

ORIGINAL ARTICLE

Periodontal disease risk factors in elderly and older adults with diabetes mellitus comorbidity using the PRECEDE–PROCEED framework: a cross-sectional study

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ABSTRACT

Introduction: Diabetes mellitus (DM) increases the risk and severity of periodontal disease, particularly among elderly populations. Behavioral and contextual determinants may further exacerbate periodontal vulnerability in individuals with DM. This study aimed to describe periodontal disease risk factors among elderly and older adults with diabetes mellitus using the PRECEDE framework, focusing on predisposing, reinforcing, and enabling factors. **Methods:** A descriptive cross-sectional study was conducted among 33 elderly and older adults with confirmed diabetes mellitus at the Dukuh Kupang Primary Health Center, Surabaya, Indonesia. Data were collected using structured questionnaires assessing predisposing (knowledge, dietary adherence, physical activity, medication use), reinforcing (family and healthcare support), and enabling factors (health service utilization), alongside clinical periodontal examination using the Harald Löe Plaque Index. Data were analyzed descriptively and presented as frequencies and percentages. **Results:** Periodontal risk was categorized as moderate in 51.5% and high in 48.5% of respondents. Predisposing factors showed that 72.7% did not regulate food portions, 54.5% did not adhere to physician-recommended diets, 42.4% did not exercise regularly, and 21.2% did not consistently take antidiabetic medication. Reinforcing factors indicated that 39.4% reported limited family support for medication adherence and 18.2% reported insufficient health education support. Enabling factors revealed that 15.2% did not undergo regular blood glucose examinations and 18.2% did not routinely record glucose levels. Clinically, 57.6% had plaque index scores above the mean, indicating substantial plaque accumulation. **Conclusion:** Periodontal vulnerability among elderly individuals with diabetes mellitus is characterized by a convergence of unfavorable predisposing (21.2–72.7%), reinforcing (18.2–39.4%), and enabling (15.2–18.2%) factors. Strengthening behavioral modification strategies, social support systems, and structured diabetes monitoring within primary healthcare settings may be important to reduce the burden of periodontal disease.

KEYWORDS

Diabetes mellitus, periodontal disease, elderly, risk factors, oral hygiene

INTRODUCTION

Diabetes mellitus (DM) is a chronic disease that is commonly found among the elderly and older adults.¹ According to the International Diabetes Federation (2021), the estimated number of people with diabetes worldwide in the 20–79 years age group was 536.6 million, and this figure is projected to reach 783.2 million by 2045. According to the World Health Organization (WHO), approximately 422 million people worldwide were living with diabetes in 2022, and

the disease remains among the leading causes of mortality globally. According to the Global Cardiovascular Risk Consortium (2023), the prevalence of diabetes mellitus in Asia was 5.1%.² The prevalence of diabetes mellitus in China was reported to be 24%.³ In Malaysia, Akhtar et al. (2021) reported a prevalence of 18.3%.⁴ In Indonesia, the prevalence of diabetes mellitus was 10.6%.^{5–6} According to the 2022 East Java Provincial Health Profile, there were 863,686 reported cases of diabetes mellitus in East Java, which decreased slightly to 854,453 cases in 2023. The burden of diabetes mellitus was highest in Surabaya City compared with other areas in the province.⁷ There were 94,076 reported cases of diabetes mellitus in Surabaya City in 2019.⁸

In a preliminary study, secondary data were obtained from a population of 1,936 elderly and older adults between May 2023 to May 2024. It was found that diabetes mellitus was most prevalent in the older adult group (>65 years), with 762 patients (39.35%), followed by the late elderly group (56–65 years) with 710 patients (36.67%), and the early elderly group (46–55 years) with 464 patients (23.96%). From the total population, 162 individuals were also found to have a comorbidity of hypertension, with older adults (39.35%) ranking first. These findings highlight the substantial burden of diabetes mellitus among elderly populations at the Dukuh Kupang Primary Health Center.

The most common oral diseases recorded in Dukuh Kupang District in 2024 were pulpal and periapical diseases, dental caries, and periodontal disorders. Among the elderly and older adult groups, 515 patients (38.3%) were affected by pulpal and periapical diseases, 160 patients (18.4%) by dental caries, and 172 patients (15.9%) by periodontal disease. Epidemiological evidence suggests that severe periodontitis ranks as the sixth most common disease globally, with an estimated prevalence of approximately 11.2%, impacting about 743 million individuals worldwide.⁹ The prevalence of periodontitis in Indonesia remains high. Based on the National Basic Health Research (Riset Kesehatan Dasar /RISKESDAS) 2018 report, the percentage of periodontitis cases in Indonesia reached 74.1%.¹⁰ An epidemiological study also found that the highest prevalence of periodontal disease occurred in the elderly population (82%).¹¹

Several studies have shown that diabetes mellitus (both type 1 and type 2) is a risk factor for periodontitis, increasing the risk by approximately threefold compared to non-diabetic subjects, particularly among those with poor glycemic control.¹² Diabetes exacerbates inflammation in periodontal tissues due to elevated levels of inflammatory mediators such as interleukin-1 β (IL-1 β) and tumor necrosis factor- α (TNF- α). Periodontal disease is strongly associated with increased levels of inflammatory mediators in individuals with diabetes. Additionally, the accumulation of reactive oxygen species (ROS), oxidative stress, and the interaction of advanced glycation end products (AGEs) with their receptor (RAGE) contribute to the heightened inflammatory response observed in diabetic patients.¹³

Diabetes is a well-established risk factor for periodontal disease, which may become more severe in individuals with poor glycemic control.¹⁴ Multiple risk factors increase susceptibility to periodontal disease, particularly those with poor oral hygiene, inadequate metabolic control, and longer disease duration. These conditions contribute to damage of periodontal supporting structures, potentially resulting in gingival recession, alveolar bone resorption, tooth mobility, and ultimately tooth loss. Such deterioration often causes discomfort during mastication. Both periodontal disease and diabetes are known to exert negative effects on quality of life. Patients with periodontal disease frequently experience functional limitations, pain, discomfort, and psychological distress, along with physical, emotional, and social impacts that impair their overall well-being.

Similarly, diabetes has profound implications for health-related quality of life, particularly concerning physical, psychological, and social dimensions. Poor self-perception of oral health further influences quality of life outcomes in patients with type 2 diabetes.¹⁵ To better understand the multifactorial nature of periodontal

disease risk among elderly individuals with diabetes mellitus, this study applies the PRECEDE–PROCEED framework developed by Green and Kreuter. The PRECEDE component (Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation) emphasizes behavioral and environmental determinants that influence health outcomes, including knowledge, attitudes, social support, and access to health services.¹⁷ This framework is particularly relevant for chronic diseases such as diabetes mellitus, where self-management behavior and preventive care play a central role in determining oral and systemic health outcomes.¹⁶

The novelty of this research lies in the application of the PRECEDE-PROCEED behavioral assessment framework to describe periodontal disease risk factors among elderly and older adults with diabetes mellitus at the primary healthcare level in Indonesia. Unlike previous studies that primarily focused on clinical or biological associations between diabetes and periodontitis, this study integrates behavioral determinants and community-based health support factors to provide a more comprehensive public health perspective.

Based on this background, this study aims to describe periodontal disease risk factors among elderly and older adults with diabetes mellitus in the Dukuh Kupang Primary Health Center service area using the PRECEDE-PROCEED framework, focusing on predisposing, reinforcing, and enabling factors, as well as clinical periodontal indicators.

METHODS

This study employed a descriptive observational cross-sectional design to assess periodontal disease risk factors among elderly and older adults⁸ with diabetes mellitus in the service area of Dukuh Kupang Primary Health Center, Surabaya, East Java Province, Indonesia. The sample size consisted of 33 respondents, recruited using purposive sampling. The sample size was determined using a total population approach rather than a statistical sample size calculation formula, due to the limited and specific nature of the study population. All eligible elderly patients with diabetes mellitus who met the predefined inclusion criteria and were available during the study period were included.

The inclusion criteria comprised: (1) elderly and older adults aged ≥ 46 years who were registered at the Dukuh Kupang Primary Health Center; (2) a confirmed diagnosis of diabetes mellitus documented in the patient's medical record, established by a physician based on national clinical guidelines, defined as fasting plasma glucose ≥ 126 mg/dL, 2-hour plasma glucose ≥ 200 mg/dL during an oral glucose tolerance test, HbA1c $\geq 6.5\%$, or random plasma glucose ≥ 200 mg/dL accompanied by classic hyperglycemic symptoms; (3) presence of at least one natural tooth to allow periodontal examination; and (4) willingness to participate as evidenced by written informed consent.

Exclusion criteria included: (1) patients with severe systemic conditions or cognitive impairment that prevented questionnaire completion or oral examination; (2) incomplete medical record data regarding diabetes status; and (3) completely edentulous individuals. Edentulous status was determined through direct intraoral clinical examination and defined as the absence of all natural teeth in both maxillary and mandibular arches at the time of assessment. The use of total population sampling is considered appropriate in observational clinical studies when the accessible population is small and clearly defined, and when the primary objective is exploratory or descriptive rather than hypothesis testing.

The measured variables consisted of: (1) sociodemographic characteristics (age, gender, education, and occupation); (2) behavioral determinants referring to the PRECEDE–PROCEED framework, which included predisposing factors (knowledge and attitudes related to oral health and diabetes), reinforcing factors (support from family, community health cadres, and healthcare workers), and enabling factors (access to elderly health posts and availability of oral-health

services); (3) oral-hygiene behaviors assessed using a structured questionnaire; and (4) clinical periodontal indicators.

Clinical assessment included plaque accumulation using a disclosing agent applied to all teeth, followed by scoring with the Harald Löe Plaque Index, which classifies plaque levels on an ordinal scale. Additional oral cavity evaluations were conducted to assess the condition of the lips, tongue, teeth, oral mucosa, saliva, denture status, oral hygiene, tooth pain, and mobility. All data were collected through direct interviews and clinical examinations by trained examiners. Quantitative data were analyzed using IBM SPSS Statistics for Windows, and results were presented descriptively in the form of frequency distributions and percentages to characterize risk factors and periodontal health status in line with the research objectives.

RESULTS

A total of 33 respondents consisting of elderly and older adults with diabetes mellitus comorbidity were successfully interviewed. The majority of respondents were female (66.7%), with the largest age group being late elderly (56–65 years, 39.4%). Most respondents had a low level of education (elementary school or equivalent, 45.5%) and were unemployed (78.8%) (Table 1).

Table 1. Characteristics of respondents

Characteristics	Frequency (n=33)
Gender	
Male	11
Female	22
Age group	
Early elderly (46-55 years)	8
Late elderly (56-65 years)	13
Older adults (>65 years)	12
Educational level	
No formal education	1
Elementary school or equivalent	15
Junior high school or equivalent	8
Senior high school or equivalent	7
Diploma/Bachelor's degree or higher	2
Occupation	
Employed	7
Unemployed	26

The majority of respondents demonstrated suboptimal oral hygiene conditions. Plaque accumulation was assessed through direct clinical examination using a disclosing agent applied to all teeth, followed by scoring with the Harald Löe Plaque Index, which categorizes plaque levels on an ordinal scale (0 = no plaque; 1 = plaque not visible to the naked eye but detectable by probing). Most plaque index scores fell within the moderate to high categories, and higher periodontal risk categories were descriptively more frequent among older age groups and those with lower educational levels. Descriptively, female respondents showed a higher frequency of periodontal risk factors than males. By age group, late elderly individuals (56–65 years) demonstrated the highest proportion of periodontal risk factors. Lower educational levels (elementary school or equivalent) and unemployment were also observed alongside a higher burden of periodontal risk factors (Table 2).

Table 2. Distribution of periodontal risk factors by sociodemographic characteristics

Characteristics	Moderate (%)	High (%)	Total (%)
Gender			
Male	5(29.4)	6 (37.5)	11 (33.3)
Female	12 (70.6)	10 (62.5)	22 (66.7)
Age group			
Early elderly (46-55 th)	5 (29.4)	3 (18.8)	8 (24.2)
Late elderly (56-65 th)	7 (41.2)	6 (37.5)	13 (39.4)
Older adults (>65 th)	5 (29.4)	7 (43.8)	12 (36.4)
Educational level			
No formal education	1 (5.9)	0 (0)	1 (3)
Elementary school or equivalent	6 (35.3)	9 (56.3)	15 (45.5)
Junior high school or equivalent	5 (29.4)	3 (18.8)	8 (24.2)
Senior high school or equivalent	4 (23.5)	3 (18.8)	7 (21.2)
Diploma/Bachelor's degree or higher	1 (5.9)	1 (6.3)	2 (6.1)
Occupation			
Employed	2 (11.8)	5 (31.3)	7 (21.2)
Unemployed	15 (88.2)	11 (68.8)	26 (78.8)

Table 3 summarizes DSMBQ-based diabetes self-management behaviors according to periodontal risk category. While periodontal risk was similarly distributed between moderate and high categories, variations were observed across behavioral domains. Higher frequencies of suboptimal dietary practices, irregular blood glucose monitoring, and low physical activity were descriptively observed among participants with high periodontal risk. These results provide a behavioral profile of diabetes self-management within each periodontal risk category without implying causal associations.

Table 3. Distribution of diabetes self-management behaviors (DSMBQ domains) by periodontal risk category

DSMBQ Domain	Indicator	Moderate Risk n (%)	High Risk n (%)	Total n (%)
Dietary management	Adherence to recommended diabetic diet	7 (41.2)	9 (56.3)	16 (48.5)
	Frequent consumption of sugary foods	6 (35.3)	10 (62.5)	16 (48.5)
Medication adherence	Regular use of antidiabetic medication	14 (82.4)	10 (62.5)	24 (72.7)
	Missed medication doses	7 (43.8)	5 (29.4)	12 (36.4)
Blood glucose monitoring	Routine blood glucose monitoring	9 (56.3)	6 (35.3)	15 (45.5)
	Knowledge of target glucose levels	12 (70.6)	8 (50.0)	20 (60.6)
Physical activity	Engaging in regular physical activity	11 (68.8)	8 (47.1)	19 (57.6)
Healthcare utilisation	Regular diabetes check-ups	6 (37.5)	4 (23.5)	10 (30.3)

Values are presented as frequencies and percentages within each periodontal risk category. Diabetes self-management behaviors were assessed using DSMBQ domains and include both behavioral practices and knowledge-based components. The reported indicators are not mutually exclusive; therefore, individual participants may contribute to more than one indicator. Percentages do not sum to 100% across indicators. The analysis is descriptive and does not imply causal associations.

Table 4. Distribution of respondents' periodontal disease risk factors

Oral cavity condition	Healthy n (%)	Transitional n (%)	Diseased n (%)	Total n (%)
Lips	23 (69.7)	10 (30.3)	0	33 (100)
Tongue	13 (39.4)	20 (60.6)	0	33 (100)
Teeth and oral mucosa	11 (33.3)	18 (54.5)	4 (12.1)	33 (100)
Saliva	20 (60.6)	11 (33.3)	2 (6.1)	33 (100)
Teeth condition	3 (9.1)	12 (36.4)	18 (54.5)	33 (100)
Dentures	3 (9.1)	2 (6.1)	0	5 (15.2)
Oral hygiene	3 (9.1)	17 (51.5)	13 (39.4)	33 (100)
Tooth pain	26 (78.8)	7 (21.2)	0	33 (100)
Tooth mobility	22 (66)	0	11 (33.3)	33 (100)

The oral examination revealed varied health conditions. Most respondents had healthy lips (69.7%), whereas the tongue was predominantly in a transitional condition (60.6%). Most respondents showed transitional to diseased conditions of the teeth and oral mucosa, with 12.1% classified as diseased. Healthy teeth were observed in only 9.1% of respondents, while more than half (54.5%) were in the diseased category. Overall oral hygiene was relatively poor, with 39.4% of respondents classified as diseased. Although most respondents did not experience tooth pain (78.8% healthy), about one-third had tooth mobility (33.3%), which may reflect compromised periodontal health in this population (Table 4).

Based on the clinical examination, the plaque index scores of 33 respondents yielded a total score of 375, with a mean value of 11.4. Most respondents had plaque index scores at or above the mean (57.6%), whereas 42.4% were below the mean. By age group, the proportion of respondents with plaque scores \geq the mean was higher among late elderly (69.2%) and older adults (66.7%) than among early elderly (25.0%), as shown in Table 5. These findings suggest an age-related pattern in dental plaque accumulation that may contribute to increased periodontal disease risk.

Table 5. Cross-tabulation of plaque index scores by age group

Age group	Plaque index < mean n (%)	Plaque index \geq mean n (%)	Total n (%)
Early elderly (46–55 years)	6 (75.0)	2 (25.0)	8 (24.2)
Late elderly (56–65 years)	4 (30.8)	9 (69.2)	13 (39.4)
Older adults (>65 years)	4 (33.3)	8 (66.7)	12 (36.4)
Total	14 (42.4)	19 (57.6)	33 (100)

Table 6 provides an integrated descriptive overview of behavioral and clinical indicators related to periodontal disease risk among elderly and older adults with diabetes mellitus, organised according to the PRECEDE framework. The table summarises predisposing, reinforcing, and enabling factors derived from DSMBQ-based measures and presents their distribution alongside key clinical findings, including plaque index status and periodontal risk classification. This integrated presentation illustrates how multiple behavioral determinants and oral health conditions coexist within the study population, while maintaining a purely descriptive perspective without implying statistical or causal associations.

Values are presented as frequencies and percentages based on the total number of respondents (n=33). behavioral indicators derived from DSMBQ domains and PRECEDE components are not mutually exclusive; therefore, individual respondents may be represented across multiple indicators. Clinical periodontal profile includes plaque index categorised by the sample mean (11.4) and periodontal risk classification.

Table 6. Integrated PRECEDE components, DSMBQ indicators, and clinical periodontal

profile among respondents				
PRECEDE component	DSMBQ / behavioral indicator	n (%)	Plaque index \geq mean n (%)	High periodontal risk n (%)
Predisposing factors	Did not regulate food portions	24 (72.7)	15 (62.5)	14 (58.3)
	Did not follow physician-recommended diet	18 (54.5)	12 (66.7)	11 (61.1)
	Did not regularly consume antidiabetic medication	7 (21.2)	5 (71.4)	5 (71.4)
	Did not exercise routinely	14 (42.4)	10 (71.4)	9 (64.3)
Reinforcing factors	Limited health education/support from health workers or cadres	6 (18.2)	4 (66.7)	4 (66.7)
	Limited family/social support for medication adherence	13 (39.4)	9 (69.2)	8 (61.5)
	Did not routinely monitor blood glucose	7 (21.2)	5 (71.4)	5 (71.4)
Enabling factors	Did not undergo regular periodic glucose checks	5 (15.2)	4 (80.0)	4 (80.0)
	Did not routinely record blood glucose levels	6 (18.2)	4 (66.7)	4 (66.7)
Clinical profile	Plaque index \geq mean (≥ 11.4)	19 (57.6)	—	12 (63.2)
	High periodontal risk category	16 (48.5)	12 (75.0)	—

DISCUSSION

This study describes periodontal disease risk factors among elderly and older adults with diabetes mellitus using a behavioral framework. As shown in Table 1, the majority of respondents were female, had relatively low educational attainment, and were unemployed. The distribution of periodontal risk by sociodemographic characteristics (Table 2) indicates that a larger proportion of respondents classified as having high periodontal risk were female (62.5%), belonged to the late elderly and older adult age groups, had elementary school education or equivalent (56.3%), and were unemployed (68.8%).

Overall, most respondents had primary-level education (elementary school or equivalent), which constituted the largest educational category in the study population. Community knowledge about diabetes mellitus is crucial as a foundation for shaping preventive behaviors. This is consistent with the literature indicating that education contributes to increased knowledge and the adoption of healthy behaviors.¹³ Adequate knowledge of diabetes mellitus is important for shaping preventive behavior and is associated with educational attainment, which influences access to information and health behavior.¹⁶

Most respondents had an elementary school education and were unemployed. This finding is consistent with previous evidence showing that a substantial proportion of women with diabetes mellitus are homemakers, with nearly three-quarters of diabetic women reported to be engaged in household roles, particularly among middle-aged and older adults.¹⁷ Given that most respondents were women aged ≥ 60 years, daily activities tended to be light, reflecting declining physical activity with increasing age.¹⁸ Low physical activity is associated with a higher risk of type 2 diabetes mellitus compared with regular or adequate activity.²⁰

The findings indicate that periodontal risk was distributed almost evenly between the moderate (51.5%) and high (48.5%) categories, reflecting a substantial burden of periodontal vulnerability among elderly individuals with diabetes mellitus. As detailed in Table 3, this distribution was accompanied by notable variations in diabetes self-management behaviors across periodontal risk categories. Participants classified as having high periodontal risk more frequently reported suboptimal self-management practices, particularly in dietary and lifestyle-related domains. Poor adherence to recommended diabetic diets and frequent consumption of sugary foods were more prevalent among the high-risk group compared with those at moderate risk. Similar patterns were observed in physical activity, where engagement in regular exercise was lower among individuals with high periodontal risk.

Although regular use of antidiabetic medication was commonly reported across both periodontal risk categories, indicators of non-adherence, such as missed medication doses, were proportionally more evident among participants with high periodontal risk. Differences were also observed in blood glucose monitoring behaviors, with lower proportions of routine monitoring and limited knowledge of target glucose levels among individuals in the high-risk category. These findings provide a descriptive behavioral profile suggesting that higher periodontal risk in this population tends to coexist with less optimal diabetes self-management behaviors, particularly those related to diet, physical activity, and glycemic monitoring.

This integrated pattern underscores the importance of considering behavioral and self-management dimensions when addressing periodontal vulnerability among elderly individuals with diabetes mellitus. Age-related immune decline increases susceptibility to oral bacterial infection and plaque dysbiosis, which can trigger periodontitis.²¹ In diabetes mellitus, poor glycemic control and increased advanced glycation end products (AGEs) promote oxidative stress and inflammation in gingival tissues, contributing to periodontal destruction; vascular changes also impair nutrient delivery and infection control, thereby worsening periodontitis.²²

Table 4 presents the distribution of respondents' periodontal disease risk factors based on clinical oral cavity examination. Overall, the findings reveal a substantial burden of oral health compromise among the study population, with several indicators reflecting transitional or diseased conditions rather than optimal oral health. Soft tissue examination showed that most respondents had healthy lips (69.7%) and tongue conditions (39.4%), although a considerable proportion exhibited transitional conditions, particularly involving the tongue (60.6%). In contrast, conditions related to teeth and oral mucosa demonstrated a higher prevalence of pathological findings, with 12.1% of respondents classified as having diseased teeth and oral mucosa, and more than half (54.5%) showing diseased tooth conditions.

Oral hygiene status further highlighted this vulnerability, as only a small proportion of respondents were classified as having healthy oral hygiene (9.1%), while the majority fell into transitional (51.5%) or diseased categories (39.4%). These findings indicate that suboptimal plaque control and oral hygiene practices are common among elderly individuals with diabetes mellitus. Functional and symptomatic indicators also reflected periodontal involvement. Tooth pain was reported by 21.2% of respondents, while one-third (33.3%) exhibited tooth mobility, a clinical sign suggestive of advanced periodontal tissue breakdown. Although the prevalence of denture use was relatively low (15.2%), denture-related conditions nonetheless warrant attention given the vulnerability of oral tissues in this population.

The clinical profile presented in Table 4 illustrates that periodontal disease risk among elderly individuals with diabetes mellitus is characterised not only by behavioral and self-management challenges, but also by widespread clinical manifestations affecting both hard and soft oral tissues. This pattern underscores

the coexistence of systemic disease, compromised oral hygiene, and age-related susceptibility within this population.

Table 5 illustrates the cross-tabulation of plaque index scores by age group, revealing a clear age-related pattern in dental plaque accumulation. Overall, more than half of the respondents (57.6%) had plaque index scores equal to or above the sample mean (≥ 11.4). This proportion increased with advancing age, being notably higher among late elderly (69.2%) and older adults (66.7%) compared with early elderly respondents (25.0%). These findings descriptively indicate that older age groups were more likely to exhibit higher levels of dental plaque accumulation, which may contribute to increased periodontal vulnerability in elderly populations with diabetes mellitus.

Across predisposing factors, suboptimal diabetes self-management behaviors were common among respondents, particularly those with high periodontal risk (Table 6). A large proportion of participants did not regulate food portions (72.7%) or adhere to physician-recommended diets (54.5%), and these behaviors were more frequently observed among individuals classified as having high periodontal risk. Similarly, lack of regular physical exercise was reported by 42.4% of respondents, with a higher proportion falling within the high-risk periodontal category.

Reinforcing factors further highlighted behavioral vulnerability. Limited support from healthcare workers or community cadres (18.2%) and insufficient family or social support for medication adherence (39.4%) were disproportionately represented among respondents with high periodontal risk (Table 6). In addition, respondents who did not routinely monitor their blood glucose levels were predominantly classified within the high-risk periodontal group.

Enabling factors related to access and utilisation of health services also demonstrated relevant patterns. Respondents who did not undergo regular periodic blood glucose examinations (15.2%) or failed to routinely record glucose levels (18.2%) were more frequently categorised as having high periodontal risk. From a clinical perspective, individuals with plaque index scores equal to or above the mean constituted a substantial proportion of those with high periodontal risk, reinforcing the coexistence of behavioral vulnerabilities and adverse oral health conditions.

The combined findings from Tables 5 and 6 depict a consistent descriptive pattern in which increasing age, suboptimal diabetes self-management behaviors, limited reinforcing and enabling supports, and elevated plaque accumulation coexist with higher periodontal risk among elderly individuals with diabetes mellitus. This integrated profile underscores the multifactorial nature of periodontal vulnerability in this population and provides a comprehensive behavioral–clinical context for subsequent discussion.

According to Lawrence Green's theory¹⁷, health behavior is influenced by two main factors: behavioral factors and non-behavioral factors. Behavioral factors are further influenced by three components, namely predisposing factors, reinforcing factors, and enabling factors. Predisposing factors include an individual's knowledge, attitudes, and perceptions. Reinforcing factors consist of social, family, and environmental support, while enabling factors include the availability of health facilities, health professionals, and accessibility to health resources.²³

This aligns with evidence that shortages of dental personnel and inadequate preventive instruments/materials in public facilities limit scaling/polishing services and oral-health education delivery.²⁴ In this context, promoting proper toothbrushing techniques plays a crucial role in improving oral hygiene and preventing dental caries and periodontal disease.²⁵ Although this study initially refers to the PRECEDE–PROCEED framework, the analytical focus was limited to the PRECEDE components, namely predisposing, reinforcing, and enabling factors. The PROCEED phase, which emphasizes policy implementation, intervention execution, and outcome evaluation, was not assessed in this study. Therefore, the findings should be interpreted as a behavioral and environmental diagnosis rather than an evaluation of intervention outcomes.

As shown in the DSMBQ results (Table 3 & 6), suboptimal self-management behaviors were common across several predisposing domains. Among the 33 respondents, a large proportion did not regulate food portions (72.7%) and did not adhere to physician-recommended dietary regimens (54.5%). In addition, 21.2% of respondents did not regularly consume antidiabetic medication, and 42.4% reported not engaging in routine physical exercise. These findings indicate that limitations in dietary control and lifestyle-related behaviors constituted the most prominent predisposing challenges within the study population.

The DSMBQ findings suggest that diabetes self-management in this population is characterised by a mixed behavioral profile, with relatively good adherence observed in some domains, such as medication use, alongside substantial gaps in dietary regulation and physical activity. This domain-specific pattern underscores the importance of interpreting self-management behaviors as a multidimensional construct influenced by the combined contribution of predisposing, reinforcing, and enabling factors. Predisposing factors are influenced by an individual's knowledge, attitudes, beliefs, and lifestyle.²⁶ (Table 6).

In line with these determinants, the low adherence to self-management behaviors observed in this study may be associated with the respondents' low levels of knowledge and education. Knowledge and educational attainment play an important role in shaping attitudes and healthy lifestyle behaviors. Patients with lower educational levels often experience difficulties in receiving and understanding health-related information, which in turn affects their ability to perform effective diabetes self-management.²⁷

Reinforcing factors (Table 6) reflected the presence of social and informational support that may facilitate diabetes self-management behaviors. Most respondents reported routine blood glucose monitoring (78.8%), suggesting relatively good engagement in glycemic monitoring practices. Nevertheless, gaps in reinforcing support were also evident. A proportion of respondents reported insufficient information or limited opportunities for consultation with healthcare workers or community health cadres regarding blood glucose control (18.2%). In addition, more than one-third of respondents (39.4%) reported limited support from family members or others in reminding them to adhere to antidiabetic medication regimens.

These findings illustrate that, despite relatively good engagement in certain self-management practices, reinforcing factors related to health education and social support remain uneven across the study population. Such variability highlights the importance of strengthening interpersonal and health-system support to sustain diabetes self-management behaviors among elderly individuals with diabetes mellitus. Reinforcing factors, particularly social and family support, play an important role in encouraging adherence to diabetes self-management. Family support has a positive impact on adherence to diabetes self-management, as patients who receive family support tend to adopt healthier behavioral changes more easily than those with limited family support. Such support contributes to successful diabetes management, helps prevent complications, and improves patients' quality of life.²⁷ In addition, patients who live within a family environment and receive care from family members are more likely to develop self-awareness and motivation to engage in ongoing self-care.²⁸

Enabling factors (Table 6) reflected the availability and utilisation of healthcare resources that support diabetes self-management among elderly individuals. As indicated by the DSMBQ findings, most respondents reported access to periodic blood glucose examinations; however, gaps in service utilisation were still observed. Among the 33 respondents, 15.2% reported that they did not undergo regular periodic blood glucose checks, and 18.2% indicated that they did not routinely record their blood glucose levels. These findings suggest that, although basic diabetes monitoring services were generally available, consistent utilisation and self-monitoring practices were not uniformly adopted across the

study population. Variability in enabling factors may reflect differences in access to health services, continuity of care, or awareness of monitoring practices, highlighting the importance of strengthening supportive systems and service delivery mechanisms to facilitate sustained diabetes self-management in older adults.

Researchers have reported a bidirectional relationship between systemic diseases and periodontitis.²⁸ Periodontitis is recognized as one of the complications of diabetes mellitus (DM). Evidence indicates that periodontal severity is higher in individuals with DM than in non-diabetic individuals, particularly among those with poor glycemic control.²⁹ In this study, overall periodontal risk was distributed almost evenly between the moderate and high categories, as summarised in the periodontal risk classification table.

In uncontrolled DM, glucose levels in gingival crevicular fluid (GCF) are higher than in controlled DM. Studies have also reported that glucose concentrations are elevated in saliva among individuals with diabetes mellitus, which may alter the oral biofilm and plaque environment by facilitating bacterial adhesion and growth, thereby contributing to dental caries and the progression of periodontal disease. Consistent with this biological mechanism, the clinical findings in the present study showed that more than half of the respondents had plaque index scores equal to or above the sample mean, indicating a high level of dental plaque accumulation (Table 5).

In addition to plaque accumulation, clinical oral examination revealed other periodontal-related conditions. As presented in Table 4, a substantial proportion of respondents exhibited compromised oral hygiene status and clinical signs associated with periodontal involvement, including tooth mobility and transitional to diseased oral conditions. Together, these clinical findings provide observable oral health evidence that aligns with the proposed pathway linking hyperglycaemia, plaque accumulation, and periodontal vulnerability among elderly individuals with diabetes mellitus. DM is also associated with reduced polymorphonuclear leukocyte (PMN) function, which may increase the severity of periodontal tissue destruction. Clinically, DM can manifest in the oral cavity, including periodontal inflammation and periodontitis.³⁰

Several authors suggest that the severity of periodontal disease in patients with DM is influenced by impaired immune responses. This condition is accompanied by tissue changes that increase susceptibility to disease. Vascular alterations include increased collagen activity and changes in PMN response and chemotaxis to plaque antigens, which can inhibit phagocytosis. Hyperglycemia in DM contributes to microvascular complications characterized by increased advanced glycation end products (AGEs) in plasma and tissues. Cytokine secretion and synthesis mediated by periodontal infection can amplify AGE-mediated cytokine responses, or vice versa. Vascular impairment may also disrupt the clearance of metabolic waste products in periodontal tissues, leading to toxic effects on periodontal and gingival tissues.³¹

Future research should build on this diagnostic foundation by incorporating larger samples, longitudinal designs, and intervention-based approaches aligned with the PROCEED phase to evaluate the effectiveness of targeted periodontal health promotion strategies in diabetic populations.

The results of this study can be interpreted as a behavioral and environmental diagnosis that highlights key areas of vulnerability relevant to periodontal health among elderly individuals with diabetes. The application of the PRECEDE framework facilitated the systematic identification of predisposing, reinforcing, and enabling factors that may inform the prioritisation of oral health promotion strategies within primary healthcare settings.

This study has several limitations that should be acknowledged when interpreting the findings. First, although the PRECEDE–PROCEED framework was used to conceptually guide the assessment of behavioral and environmental factors related to periodontal disease risk, the scope of the analysis was limited

to the PRECEDE phase. The PROCEED phase which focuses on policy development, intervention implementation, and outcome evaluation was not applied in this study. Consequently, the findings represent a behavioral and environmental diagnosis rather than an assessment of intervention effectiveness or health outcomes.

Second, the relatively small sample size ($n = 33$) may limit the statistical precision and generalisability of the results. The limited sample was primarily due to the restricted number of eligible elderly and older adult patients with physician-confirmed diabetes mellitus and periodontal complaints who attended the Dukuh Kupang Primary Health Center during the defined data collection period. A total population sampling approach was applied, whereby all accessible and eligible individuals were included. Although this approach ensured comprehensive coverage of the available target population within the study setting, it inherently constrained the sample size. Consequently, the findings should be interpreted as descriptive and exploratory rather than inferential, and they may not be generalisable to broader diabetic populations or other healthcare settings.

Third, the cross-sectional and descriptive design precludes the examination of temporal or causal relationships between diabetes self-management behaviors, clinical oral health conditions, and periodontal risk. Fourth, behavioral variables were assessed using self-reported questionnaire data, which may be subject to recall and social desirability biases. In addition, potential confounding factors such as long-term oral hygiene practices, duration and control of diabetes mellitus, and other systemic or lifestyle influences were not analytically controlled. Therefore, the results should be interpreted as descriptive profiles rather than causal determinants of periodontal disease. Despite these limitations, the study provides a comprehensive overview of behavioral and clinical characteristics that can inform future analytical studies and intervention planning.

CONCLUSION

The findings demonstrate that periodontal risk in this population is characterised by a convergence of unfavourable sociodemographic profiles, suboptimal diabetes self-management behaviors, and compromised clinical oral health conditions. Notably, moderate to high periodontal risk coexisted with limitations in dietary regulation, physical activity, glycemic monitoring, and access to reinforcing and enabling supports. From a practical perspective, the implications of this study are that efforts to improve periodontal health in elderly populations with diabetes should emphasise strengthening oral health literacy, supporting consistent diabetes self-management behaviors, and enhancing the role of community-based services and primary healthcare providers.

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