia can affect the migration and phagocytic activity of mononuclear and PMN cells so that even though they are affected by the same bacteria, 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 generates an increase in inflammatory mediators such 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 type of research is observational with a cross-sectional design.[20] Data collection was conducted from June to September 2022 at PROLANIS Program, in 11 community health centers/primary care clinics in Yogyakarta with EC number KE/FK/0686/EC. Sample calculation was based on the sample size 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, but the sample size actually used in this study was 302 elderly people aged 60 years and over, which was taken using purposive sampling techniques. Inclusion criteria include residing in Yogyakarta Province, communicative and cooperative, and willing to be a respondent (agreeing to informed consent). Exclusion criteria included the respondent was ill at the time of data collection, so it could not be continued until the data collection was completed. Periodontitis severity variables were measured using clinical parameters, namely interdental CAL. Data collection was carried out by 4 dentists who had been given training in CAL measurement by 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 EEP, AAP and CDC in 2018, which used 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. This questionnaire had 3 dimensions: physical function (functional), pain or discomfort, and psychological. 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. The statistical analysis used were chi square test, independent t-test, simple linear regression and multiple linear regression test, with a significance level of 0.05, and used STATA 18 software for analysis. Diabetes Mellitus status, uncontrolled and controlled DM, and periodontitis, theoretically has an interactive relationship with OHRQoL, so an interaction analysis was performed using multiple linear regression. The regression model was determined based on AIC, where the smallest AIC was selected as the final regression model.

RESULTS

The results of this study showed that of 302 participants who had periodontitis, the majority of participants had severe periodontitis (73.8%) followed by moderate periodontitis (22.2%) and mild periodontitis (4%). The most dominant gender was female as much as 63.2%, while the most occupations 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 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 average quality of life score was higher in the controlled DM group than the uncontrolled (Table 1). Participants with severe periodontitis had a lower mean quality of life than participants with moderate or mild levels of periodontitis, while participants with uncontrolled DM status had a lower mean quality of life score 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. People 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. People 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.

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	Koefisien 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 also showed a mean quality of life score that was 6 points lower than participants who did not smoke, and the increasing age of participants significantly decreased the mean quality of life score by 0.27 points per year of age (Table 3).

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. The results also showed that there was a significant interaction between uncontrolled DM and periodontitis (Table 4).

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)

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 average quality of life score was higher in the controlled DM group than the uncontrolled (Table 1). Increasing age causes a physiological decline in organ function, resulting in an increase in the incidence of acute and chronic diseases. Diseases commonly experienced by the elderly include diabetes mellitus, heart disease, and stroke. Diabetes mellitus has macrovascular and microvascular complications, including manifestations in the oral cavity such as periodontitis and xerostomia. Complications of DM, both in general and in the oral cavity, affect an individual's quality of life. The results of this study are in line with the 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, educational 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 is a reflection of socioeconomic status, which will have an impact on determining health behavior by individuals or communities. A higher level of education is a factor that influences the level of health knowledge. Education level can support health literacy and oral health literacy skills. In addition, individuals with higher education levels have better coping skills. Individuals or communities with high socioeconomic status and education are able to choose and determine the type of health care they want, are able to afford health care costs for promotive, preventive, curative, and rehabilitative care, so that their quality of life remains optimally maintained.

Sociodemographic factors such as occupation affect DM status (Table 3). Gender and education are not included in model 2 and 3. Employment is a description of the level of income and socioeconomic status of the community in general. Socioeconomic status is related to promotive and preventive health behavior and health seeking behavior. Female gender is the most participants

with controlled DM status. Gender differences in DM status are a reflection of 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 which states 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 can result in masticatory problems, so the elderly tend to be limited in their food choices.[25]

Chronic periodontitis is associated with poorer OHRQoL compared to 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 is a modifier 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, the more severe the periodontitis and have uncontrolled DM, the lower the quality of life score, on the contrary, the more severe the periodontitis and have controlled DM, it has no effect on 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 was significantly worse in prevalence, incidence, and severity among diabetics, negatively impacting quality of life. Using life quality questionnaire and various clinical criteria, they 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 of patients without DM, and cause more bone resorption and soft tissue damage, and this still occurs even though the number and composition of bacteria between DM and non-DM patients are the same.

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 also confirmed by Hazara, states that losing all teeth can be an emotional burden, decreased 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 individuals without periodontitis, the more severe the periodontitis the worse the quality of life.[31] Diabetes had 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 improvement on quality of life.[32]

Based on these results (Table 4), statements from various researchers describe 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]

The need for policies related to the implementation of integrated strategies by primary health care facilities in managing patients with DM-periodontitis, in order to improve the effectiveness of care, reduce risk factors, prevent complications, and improve the 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 the respondents in this study were 302 elderly PROLANIS participants, so the characteristics of elderly people in the community were not yet represented in the research sample. The characteristics of elderly in a widespread community were unrepresented. Representing the sample with all its characteristics is a suggestion for further research.

CONCLUSION

Diabetes mellitus is a modifier effect on the relationship between the severity of periodontitis and OHRQoL in the elderly. The clinical implication of this study is that DM and periodontitis are 2 diseases that together can worsen the quality of life, so that the treatment of these two diseases is very important 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 uncontrolled DM. Representing the sample with a widespread community of elderly, with its all characteristics is a suggestion for further research. The implication of this research is the need for policies related to the involvement of dentists in the PROLANIS program/health center in order to prevent the severity of DM-periodontitis, which has an effect on improving the quality of life in the elderly.

Author Contributions: Conceptualization, S.U.., H.K., and D.B.; methodology, S.U, HK., and D.B.; software, S.U.; validation, S.U., H.K., D.B., and N.O.; formal analysis S.U. N.R.A., N.O., A.H.H and F.A.U; investigation, S.U. H.K., D.B.; resources, S.U. N.R.A., N.O., A.H.H and F.A.U F.N.; data curation, S.U., H.K., and D.B.; writing original draft preparation, S.U. and F.A.U; writing review and editing, S.U., H.K., and D.B.; visualization, F.A.U., N.R.A., A.H.H., and N.O.; supervision, H.K. and D.B.; project administration, S.U.; funding acquisition, S.U. All authors have read and agreed to the published version of the manuscript
Funding: This research received no funding
Institutional Review Board Statement: The study was conducted in accordance with Ethical Clearance and approved by the Research Ethics Committee of the Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada Yogyakarta (KE/FK/0686/EC/2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.
Data Availability Statement: Data is unavailable due to privacy or ethical restrictions
Conflicts of Interest: The authors declare no conflict of interest

REFERENCES

1. Chmielewski PP, Data K, Strzelec B, et al. Human Aging and Age-Related Diseases: From Underlying Mechanisms to Pro-Longevity Interventions. Aging Dis. 2025;16(4):1853. https://doi.org/10.14336/AD.2024.0280
2. World Health Organization. Global Report on Diabetes. World Health Organization; 2016. Accessed November 29, 2024. https://iris.who.int/handle/10665/204871
3. Łasica A, Golec P, Laskus A, Zalewska M, Gędaj M, Popowska M. Periodontitis: etiology, conventional treatments, and emerging bacteriophage and predatory bacteria therapies. Front Microbiol. 2024;15:1469414. https://doi.org/10.3389/fmicb.2024.1469414
4. Păunică I, Giurgiu M, Dumitriu AS, et al. The Bidirectional Relationship between Periodontal Disease and Diabetes Mellitus—A Review. Diagnostics. 2023;13(4):681. https://doi.org/10.3390/diagnostics13040681
5. Wu C zhou, Yuan Y hang, Liu H hang, et al. Epidemiologic relationship between periodontitis and type 2 diabetes mellitus. BMC Oral Health. 2020;20(1):204. https://doi.org/10.1186/s12903-020-01180-w
6. Prince Abdulrahman Advanced Dental Institute, Riyadh, Saudi Arabia., Abdulaziz Aldawish A, Mohammed Alzaben N, et al. Diabetes and periodontal disease: interconnected pathophysiology and clinical implications: a comprehensive review. Int J Adv Res. 2024;12(07):452-464. https://doi.org/10.21474/IJAR01/19074
7. Amiria F, Aini Gumilas NS. The association between poor oral hygiene and infective endocarditis risk in rheumatic heart disease patients: a systematic review. Padjadjaran J Dent. 2025;37(2):258-267. https://doi.org/10.24198/pjd.vol37no2.59405
8. Tsamarah BG, Falatehan N, Halim SR. A complete denture cleaning instruction booklet in enhancing the behavior of elderly patients: an experimental study. Padjadjaran J Dent. 2025;37(2):187-196. https://doi.org/10.24198/pjd.vol37no2.61323
9. Hoeksema AR, Peters LL, Raghoebar GM, Meijer HJA, Vissink A, Visser A. Oral health status and need for oral care of care-dependent indwelling elderly: from admission to death. Clin Oral Investig. 2017;21(7):2189-2196. https://doi.org/10.1007/s00784-016-2011-0
10. Mirzaei A, Shahrestanaki E, Daneshzad E, et al. Association of hyperglycaemia and periodontitis: an updated systematic review and meta-analysis. J Diabetes Metab Disord. 2021;20(2):1327-1336. https://doi.org/10.1007/s40200-021-00861-9
11. Agustina D, Hanindriyo L, Widita E, Widyaningrum R. The correlation between occurrence of dental caries and oral health-related quality of life (OHRQoL) of elderly population in Yogyakarta Special Region. J Thee Med Sci Berk Ilmu Kedokt. 2018;50(2). https://doi.org/10.19106/JMedSci005002201808
12. Ferreira MC, Dias-Pereira AC, Branco-de-Almeida LS, Martins CC, Paiva SM. Impact of periodontal disease on quality of life: a systematic review. J Periodontal Res. 2017;52(4):651-665. https://doi.org/10.1111/jre.12436
13. Kwon SR, Lee S, Oyoyo U, et al. Oral health knowledge and oral health related quality of life of older adults. Clin Exp Dent Res. 2021;7(2):211-218. https://doi.org/10.1002/cre2.350
14. Newman MG, Takei HH, Klokkevold PR, Carranza FA. Newman and Carranza's Clinical Periodontology. 13th ed. W.B. Saunders; 2019.
15. Fidyawati D, Masulili SLC, Iskandar HB, Suhartanto H, Kiswanjaya B, Li X. Clinical and Radiographic Parameters for Early Periodontitis Diagnosis: A Comparative Study. Dent J. 2024;12(12):407. https://doi.org/10.3390/dj12120407
16. Beard J. Simple sample size calculations for crosssectional studies. South Sudan Med J. 2024;17(4):213-216. https://doi.org/10.4314/ssmj.v17i4.12
17. Capili B. Cross-Sectional Studies. AJN Am J Nurs. 2021;121(10):59-62. https://doi.org/10.1097/01.NAJ.0000794280.73744.fe
18. Fageeh HI, Fageeh HN, Ibraheem WI, et al. Accuracy in Diagnosing Periodontitis Using the AAP/EFP 2017 Classification. Int Dent J. 2025;75(6):103907. https://doi.org/10.1016/j.identj.2025.103907
19. Vettore MV, Rebelo MAB, Rebelo Vieira JM, Cardoso EM, Birman D, Leão ATT. Psychometric Properties of the Brazilian Version of GOHAI among Community-Dwelling Elderly People. Int J Environ Res Public Health. 2022;19(22):14725. https://doi.org/10.3390/ijerph192214725
20. Suyitno S, Cahyati WH. Type of Occupation and Smoking Behavior: A Multinomial Analysis of Global Adults Tobacco Survey (GATS) Indonesia. J INFO Kesehat. 2025;23(2):301-308. https://doi.org/10.31965/infokes.Vol23.Iss2.1984
21. Lee CJ, Ho MH, Joo JY, et al. Gender differences in the association between oral health literacy and oral health-related quality of life in older adults. BMC Oral Health. 2022;22(1):205. https://doi.org/10.1186/s12903-022-02237-8
22. Slowik J, Panasiuk A, Kaczor M, Wnuk M. Oral health-related quality of life in patients with periodontitis: a systematic review and meta-analysis. Front Oral Health. 2025;6:1503829. https://doi.org/10.3389/froh.2025.1503829
23. Ahmed MA, Jouhar R, Faheemuddin M, et al. Assessment of Oral Health Knowledge, Attitude, Practice and DMFT Scores among Patients at King Faisal University, Al-Ahsa. Medicina (Mex). 2023;59(4):688. https://doi.org/10.3390/medicina59040688
24. Graziani F, Tsakos G. Patient-based outcomes and quality of life. Periodontol 2000. 2020;83(1):277-294. https://doi.org/10.1111/prd.12305
25. Sosiawan A, Wahjuningrum DA, Setyowati D, et al. The relationship between parents' oral hygiene knowledge and children with Down Syndrome's oral hygiene via OHI-S [version 2; peer review: 2 approved]. Published online 2022. https://doi.org/10.12688/f1000research.87848.1
26. Abe M, Mitani A, Hoshi K, Yanagimoto S. Large Gender Gap in Oral Hygiene Behavior and Its Impact on Gingival Health in Late Adolescence. Int J Environ Res Public Health. 2020;17(12):4394. https://doi.org/10.3390/ijerph17124394
27. Fuller J, Donos N, Suvan J, Tsakos G, Nibali L. Association of oral health-related quality of life measures with aggressive and chronic periodontitis. J Periodontal Res. 2020;55(4):574-580. https://doi.org/10.1111/jre.12745
28. Cervino G, Terranova A, Briguglio F, et al. Diabetes: Oral Health Related Quality of Life and Oral Alterations. BioMed Res Int. 2019;2019:1-14. https://doi.org/10.1155/2019/5907195

29. Romito GA, Collins JR, Hassan MA, Benítez C, Contreras A. Burden and impact of periodontal diseases on oral health-related quality of life and systemic diseases and conditions: Latin America and the Caribbean Consensus 2024. Braz Oral Res. 2024;38(suppl 1):e117. https://doi.org/10.1590/1807-3107bor-2024.vol38.0117
30. Chan AKY, Tamrakar M, Jiang CM, Lo ECM, Leung KCM, Chu CH. Common Medical and Dental Problems of Older Adults: A Narrative Review. Geriatrics. 2021;6(3):76. https://doi.org/10.3390/geriatrics6030076
31. Ortíz-Barrios LB, Granados-García V, Cruz-Hervert P, Moreno-Tamayo K, Heredia-Ponce E, Sánchez-García S. The impact of poor oral health on the oral health-related quality of life (OHRQoL) in older adults: the oral health status through a latent class analysis. BMC Oral Health. 2019;19(1):141. https://doi.org/10.1186/s12903-019-0840-3
32. Desai R, Khobaragade B, McCracken G, et al. Impact of diabetes and periodontal status on life quality. BDJ Open. 2021;7(1):9. https://doi.org/10.1038/s41405-021-00061-w
33. Mohseni Homagarani Y, Adlparvar K, Teimuri S, Tarrahi MJ, Nilchian F. The effect of diabetes mellitus on oral health-related quality of life: A systematic review and meta-analysis study. Front Public Health. 2023;11:1112008. https://doi.org/10.3389/fpubh.2023.1112008