Association Between Oral Candidiasis and Blood Glucose Level: A Case Control Study

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KEYWORDS	ABSTRACT
Oral candidiasis, blood glucose, HbA1c, oral hygiene, socio-demographics	**Background:** Background: Oral candidiasis, a fungal infection of the mucous diabetes membranes caused by Candida species, is a common health issue, particularly among diabetic individuals. In Bangladesh, the prevalence of diabetes and oral diseases like candidiasis is rising, but there is limited data on the association between oral candidiasis and blood glucose levels.
	Aim of the study: This study aimed to explore the association between oral candidiasis and blood glucose levels in patients with diabetes, while examining the impact of socio- demographic factors, oral hygiene, and other habitual factors.
	Methods: This case-control study was conducted at the Department of Oral and Maxillofacial Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, over one year. A total of 290 participants were enrolled, divided into two groups: Group A (patients diagnosed with oral candidiasis, n=97) and Group B (healthy controls, n=193). Data on socio-demographics, oral hygiene, blood glucose levels (FBS, 2HABF, HbA1c), and oral candidiasis were collected through interviews and laboratory tests. Statistical analysis was performed using SPSS software version 24, with significance set at p≤0.05.

Result: The study found that 28.9% of patients with oral candidiasis had HbA1c levels ≥7%, compared to 17.1% in the control group (p=0.020). A significant association was observed between lower educational levels and the development of oral candidiasis (OR=3.533, 95% CI: 1.977–6.315), as well as higher HbA1c levels (OR=1.968, 95% CI: 1.105–3.505). Poor oral hygiene was also significantly associated with candidiasis in the case group.

Conclusion: The study suggests a significant relationship between oral candidiasis and poor glycemic control in diabetic patients. It emphasizes the need for improved diabetes management and oral hygiene, particularly for elderly and low-education groups

INTRODUCTION

Oral diseases, particularly periodontal disease and oral candidiasis, are major health concerns in developing countries, exacerbated by poverty, poor living conditions, and inadequate healthcare policies. In Bangladesh, these issues are intensified by high population density, widespread poverty, and limited oral health awareness, with many individuals suffering from conditions like diabetes mellitus and oral candidiasis. Oral candidiasis is a fungal infection of the mucous membranes caused by Candida species, specially by Candida albicans being the most frequently implicated pathogen. This opportunistic infection affects diverse populations worldwide, regardless of age or health status [1]. Oral colonization by Candida species is well-documented, and diabetes mellitus is recognized as a predisposing factor for fungal infections, particularly those caused by Candida species [2,3]. Poor glycemic control in diabetic patients is associated with a higher risk of oral candidiasis due to increased fungal carriage and density. However, the strength of this relationship remains uncertain, requiring further research [4]. Diabetes mellitus, the most common endocrine disorder, is characterized by impaired glucose regulation due to insufficient insulin production, dysfunction, or resistance in target organs like skeletal muscles and the liver. Many cases go undiagnosed as individuals may be asymptomatic. Classic symptoms include polydipsia, polyuria, and polyphagia, caused by hyperglycemia. In addition to systemic complications, diabetes increases the risk of infections, including oral candidiasis [5]. There is consensus that diabetes mellitus increases the prevalence and severity of oral candidiasis [6,7]. Elevated blood glucose levels and the accumulation of advanced glycogen end products (AGEs) in gingival tissue are key mechanisms driving both oral and systemic complications of diabetes [8]. Additionally, diabetes-related immune dysfunction, including impaired leukocyte's chemotaxis, phagocytosis, and bactericidal activity, significantly raises susceptibility to infections like oral candidiasis [9]. Certain diabetic populations appear to be at particularly high risk for oral candidiasis, including individuals with poor oral hygiene, inadequate metabolic control, advanced age, long-standing diabetes, or other diabetes-related complications [10]. Additionally, individuals with poorly controlled diabetes experience greater periodontal attachment loss and a higher likelihood of recurrent infections [11]. Both type 1 and type 2 diabetic patients are susceptible to oral candidiasis [12]. Individuals with pre-diabetes, characterized by impaired fasting glucose (IFG) and impaired glucose tolerance (IGT), may also be at risk of developing oral candidiasis, which could serve as a potential early indicator of diabetes [13]. Although the link between diabetes and oral candidiasis is well- established, Bangladesh lacks a national database on the oral health status of diabetic patients. A national survey conducted between November 2009 and April 2010 found that 83.0% of the population had never measured their blood glucose levels, and only 3.9% self-reported having diabetes. However, other studies show an increasing diabetes prevalence, ranging from 2.2% to 8.1% in rural and urban areas [14,15]. Oral candidiasis may be linked to undiagnosed hyperglycemia or diabetes, emphasizing the need for further evaluation, including HbA1c testing. Research on this association could help to identify oral candidiasis as a potential early predictor of diabetes. This study aims to explore the association between oral candidiasis and blood glucose levels while assessing habitual factors and socio-demographic characteristics.

METHODOLOGY & MATERIALS

This study was conducted in the Department of Oral and Maxillofacial Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh. The study spanned one year, from 1st January 2020 to 31 December 2020 and focused on patients diagnosed with oral candidiasis. Using a purposive sampling method, a total of 290 participants were enrolled, forming a clearly defined study cohort. Ethical clearance was obtained from the IRB of BSMMU, ensuring informed consent, confidentiality, participant autonomy, and access to necessary medical care. Participants were systematically divided into two distinct groups based on their clinical presentation:

Group A Case (n=97): Patients diagnosed with oral candidiasis.

Control B Control (n=193): Healthy attendants.

Inclusion Criteria
- Patients diagnosed with oral candidiasis attending the outpatient department.
- Patients without oral candidiasis, matched for age, sex, dental status, and smoking habits.
- Patients who provided informed consent.

Exclusion Criteria
- Patients who had taken antibiotics in the last four weeks.
- Patients who had taken steroids in the last four weeks.

Data Collection:

The study subjects were selected based on predefined selection criteria. Data were systematically collected from all participants using a structured and validated questionnaire. Key variables assessed age and gender, the type and duration of diabetes, comorbidities such as hypertension and dyslipidemia, oral hygiene status evaluated using the Simplified Oral Hygiene Index, behavioral factors like the frequency of tooth brushing, flossing, and dental visits, laboratory results including blood glucose levels (fasting blood glucose, 2-hour postprandial blood glucose, and HbA1c), examination findings from a clinical assessment of the oral cavity, and histopathological examination of tissue samples from two oral sites. The data collection tool consisted of a pre-determined sheet filled out by the investigator through an interview, supplemented by documentary evidence. Oral hygiene status was assessed using the Simplified Oral Hygiene Index OHI-S (Simplified Debris (plaque) Index DI-S and Simplified Calculus Index CI-S), as described by Greene-Vermillion (1967) [16]. Histopathological examination was performed on two different sites of the oral cavity by an experienced dental surgeon.

Statistical Analysis:

The data were analyzed using SPSS software (version 24, IBM Corporation, Armonk, NY, USA). Descriptive statistics were applied to summarize demographic data, clinical history, examination findings, and laboratory results. The histopathological examination results were used as a reference to calculate sensitivity and specificity, with a 95% confidence interval (CI). Unpaired t-tests were employed to compare normally distributed continuous variables, while Mann–Whitney U tests were used for non-normally distributed variables. Chi-square tests were applied to compare categorical variables. Odds ratios (ORs) and 95% CIs were calculated to assess associations between oral candidiasis and diabetes mellitus. A p-value ≤0.05 was considered statistically significant.

RESULT

A total of 290 respondents participated, consisting of case and control groups. Age distribution showed that most controls (76.2%) were under 40 years, compared to 41.2% of cases. A larger proportion of cases (32%) were aged 41–50 years versus controls (13%). The 51–60 age group was represented similarly in both groups (17.5% cases, 8.8% controls). A higher proportion of cases (9.3%) were over 61 years, compared to controls (2.1%). Sex distribution was nearly equal in both groups: 48.5% males and 51.5% females in cases, and 45.1% males and 54.9% females in controls. Most participants were Muslim (95.9% cases, 94.8% controls) (Table 1). Regarding employment, the majority of control participants worked in the NGO sector (40.9%), while a lower proportion of case participants (29.9%) did so.

Homemakers comprised a larger proportion in the case group (29.9%) compared to the control group (22.3%) (Figure 1). Figure 2 demonstrated that income distribution showed that 49.5% of the case group had an income of ≤10,000 Tk/month, compared to 43.1% in the control group. Educationally, a higher proportion of control participants had completed higher secondary education or above (60.8%) compared to the case group (37.5%) (Figure 3). Symptom analysis revealed that 13.4% of cases exercised regularly, compared to 19.7% in the control group. However, this difference was not statistically significant (χ^2 = 1.761, P = 0.185). HbA1c levels were significantly higher in the case group, with 28.9% of cases having HbA1c ≥7 compared to 17.1% in the control group (χ^2 = 5.382, P = 0.020) (Table 2). However, table 3 represented that the mean HbA1c difference was not statistically significant (t = 8.935, P = 0.296). The mean score for oral candidiasis was significantly higher in the case group (2.705±1.306) compared to the control group (1.367±0.963), with a statistically significant difference (t = 1.047, P < 0.01). Risk factor analysis showed that lower educational levels were significantly associated with disease development (OR = 3.533, 95% CI: 1.977–6.315). Higher HbA1c levels also increased the risk (OR = 1.968, 95% CI: 1.105–3.505). No significant associations were found for smoking habits or mouth rinse use (Table 4).

Table 1: Distribution of respondents by socio demographic characteristics (n = 290)

Variables	Case		Control	
	n	%	n	%
Age (Years)				
< 40	40	41.20	147	76.20
41 - 50	31	32.00	25	13.00
51 - 60	17	17.50	17	8.80
> 61	9	9.30	4	2.10
Sex				
Male	47	48.50	87	45.10
Female	50	51.50	106	54.90
Religion				
Muslim	93	95.90	183	94.80
Hindu	4	4.10	10	5.20
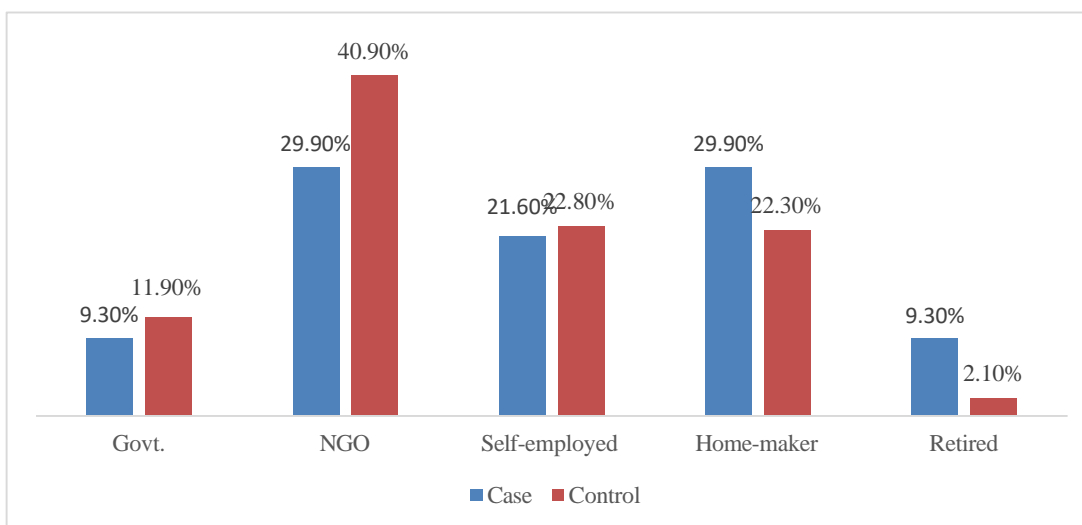
Figure 1: Distribution of respondents according to Occupation (n = 290)
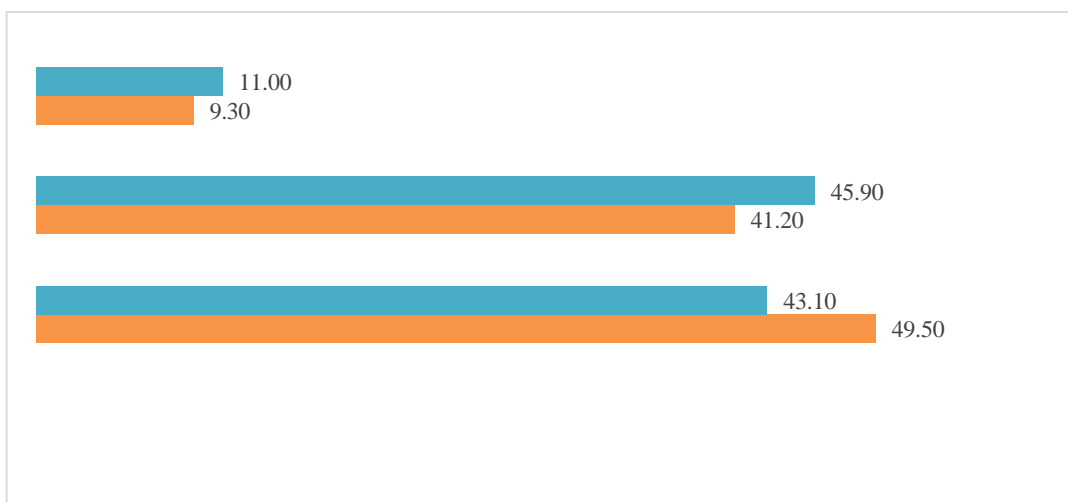
Figure 2: Distribution of respondents according to Monthly income (TK) (n = 290)

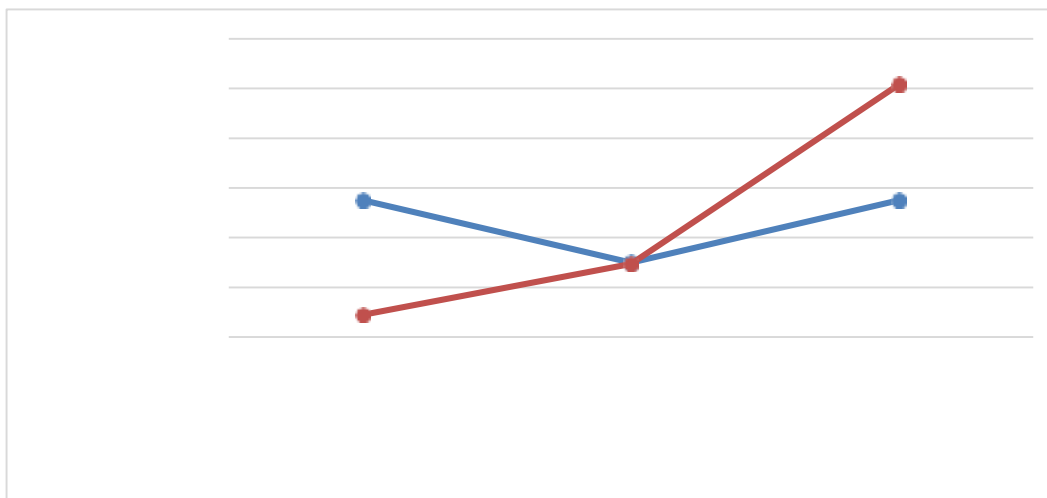|	<=10000	11000-20000	>=21000
▪ Control(%)	43.10	45.90	11.00
▪ Case(%)	49.50	41.20	9.30

Figure 3: Distribution of respondents according to educational status (n = 290)

Table 2: Distribution of respondents according to symptoms related to high blood glucose level

	Primary or less	Secondary	Higher Secondary or above
Case(%)	37.50	25.00	37.50
Control(%)	14.50	24.70	60.80

Variables	Case		Control		Test-statistics
	n	%	n	%	
Regularity of Exercise					
Yes	13	13.40	38	19.70	P = 0.185
No	84	86.60	155	80.30	
No	19	19.6	72	37.30	
HbA1c value					
≥7	28	28.9	33	17.10	P = 0.020
<7	69	71.1	160	82.90	

Table 3: Mean comparison of the respondents regarding glucose level and oral candidiasis

Variables	Case (Mean + SD)	Control (Mean + SD)	Test statistics
HbA1c	5.807 + 2.284	5.523 + 1.935	t = 8.935, P = 0.296
Oral Candidiasis	2.705 + 1.306	1.367 + 0.963	t = 1.047, P < 0.01

Table 4: Factors exhibiting risk regarding disease development (n = 290)

Variables	Case		Control		OR (95% CI)
	n	%	n	%	
Education	36	37.50	28	14.50	3.533 (1.977, 6.315)
Monthly income	48	49.50	83	43.10	1.294 (0.789, 2.122)

HbA1c	28	28.90	33	17.10	1.968 (1.105, 3.505)
Smoking habit	18	18.60	42	21.80	0.819 (0.443, 1.516)
Mouth rinse	13	13.40	40	20.70	0.592 (0.300, 1.168)

DISCUSSION

Oral candidiasis, commonly known as thrush, is a fungal infection caused by the overgrowth of Candida species in the oral cavity [17]. While Candida is a normal inhabitant of the mouth, certain conditions can lead to its excessive proliferation [18]. One significant factor is diabetes mellitus, a chronic condition characterized by elevated blood glucose levels. In individuals with diabetes, high blood sugar levels can create an environment conducive to Candida growth, leading to infections such as denture stomatitis, pseudomembranous candidiasis, median rhomboid glossitis, and angular cheilitis [17-18]. Moreover, compromised immune function associated with diabetes further predisposes individuals to such infections [19]. Understanding the interplay between blood glucose control and oral Candida infections is crucial for effective prevention and management strategies. In our study, we evaluated the association between oral candidiasis and blood glucose levels in individuals with high blood glucose levels.Our findings revealed a significant association between elevated HbA1c levels and the presence of oral candidiasis, with those in the case group (individuals with oral candidiasis) having a higher mean HbA1c compared to the control group. This result aligns with the findings of a study by Gamil et al. (2024), which demonstrated a higher prevalence of oral candidiasis among individuals with uncontrolled diabetes [20]. Additionally, our study revealed that the prevalence of oral candidiasis was notably higher in individuals with HbA1c levels ≥7, suggesting that poor glycemic control may contribute to an increased risk of oral fungal infections, as corroborated by previous research [21]. Several studies have investigated the relationship between glycemic control, as indicated by HbA1c levels, and the prevalence of oral candidiasis in individuals with diabetes mellitus, supporting a significant association between elevated HbA1c and an increased risk of oral Candida infections [22]. However, some studies did not find a direct correlation between HbA1c levels and the development of oral candidiasis. One study reported a higher prevalence of candidiasis in diabetic patients (51.85%) compared to non-diabetics (31.70%) but did not establish a significant relationship between HbA1c levels and oral candidiasis in either group [23]. Additionally, research has shown that patients with periodontitis and HbA1c levels >9 exhibit a higher frequency of Candida infections compared to those with well-controlled glycemic levels (HbA1c <6) [24]. Furthermore, our findings indicate that lower educational levels were associated with a higher likelihood of developing oral candidiasis. This aligns with previous studies, which have reported a correlation between lower education levels, poor diabetes management, and an increased prevalence of oral diseases [25]. While the association between income and oral candidiasis was not statistically significant, a noticeable trend suggests that individuals with lower monthly incomes may be more vulnerable, possibly due to limited access to healthcare resources or inadequate diabetes management tools [26]. Compared to the control group, individuals in the case group reported a lower frequency of regular exercise (13.4% vs. 19.7%, respectively), suggesting that a lack of physical activity could be an additional risk factor for both poor blood glucose control and oral candidiasis. This finding aligns with previous studies that emphasize the beneficial role of physical activity in lowering blood glucose levels and preventing diabetes-related complications [27]. Notably, no significant difference was observed in smoking habits between the case and control groups, indicating that smoking may not directly contribute to the development of oral candidiasis in this cohort. However, the potential confounding effects of smoking on oral health and glycemic control should be considered, as it is well-established that smoking independently affects both factors [23]. For example, a study conducted in Rafsanjan, Iran, reported no significant association between cigarette consumption and the prevalence of oral candidiasis [28]. Moreover, smoking cessation has been linked to improved glycemic control in individuals with type 2 diabetes, underscoring the intricate relationship between smoking, glycemic control, and oral health [29].

Limitations of the study: Every hospital-based study has some limitations and the present study undertaken is no exception to this fact. The limitations of the present study are mentioned. The present study was conducted in a limited area and within the same group of population, so the study findings may not be signifying for the entire population. The time frame was short to comment on the association. Moreover, this study was conducted with small sample size.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates a significant association between elevated HbA1c levels and the presence of oral candidiasis, underscoring the role of poor glycemic control in increasing susceptibility to oral fungal infections. Our findings further suggest that sociodemographic and lifestyle factors—such as lower educational attainment, reduced physical activity, and limited income—may contribute to this risk, likely through their influence on diabetes self-management and overall health behaviors. Although no direct association was observed between smoking and oral candidiasis in this cohort, the potential confounding effects of smoking on oral and metabolic health warrant consideration. Taken together, these results highlight the importance of comprehensive diabetes management strategies that not only focus on glycemic control but also address broader social and behavioral determinants, in order to reduce the burden of oral candidiasis among individuals with diabetes.

Conflict of interest: None declared

Ethical Approval: The Study was Approved by the Institutional Review Board (IRB)

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