

Impact of Glycemic Control, Biochemical Parameters, and Diabetes Duration on Xerostomia in Diabetic Patients

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ABSTRACT

Background: Xerostomia, or dry mouth, is a common condition among diabetic patients, potentially affecting their quality of life. The study aimed to investigate the prevalence of xerostomia and its association with various demographic, medical, and biochemical variables.

Methods: A cross-sectional study was conducted with 117 diabetic patients at the Department of Oral and Maxillofacial Surgery, Abbasi Shaheed Hospital, Karachi Medical and Dental College, Karachi, for six months from November 2022 to April 2023. Demographic, medical, and biochemical data were collected, including age, gender, diabetes duration, presence of complications, and RBS levels. The prevalence of xerostomia was assessed through a self-reported questionnaire. The severity of salivary dysfunction was categorized according to RBS levels. Data entry and analysis were performed using SPSS version 22. Post-stratification chi-square test was applied, with a p-value of ≤ 0.05 considered statistically significant.

Results: The mean age of participants was 47.16 ± 7.04 years, and the mean duration of diabetes was 10.6 ± 4.86 years. The prevalence of xerostomia in the sample was 55(47.0%). A significant relationship was found between higher RBS levels and more severe salivary dysfunction ($p = 0.013$). No significant associations were observed between xerostomia and age, gender, dental caries, smoking, alcohol consumption, or medical history. Patients with diabetes for more than 10 years exhibited a higher prevalence of xerostomia, though this association was not statistically significant ($p = 0.059$).

Conclusion: Poor glycemic control and long-term diabetes duration significantly increased the prevalence of xerostomia among diabetes patients. The results suggest the need for regular monitoring and management of blood glucose so that salivary dysfunction is reduced. Further research is needed to assess other contributing factors and potential prevention.

Keywords: Xerostomia, Diabetes, Prevalence, Glycemic Control.

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INTRODUCTION

Diabetes mellitus is an enduring consequence disorder classified as a disorder of metabolism characterized by chronic hyperglycemia caused by defective insulin secretion, declining insulin sensitivity, or some combination of both¹. According to the International Diabetes Federation (IDF), more than 537 million adults worldwide are estimated to be living with diabetes as of now, which is expected to dramatically increase in the coming years². While the systemic manifestations and complications of diabetes, which include cardiovascular disease, nephropathy, neuropathy, and retinopathy, are well elucidated, systemic underpinnings that affect oral health are less explored yet seriously impactful^{3, 4}.

Diabetic patients can experience common oral manifestations, including periodontal disease, oral infections, burning mouth syndrome, and xerostomia, which is defined as the sensation of dry mouth⁵. Xerostomia in the diabetic patient is multifactorial due to not only peripheral neuropathy and dehydration from polyuria, but also unique changes in the biochemistry involved⁶. When there is poor glycemic control, blood glucose levels rise, leading to a rise in salivary glucose levels, which limits salivary function⁷. Elevated glucose levels in saliva can inhibit salivary antimicrobial functions and therefore put the diabetic patient at risk for oral infectious diseases, such as candidiasis⁸. Additionally, chronic exposure to hyperglycemia leads to chronic systemic inflammation⁹. There is an increase in the inflammatory cytokines IL-6 and TNF- α due to chronic hyperglycemia, which can also have negative effects on the functional status of the salivary glands and decrease salivary flow¹⁰. Biochemical markers of oxidative stress and changed immune responses are also important aspects of the pathophysiology as it relates to oral complications in diabetes¹¹. Oxidative stress increases salivary gland tissue damage, microvascular changes reduce the perfusion of the glands, and collectively, these changes reduce salivary secretion, which is critical¹². In addition, the saliva of diabetics has changed concentrations of electrolytes, immunoglobulins, and enzymes, which also decreases the protective effect of saliva¹³. The presence of xerostomia can contribute to difficulty with mastication, speech, swallowing, and taste, which can affect the nutrition and quality of life of the diabetic patient¹⁴. Xerostomia can also increase

the risk of dental caries, periodontal disease, and oral mucosal infections, which can exacerbate glycemic control, perpetuating a destructive cycle¹⁵. As there is a bidirectional relationship between diabetes and oral health, timely identification and treatment of xerostomia are paramount in achieving the best oral and systemic outcomes¹⁶.

It is crucial to understand the frequency of xerostomia and its potential biochemical mechanisms in patients with diabetes. This knowledge can facilitate a more comprehensive health care model wherein medical and dental health professionals address the range of diabetes-related complications to connect patients with services and improve health. Diabetes mellitus affects more than systemic health; it also affects the oral environment via biochemical and functional changes in saliva. Xerostomia is a common and debilitating complaint in people with diabetes and is not just a subjective symptom; it is an endpoint in a range of metabolic disorders, including oxidative stress due to hyperglycemia, inflammation, and compromised blood supply to salivary glands¹⁴.

Examining the prevalence and consequences of xerostomia in diabetes patients, along with the biochemical factors, will contribute to understanding xerostomia's place in the wider array of diabetic complications, while further establishing the need for a multidisciplinary approach to management by incorporating oral health assessment as a key part of diabetes treatment. Identifying and managing xerostomia early on can help limit infections in the mouth and improve glycemic control and quality of life for diabetic patients. The study aimed to investigate the prevalence of xerostomia and its association with various demographic, medical, and biochemical variables of the diabetic participants.

METHODS

This study was executed in a cross-sectional design at the Department of Oral and Maxillofacial Surgery, Abbasi Shaheed Hospital, and Karachi Medical and Dental College, Karachi. This study was conducted for six months from November 2022 to April 2023, using non-probability consecutive sampling. Ethical approval was obtained from the Ethical Review Board of Karachi Medical & Dental College &

Abbasi Shaheed Hospital (Reference Number: 16/22, Dated: April 27, 2022). Strict confidentiality of patient data was maintained throughout the study. The sample size was calculated as 117 through the OpenEpi sample size calculator, considering a 56% prevalence rate of xerostomia among diabetic patients, a 9% margin of error, and a 95% confidence level¹⁷. Patients aged between 35 and 75 years, diagnosed with either type I or type II diabetes mellitus for more than three years, and following a treatment regimen either with oral hypoglycemic agents or insulin injections, were included. Both male and female patients visiting the maxillofacial outpatient department with complaints related to dental causes, oral and facial pathologies like trauma, or tumors (excluding salivary tumors), and any premalignant lesions were eligible. Patients were excluded if they had systemic illnesses such as hypothyroidism, hepatitis, psychological diseases, were smokers or alcoholics, or had a history of radiotherapy or chemotherapy within the past three months. Furthermore, individuals taking medications known to cause dry mouth, such as antihistamines, anticholinergics, antihypertensives, tricyclic antidepressants, or those suffering from salivary gland diseases like Sjogren's syndrome, systemic lupus erythematosus (SLE), rheumatoid arthritis, or salivary gland tumors were excluded.

Following the approval of the synopsis by Karachi Medical & Dental College & Abbasi Shaheed Hospital ethical committee, written informed consent was obtained from all study participants. Patients fulfilling the inclusion criteria were selected from the outpatient department, and demographic details including name, age, gender, OPD number, and date of admission were recorded in a structured proforma. The stimulated salivary flow rate (SSFR) was assessed by having patients sit comfortably while chewing sterile wax for five minutes with the head slightly tilted forward, spitting the saliva into a sterile measuring cup¹⁸. Patients wearing dental prostheses were instructed to remove them and rinse their mouths for one minute before saliva collection to avoid contamination. The

Table 1: Characteristics of the study participants

Variables	Mean	Std. Deviation	Median	IQR
Age (Years)	47.16	7.04	45	12
Duration of Diabetes (Years)	10.60	4.86	10	5
Random Blood Sugar (RBS)	218.14	16.81	210	30
Amount of Salivary Flow (ml/min)	0.676	0.186	0.78	0.31

volume of saliva produced over one minute was measured in milliliters per minute (ml/min). Stimulated salivary flow of less than 0.7 ml/min was considered low. Patients were carefully instructed not to swallow any saliva during the procedure.

Data entry and analysis were performed using SPSS version 22. The normality of quantitative data was assessed through the Shapiro-Wilk test. For quantitative variables such as age, duration of diabetes, random blood sugar (RBS) levels, and salivary flow rate, mean and standard deviation or median and interquartile range (IQR) were calculated. Frequency and percentage were used to summarize categorical variables such as gender, etiology, complications like dental caries and burning sensation, medical history, and presence of xerostomia. Stratification was performed to control for effect modifiers such as age, gender, smoking status, alcohol use, medication intake, duration of disease, etiology, and oral complications. Post-stratification chi-square test was applied, with a p-value of ≤ 0.05 considered statistically significant. Biochemical variables such as random blood sugar levels were particularly noted to explore their relationship with the severity of salivary dysfunction among diabetic patients.

RESULTS

The results suggest that Xerostomia is predominantly found in patients with both longer duration of diabetes and a history of higher RBS levels, which may be due to chronic hyperglycemia, resulting in autonomic neuropathy that reduces the function of the salivary glands. In addition, poor glycemic control over time leads to microvascular complications and dehydration, both of which similarly affect parotid gland salivary flow. However, no significant associations were found between xerostomia and factors such as age, gender, dental caries, smoking, alcohol consumption, medical history, or drug history. Elevated RBS levels were significantly linked to increased severity of salivary dysfunction, underlining the importance of glycemic control in mitigating salivary dysfunction among diabetic patients.

The study aimed to investigate the relationship between xerostomia (dry mouth) and various demographic, medical, and biochemical variables in diabetic patients. The sample consisted of 117 diabetic individuals, with a mean age of 47.16 years (SD = 7.04) and a median age of 45 years. The duration of diabetes had a mean of 10.6 years (SD = 4.86), and a median duration of 10 years. The average Random Blood Sugar (RBS) level was 218.14 mg/dL (SD = 16.81), with a median of 210 mg/dL. The salivary flow rate in the participants averaged 0.676 ml/min (SD = 0.186), with a median of 0.78 ml/min. There were 54(46.0%) male and 63(54.0%) female. (Table 1; Figure 1)

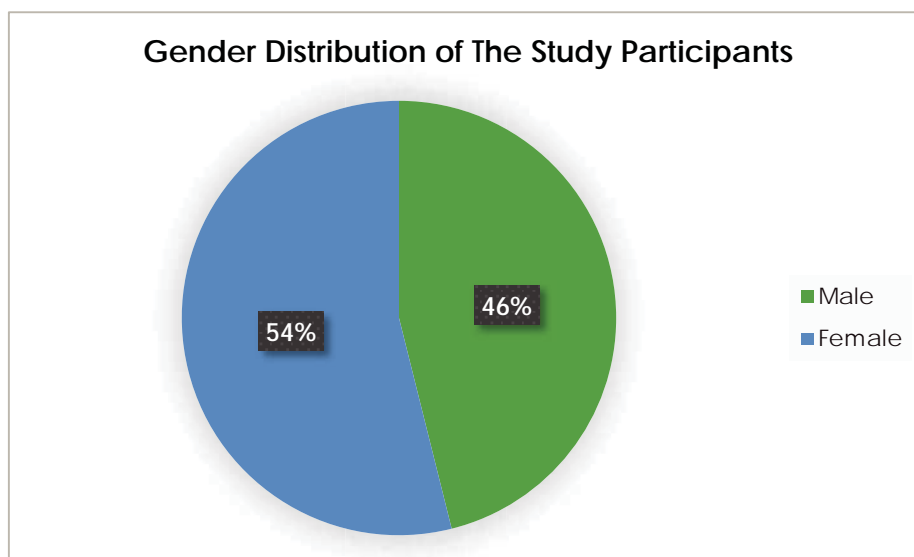


Figure 1: A Pie Chart Showing the Gender Distribution of the Study Participants

Table 2: Complications, Etiology, and Addiction of the study participants (n=117)

Variables	Count	Percentage (%)
Dental Caries		
Yes	60	51.3%
No	57	48.7%
Burning sensation		
Yes	51	43.6%
No	66	56.4%
Smokers		
Yes	29	24.8%
No	88	75.2%
Alcoholics		
Yes	16	13.7%
No	101	86.3%
Medical History		
Yes	38	32.5%
No	79	67.5%

Drug History		
Yes	23	19.7%
No	94	80.3%

Regarding the presence of complications and other factors, 51.3% of the patients had dental caries, while 48.7% did not. A significant proportion of the participants (43.6%) reported experiencing a burning sensation in the mouth, whereas 56.4% did not. Smoking was prevalent among 24.8% of the patients, and 13.7% were alcoholics. Additionally, 32.5% of patients had other medical conditions, while 19.7% were on medications that could potentially affect salivary function. The frequency of xerostomia in diabetic patients was observed in 54(46.15%). (Table 2; Figure 2)

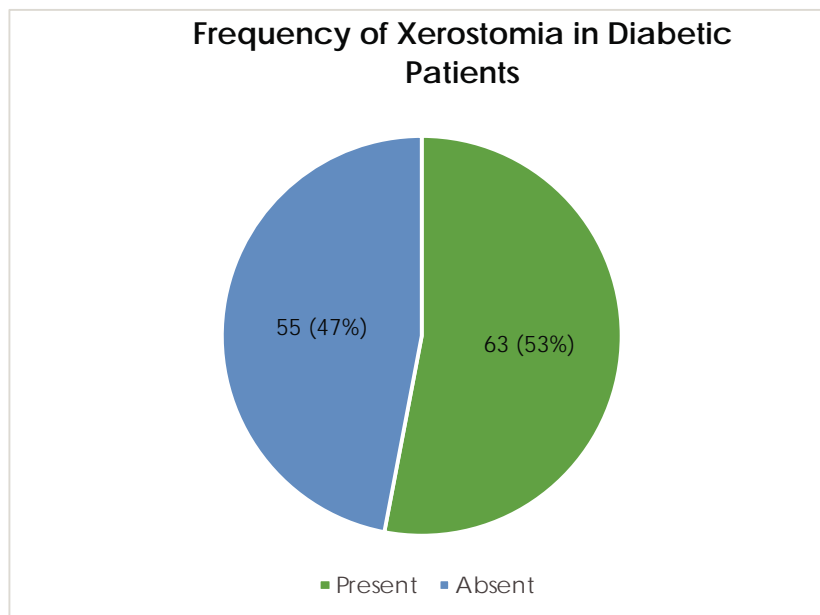


Figure 2: Frequency of Xerostomia in Diabetic Patients

Table 3: Frequency of Xerostomia in Diabetic Patients According to Stratified Variables

Variables	Xerostomia		P-Value
	Present	Absent	
Age (Years)			
35-40	13 (56.5%)	10 (43.5%)	0.530
41-50	24 (42.9%)	32 (57.1%)	
>50	17 (44.7%)	21 (55.3%)	
Gender			
Male	28 (51.9%)	26 (48.1%)	0.252
Female	26 (41.3%)	37 (58.7%)	
Duration of Disease			
≤10 years	24 (38.1%)	39 (61.9%)	0.059
>10 years	30 (55.6%)	24 (44.4%)	

Dental Caries			
Yes	24 (47.1%)	27 (52.9%)	0.863
No	30 (45.5%)	36 (54.5%)	
Burning Sensation			
Yes	26 (43.3%)	34 (56.7%)	0.530
No	28 (49.1%)	29 (50.9%)	
Smokers			
Yes	13 (44.8%)	16 (55.2%)	0.860
No	41 (46.6%)	47 (53.4%)	
Alcoholics			
Yes	11 (68.8%)	5 (31.3%)	0.051
No	43 (42.6%)	58 (57.4%)	
Medical History			
Yes	21 (55.3%)	17 (44.7%)	0.170
No	33 (41.8%)	46 (58.2%)	
Drug History			
Yes	10 (43.5%)	13 (56.5%)	0.774
No	44 (46.8%)	50 (53.2%)	

Table 3 shows that the study also explored the frequency of xerostomia in diabetic patients according to various stratified variables. The results showed that among patients aged 35–40 years, 56.5% experienced xerostomia, compared to 42.9% in the 41–50 years age group and 44.7% in those over 50 years. However, the p-value for age was 0.530, indicating no statistically significant difference in xerostomia occurrence across different age groups. For gender, 51.9% of male patients had xerostomia, while 41.3% of female patients experienced it. The p-value of 0.252 suggests that gender did not have a significant effect on xerostomia prevalence. When stratifying by the duration of diabetes, it was found that 38.1% of patients with diabetes for 10 years or less reported xerostomia, while 55.6% of those with diabetes for more than 10 years had xerostomia. The p-value of 0.059 indicates a borderline non-significant trend, with a higher prevalence of xerostomia in patients with longer diabetes duration. The presence of dental caries was not significantly associated with xerostomia, with 47.1% of patients with caries and 45.5% of those without caries reporting xerostomia ($p = 0.863$). Similarly, a burning sensation did not significantly affect xerostomia prevalence ($p = 0.530$), with 43.3% of those with a burning sensation and 49.1% of those without it experiencing xerostomia. Smoking and alcohol consumption did not significantly impact xerostomia. Among smokers, 44.8% had xerostomia, while 46.6% of non-smokers experienced it ($p = 0.860$). Among alcoholics, 68.8% had xerostomia, compared to 42.6% of non-alcoholic patients, with a borderline significant p-value of 0.051. A medical history of other conditions was associated with a slightly higher prevalence of xerostomia (55.3% vs. 41.8%) but was not statistically significant ($p = 0.170$). Similarly, drug use did not appear to significantly affect xerostomia, with 43.5% of patients on medication and 46.8% of those not on medication reporting xerostomia ($p = 0.774$).

Table 4: Association of Random Blood Sugar (RBS) Levels with Severity of Salivary Dysfunction

RBS Range (mg/dL)	Salivary Dysfunction (%)			P-Value
	Mild	Moderate	Severe	
150–200	11 (9.4%)	6 (5.1%)	1 (0.8%)	0.013*
201–250	14 (11.9%)	19 (16.2%)	3 (2.5%)	
>250	7 (5.9%)	18 (15.3%)	11 (9.4%)	

The study further explored the association between Random Blood Sugar (RBS) levels and the severity of salivary dysfunction. A significant relationship was found ($p = 0.013$), with higher RBS levels being associated with greater severity of salivary dysfunction. Among patients with RBS levels between 150–200 mg/dL, 9.4% had mild salivary dysfunction, 5.1% had moderate dysfunction, and 0.8% had severe dysfunction. In patients with RBS levels between 201–250 mg/dL, 11.9% had mild dysfunction, 16.2% had moderate dysfunction, and 2.5% had severe dysfunction. For those with RBS levels greater than 250 mg/dL, 5.9% had mild dysfunction, 15.3% had moderate dysfunction, and 9.4% had severe dysfunction. These findings suggest that higher RBS levels contribute to more severe salivary dysfunction **Table 4**.

DISCUSSION

This study aimed to determine the prevalence of xerostomia and its association with multiple demographics, medical, and biochemical variables in diabetic patients. The results from this study provide a full understanding of xerostomia in diabetic conditions by collating factors related to the duration of diabetes and Random Blood Sugar (RBS). The comparison made when discussing it with other existing studies found in literature relates to this and provides understanding into the pathophysiology of xerostomia in diabetes as a whole.

In our study, 46.15% of diabetic patients reported having xerostomia, which is in line with several studies suggesting similar prevalence rates. Multiple studies reported a prevalence of 60.0% and 52.4% among diabetic individuals^{19, 20}. The studies showed that xerostomia is a common complication of diabetes mellitus and is likely a result of low salivary flow because of the effects of hyperglycemia on the salivary gland.

In this study, the duration of diabetes had a borderline non-significant association with xerostomia prevalence, as 55.6% of those with diabetes for more than 10 years and 38.1% of those with less duration of diabetes experienced xerostomia or dry mouth. These results are similar to the research study, where it was noted that the longer someone has diabetes, the more likely the person is to develop xerostomia¹⁴. The reasoning for this association may be due to the physiologic mechanism of cumulative damage to the autonomic nervous system and salivary glands associated with prolonged periods of hyperglycemia, as salivary secretion can be impaired. Although the p-value (0.059) in this study was not statistically significant, the association does

suggest that with longer durations of diabetes, there may be a substantially increased risk of xerostomia, and future studies should consider a larger sample size or longitudinal studies to investigate this.

One of the most significant findings in this study was the association between higher RBS levels and greater severity of salivary dysfunction. Diabetic patients with higher RBS levels exhibited a higher prevalence of moderate and severe salivary dysfunction. This aligns with studies that reported that poor glycemic control is strongly associated with xerostomia in diabetic patients^{21, 22}. Hyperglycemia leads to dehydration, which can decrease the secretion of saliva and worsen the symptoms of dry mouth. The significant p-value of 0.013 in our study underscores the importance of glycemic control in managing xerostomia and suggests that controlling blood sugar could help mitigate the severity of this condition.

Our study found no significant association between xerostomia and factors such as gender, smoking, alcohol consumption, dental caries, medical history, or drug use. Similar findings have been reported in previous studies, which found that smoking and alcohol use had no significant effect on xerostomia in diabetic patients²³. Nevertheless, some studies like indicated that tobacco use and alcohol consumption have the potential to influence xerostomia through the effect that tobacco and alcohol have on the salivary glands^{24, 25}. In our study, the high level of xerostomia in alcoholics (68.8%) is remarkable, and while the association appeared to be non-significant ($p = 0.051$), it did suggest that alcohol may further aggravate salivary dysfunction in diabetic patients, and thus is worth further study.

The lack of significant associations between xerostomia and other variables, including dental

caries, burning sensation, and medical history, is likely a result of our smaller sample size. Larger studies may aid in determining if there are significant associations between xerostomia and other variables, and specifically if dental caries, since dental caries has been related to xerostomia in past literature. This analysis emphasized the significant relationship of elevated Random Blood Sugar (RBS) levels and severity of salivary dysfunction among diabetes patients and the importance of good glycemic control as part of the maintenance of oral health. In consideration of the above, clinicians should proceed with caution concerning xerostomia or other salivary dysfunctions among diabetes patients, especially those patients who are poorly controlled concerning their glycemic status, or who have maintained their diabetes for a prolonged period. While the oral health status could be monitored continuously, through regular check-ups and medical intervention, clinicians must also aim to provide respective management of blood sugar levels to further limit the chances of xerostomia and/or the severity of xerostomia. Management of xerostomia levels could contribute to good overall quality of life for diabetes patients.

CONCLUSION

This research study shows that xerostomia (dry mouth) is very high in diabetic patients, and possibly even higher in those with longer durations of diabetes and perhaps even higher RBS levels. The research highlights the importance of effective glycemic control for preventing salivary dysfunction and/or alleviating xerostomia. Although the study did not find significant associations with additional factors such as age, gender, dental caries, smoking, alcohol consumption, medical history or drug use, the study and implications for further research demonstrate the need for more research with larger sample sizes and longitudinal datasets to better understand the relationship between these dynamic variables and xerostomia.

Future research should also examine the potential interventions for people living with diabetes and xerostomia, to include saliva substitutes. Another line of potential investigation is to explore the salivary dysfunction concerning improved glycemic control, to determine if improvements in glycemic status are improvements in salivary function.

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research.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ETHICAL APPROVAL

The study was approved by the Ethical Review Committee of the Karachi Medical & Dental College & Abbasi Shaheed Hospital (Approval Number: 16/22).

PATIENT CONSENT

Informed consent was obtained from all patients involved in the study.

AUTHORS' CONTRIBUTION

All authors equally contributed as per the ICMJE policy.

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