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# Table of Contents

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# Early Hyperglycemia in Diabetics as a Predictor of Disease Severity in COVID-19

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## Abstract

**Background:** Hyperglycemia is an important predictor of prolonged hospitalization and mortality. The objective of this study was to analyze the role of early hyperglycemia in predicting the severity of COVID-19 illness and mortality. **Method:** Retrospective study on 259 patients with COVID-19 with measurement of average glucose during 24 hours of admission. Association of Early Hyperglycemia categorized as <180 mg/dl or >180 mg/dl; was studied with mortality, requirement of ICU stay and prognostic markers. **Results:** Early hyperglycemia (>180 mg/dl) revealed a higher median value for CRP (109 mg/l [IQR; 48 - 199]) in comparison to <180 mg/dl group (86 mg/l [IQR; 26.3 - 153]) p = 0.03. ICU stay was higher in >180 mg/dl group; 24 (15.9%) vs 14 patients (13%) [p = 0.51] in the <180 mg/dl group. Mortality in the group > 180 mg/dl was 8 (5.3%) while <180 mg/dl had a mortality rate of 4 (3.7%) [p = 0.547]. **Conclusion:** Hyperglycemia in the first 24 hours may anticipate an increased risk of ICU stay and a higher mortality rate. It may be a possible predictor of disease severity.

## Keywords

Admission Hyperglycemia, COVID-19, Diabetes, Disease Severity

## 1. Introduction

The coronavirus disease of 2019 (COVID-19) has a diverse spectrum of clinical presentation, ranging from patients being completely asymptomatic carriers to exceedingly severe outcomes such as acute respiratory distress syndrome (ARDS) and multi-organ failure, necessitating ventilatory support and critical care [1]. While Chinese cohort studies demonstrated an intensive care unit (ICU) admission rate of 7% - 26%, the numbers ranged between 5% - 12% of total positive SARS-CoV-2 cases in Italy [2] [3]. Presence of comorbidities such as diabetes mellitus, hypertension, chronic obstructive pulmonary disease (COPD) and coronary artery disease (CAD) are independent risk factors for disease progression, in addition to age over 65 and male sex [4].

Admission hyperglycemia plays an important role in predicting mortality in hospitalized patients with COVID-19 [5]. It is also associated with increased incidence in mechanical ventilation and requirement of ICU stay [6]. Various meta-analyses done in different centers have recognized diabetes mellitus as significant comorbidity in COVID-19 [7] [8]. Paramount significance is the greater incidence of poor outcomes associated with diabetes mellitus, demonstrated by 44.5% of diabetics developing severe disease [7]. Similar findings have been reflected in a single-center, retrospective, observational study in China, where 22% of critically-ill COVID-19 patients who did not survive were diabetic [2]. Diabetes was reported in a greater proportion of critical and deceased patients in comparison to non-critical patients, reiterating the role of diabetes as a significant marker of poorer outcomes [9].

Early hyperglycemia as defined by high blood sugars (>180 mg/dl) on admission and during the initial 24 hours of admission, is postulated to affect the prognosis of these patients. This study aims at identifying the link between early hyperglycemia and the requirement of intensive care as well as with the mortality rate of the patients admitted with COVID-19. We postulate that early hyperglycemia may indirectly reflect the disease course and severity. If so, then timely intervention aimed at achieving optimal glucose control will promote better outcomes. Ascertaining the association between admission hyperglycemia and duration of hospital stay gives us the dual benefit of identifying uncontrolled blood sugars as a prognostic marker of COVID-19 severity and being able to initiate early and aggressive blood sugar control regimens, thereby reducing complications and improving patient outcomes.

## 2. Objectives

**Primary**

To explore the association between early hyperglycemia and adverse outcomes as measured by requirement of intensive care (ICU) and all causes of in-hospital mortality.

**Secondary**

To correlate the levels of prognostic markers such as C-reactive protein (CRP) and D-dimer in these patients to reflect the inflammatory and prothrombotic state in patients with adverse outcomes.

## 3. Methods

### 3.1. Materials and Methods

This retrospective observational study included a total of 259 patients from one of the largest tertiary care centers in Dubai, United Arab Emirates caring for

COVID-19 patients. Relevant data were collected from the electronic medical system.

Patients were included on the basis of World Health Organization (WHO) case definition of COVID-19 with laboratory confirmation of SARS-CoV-2 by real-time polymerase chain reaction (RT-PCR) of nasopharyngeal swabs or endotracheal aspirates, which were either known to be diabetic or presented with an HbA1C above 6.5%. Patients with no previous history of diabetes and HbA1c < 6.5% were excluded.

Blood glucose levels on admission and early blood glucose profile, defined as the mean of the blood glucose values in the first 24 hours of admission were collected. Hemoglobin A1C and prognostic markers such as C-reactive protein (CRP) and D-dimer were recorded. Duration of hospital stay and ICU stay was extracted. The primary endpoint was measured by all causes of in-hospital mortality and requirement of ICU stay.

Early blood glucose profile was categorized into two groups defined as average glucose < 180 mg/dl or >180 mg/dl. The subgroup was analyzed based on these two categories with two studied outcomes as defined by presence of mortality and requirement of ICU stay respectively.

### 3.2. Statistical Analysis

Continuous variables were presented as mean ± SD or median (Q1, Q3) as appropriate, and categorical data was organized into frequency and percentages. Independent sample t-test and Mann Whitney test were used for studying numerical data for the categories of average blood glucose < 180 mg/dl or <180 mg/dl as appropriate. Chi-squared analysis was used for studying the categories of glucose level with the categories of ICU stay and mortality. All tests were two-tailed and the p-value was considered significant at <0.05. Data entry and statistical analysis were carried out with SPSSv20.0 (IBM Corp, Armonk, NY, US). This study was approved by the Research and Ethical approval committee of Dubai Health Authority with reference number DSREC-06/2020_67.

## 4. Results

### 4.1. General Characteristics of Patients

In the 259 cases studied, 224 (86.5%) were male. The mean age for our study sample was 50.5 ± 12.3 years. Median glucose on admission was 204 mg/dl [IQR; 145 - 285 mg/dl] and the mean HbA1c was 8.8% ± 2.5%. Median glucose in the first 24 hours was 205 mg/dl (139 - 259). The median duration of hospitalization for the study sample was 13 days [IQR; 7 - 19 days]. 38(14.7%) required ICU care during admission. Median duration of stay in ICU for such patients was 20.5 days [IQR; 13.7 - 28 days]. Laboratory parameters revealed a median C reactive protein of 98 [IQR; 35 - 183] and a median d dimer value of 1.1 [IQR; 0.54 - 2.5]. Mortality was noted in 12 (4.65) of the patients. Baseline characteristics of all study subjects are presented in **Table 1**.

### 4.2. Hyperglycemia and COVID-19

No consistent association between early hyperglycemia and the overall duration of hospitalization could be demonstrated. However, patients with early glycemic levels above 180 mg/dl demonstrated both a greater incidence of requiring intensive care and a longer duration of ICU stay.

24 patients (15.9%)] of the group with glucose > 180 mg/dl required ICU care vs 14 patients (13%)] [p = 0.51] in the group with glycemic levels < 180 mg/dl. Patients with an early average blood glucose levels > 180 mg/dl were noted to have longer duration of ICU stay; 21 days [16.3 - 28.8 days] in comparison to 17 days [10.8 - 27.3] in the other group, (p = 0.44) (Table 2).

**Table 1.** General characteristics of the study sample (n = 259).

| | |
|---|---|
| Male Gender | 224 (86.5) |
| Age (years ) | 50 ± 12.3 |
| Duration of stay in hospital in days | 13 (7 - 19) |
| Patients requiring ICU stay | 38 (14.7) |
| Duration of ICU stay | 20.5 (13.7 - 28) |
| Admission glucose | 204 (145 - 285) |
| Average Glucose over initial 24 hours | 205 (139 - 259) |
| Hba1c | 8.8 ± 2.5 |
| C-reactive protein | 98 (35 - 183) |
| D-dimer | 1.1 (0.55 - 2.5) |
| Deceased | 12 (4.6) |

n is the number of cases, percentages expressed in parenthesis; normal distribution expressed as mean with standard deviation; skewed data as median with interquartile range.

**Table 2.** Comparison of study parameters based on average glucose in the initial 24 hours.

| | **Glucose < 180 mg/dl n = 108** | **Glucose > 180 mg/dl n = 151** | **p value** |
|---|---|---|---|
| Male Gender | 94 (87) | 130 (86.1) | 0.83 |
| Age (years ) | 50.7 ± 12.6 | 50.4 ± 12.1 | 0.85 |
| Duration of stay in hospital in days | 12.5 (7 - 18.7) | 13 (7 - 20) | 0.7 |
| Duration of ICU stay | 17 (10.8 - 27.3) | 21 (16.3 - 28.8) | 0.44 |
| Admission glucose | 156.5 ± 50.5 | 292 ± 150.1 | <0.001 |
| Average Glucose over initial 24 hours | 134.8 ± 23.7 | 267.3 ± 73.5 | <0.001 |
| Hba1c | 7.3 ± 1.6 | 9.9 ± 2.6 | <0.001 |
| C-reactive protein | 86 (26.3 - 153) | 109 (48 - 199) | 0.03 |
| D-dimer | 0.97 (0.5 - 2) | 1.2 (0.6 - 2.8) | 0.15 |

n is the number of patients, normal data as mean ± standard deviation; skewed data as median (interquartile range).

Prognostic markers were noted to be higher in the early hyperglycemia group with a median C reactive protein: 109 [IQR; 48 - 199] in comparison to 86 [IQR; 26.3 - 153] in the group with early blood glucose profile < 180 mg/dl (p = 0.03). Median D dimer was 1.20[IQR; 0.6 - 2.8] in comparison to 0.97 [IQR; 0.5 - 2.0] in the group with <180 mg/dl (p = 0.154).

Chi square analysis revealed higher rate of mortality in the group > 180 mg/dl; 8 (5.3%) while the group with glycemic levels < 180 mg/dl had a mortality of 4 (3.7%) [p = 0.547] (Table 3)

## 5. Discussion

Our study observed the glucose readings in the initial 24 hours; this group was least likely to be affected by management with steroids. It was judged to be a more reliable reflection of the initial hyperglycemia in comparison to isolated admission glycemic reading. Early hyperglycemia could be explained by pre-existing uncontrolled diabetes or non-compliance to medications and in the light of pandemic; due to lack of access to medications. Nevertheless, role of stress hyperglycemia or new-onset diabetes cannot be understated [5]. In our population, the group without early hyperglycemia was noted to have a lower mean HbA1c which may indicate that prior glycemic control plays a role in the progression of the disease.

The group with early hyperglycemia had worse prognostic markers and in-hospital mortality. This indicates that higher glycemic levels during the initial hours may predict a poorer course of the disease. Admission hyperglycemia has been studied as a predictor of survival and risk of in-hospital complications and has been associated with increased mortality risks in acute coronary syndrome and in sepsis [10] [11]. Admission hyperglycemia has been studied as a predictor of radiographic imaging in COVID-19 patients, with acute hyperglycemia leading to the development and progression of ARDS in these patients [12]. A recent, retrospective analysis in Wuhan, China involving 605 COVID-19 patients without a prior diagnosis of diabetes demonstrated that the 28-day mortality was three-fold higher in patients with raised fasting glucose on admission (greater than or equal to 7 mmol/l), thus establishing admission hyperglycemia as an independent predictor of 28-day mortality [13]. Our study was able to reflect concordant findings but couldn't achieve statistical significance.

**Table 3.** Chi-squared analysis of glucose levels with ICU stay and mortality.

| | | Glucose < 180 mg/dl | Glucose > 180 mg/dl | p value |
|---|---|---|---|---|
| Deceased | Yes | 4 (3.7) | 8 (5.3) | 0.547 |
| | No | 104 (96.3) | 143 (94.7) | |
| Required ICU stay | Yes | 14 (13) | 24 (15.9) | 0.511 |
| | No | 94 (87) | 124 (84.1 | |

Number in parenthesis indicates percentage.

In our study, the presence of complicated disease course was studied by looking into the incidence of intensive care unit stay and mortality rates in patients with early hyperglycemia. 8 out of 151 (5.3%) patients with early hyperglycemia died during hospital stay while the mortality rate stood at 3.7% in patients without early hyperglycemia, which is suggestive of raised mortality risk in patients who present with uncontrolled blood sugars. Poorer outcomes were also demonstrated in this group of patients with 15.9% requiring intensive care unit stay vs 13% of patients with average blood glucose < 180 mg/dl requiring critical care.

The role of specific biomarkers as predictors of disease severity is crucial in early identification and risk stratification in COVID-19 patients, and helps to facilitate early and appropriate intervention measures. Elevated C-reactive protein (CRP), procalcitonin, D-dimer and ferritin were linked to composite poor outcomes reflected by mortality, severe disease, ARDS and need for ICU care in COVID-19 patients [14]. In our study, we aimed to analyze the contribution of uncontrolled blood sugars in worsening the inflammatory and thrombotic state in COVID-19 by comparing the levels of CRP and D-Dimer in patients with and without early hyperglycemia. While hyperglycemia is still not widely accepted as a biomarker of severity, acute increase in blood sugars have been associated with a concomitant increase in inflammatory mediators such as IL-6 and D-dimer [15], which have been documented in COVID-19 patients with hyperglycemia. This is supported by the findings of our study, with a higher level of D-dimer being noted in patients with high early blood glucose profiles. In addition, patients with early hyperglycemia had a higher level of CRP that achieved statistical significance. Admission hyperglycemia may hence be a simple but significant predictor of the underlying inflammatory state in diabetic COVID-19 patients and should prompt aggressive blood sugar control strategies

### Limitations

This was a retrospective study with information extracted from records. It was a single-center study. A multi-center study would be able to derive more conclusive data to support these findings. Other markers of inflammation were not studied which may have provided further light on this relationship. We have judged ICU stay as an indicator of severity which holds true for the majority of COVID-19 cases but also envelops the minority which may have required ICU care for reasons other than COVID-19. Confounding factors like chronic lung disease and hypertension; which may play a role in prognosis, were not adjusted in the results. This may have an impact on the findings but does not eliminate a relationship between hyperglycemia and COVID-19 severity.

## 6. Conclusion

Admission and early hyperglycemia may be used as a prognostic factor, affecting the course and outcome of the diabetic patients admitted with COVID-19 infection. It is an early warning sign correlating with the outcome in diabetic patients with COVID-19 and may determine the outcome as uncontrolled blood sugars could worsen the inflammatory and pro-thrombotic state and results in greater morbidity and mortality. The role of blood sugars on admission needs to be studied further as a cheap and simple biomarker in Diabetic COVID-19 patients and should be used to raise vigilance and early intervention. Prolonged hospitalization and intensive care stay are reflectors of complex disease courses and increase the risk of further complications including hospital-acquired infections. The role of admission hyperglycemia, as a marker of severity in COVID-19, is a matter of great interest and potential, as it can provide an early clue in regard to patient prognosis.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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# Socio-Demographic, Clinical, and Hygiene Profile of Syndromically Managed Sexually Transmitted Diseases: A Cross Sectional Study in a Tertiary Care Center in India

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## Abstract

**Background:** Sexually transmitted diseases are one of the several major public health concerns, the burden of which is borne by low- and middle-income countries like India. **Purpose:** The purpose is to evaluate the relationship between menstrual and sanitary hygiene and sexually transmitted diseases (STD) based on syndromic diagnosis **Methods:** An out-patient department (OPD) based cross sectional survey to determine these associations, if any exist, which would help critically analyze syndromic management. STD was reported by the presence of vaginal/cervical/urethral discharge with or without irritation and itching, lower abdominal pain and ulcer. **Results:** The prevalence of STD was 66.84% with the most commonly reported symptoms being discharged (31.18%), followed by abdominal pain (17.92%) and itching/irritation (12.90%), with ulcer (4.83%) being the least reported symptom. Perimenopausal age ((AOR: 0.420 [CI: 0.189 - 0.915]; p = 0.030), higher grades of education ((AOR: 0.228 [CI: 0.119 - 0.424]; p < 0.001) for secondary), urban residency (AOR: 0.435 [CI: 0.686 - 2.733]; p < 0.001), and contraception use (AOR: 0.531 [CI: 0.308 - 0.887]; p = 0.018) were associated with lesser odds of presenting with an STD symptom. Belonging to a minority religious community (AOR: 7.20 [CI: 1.866 - 48.251]; p < 0.012) or backward castes (AOR: 3.753 [CI: 1.587 - 10.144]; p < 0.001), having similar illness (AOR: 4.205 [CI: 2.795 - 6.439]; p < 0.001) or having an invasive gynecological procedure done in the past one year (AOR: 1.953 [CI: 1.184 - 3.295]; p = 0.010) and washing the reusable sanitary material only with water (AOR: 4.900 [CI: 2.701 - 9.116]; p < 0.001) as compared to washing it with water and soap, had a higher association with presenting with STD symptoms. Stratified analysis also showed that women presenting discharge (AOR: 2.049 [CI: 1.343

- 3.146] for vaginal and cervical; AOR: 1.426 [CI: 0.826 - 2.482] for urethral) were more likely to not have a toilet facility in an accessible condition. Women with sanitary napkin use had lesser odds (AOR: 0.780 [CI: 0.516 - 1.180]; p = 0.293) of presentation for STD in OPD than women who used other material. **Conclusion:** To better manage the group of diseases that may present with symptoms of STD under syndromic approach, we propose interventions such as menstrual hygiene education and promotion of the use of sanitary napkins among women especially those belonging to lower socio-economic sections of the society.

## Keywords

Sexually Transmitted Diseases, Menstrual Hygiene, Socio-Demographics, Sexually Transmitted Infections, Reproductive Tract Infections, Syndromic Management

## 1. Introduction

Globally, sexually transmitted diseases (STD) have a significant burden on sexual and reproductive health with profound morbidity and mortality. As per the WHO report in 2016, globally there is a 1 million sexually transmitted infections (STIs) are acquired with estimated new cases of 376 million every year [1]. The STI burden varies according to the region and gender and the prevalence is higher in resource-poor countries. The STI is one of the vital public health problems in India and nearly 6% of the adult population had one or more STI, with an annual incidence of around 30 - 35 million episodes [2].

Adverse complication of curable STIs or STD encompasses pelvic inflammatory disease, infertility, ectopic pregnancy, pregnancy loss, stillbirth, premature rupture of membranes, premature delivery and increased risk of HIV development and transmission and the neonatal outcome includes low birth weight, respiratory depression and increased neonatal ICU admission premature labor and low birth weight [3]. The three major causative pathogens in the progression of curable genital STI are *Chlamydia trachomatis*, *Neisseria gonorrhoeae* and *Trichomonas vaginalis* and they are usually asymptomatic and more commonly observed in females [4].

Due to the lack of skilled healthcare workers at the healthcare facilities and also there is a delay in early diagnosis as a result of expensive and sophisticated instruments which is not available in low-resource settings. So, there is a high chance of misdiagnoses and the infections are not properly treated. In this scenario, the chance of diagnosis is reduced to 50% and there is a high risk of transmitting the infection and the complications will still remain forever. Thus, the above factors lead to the development of syndromic management. The National AIDS Control Organization (NACO) describes 7 STI syndromes in Women. They are: urethral discharge, cervical discharge, vaginal discharge, genital ulcer-non-herpetic, genital ulcer-herpetic lower abdominal pain and inguinal bubo [5].

Previous studies conducted in Pakistan and Namibia report that there is a lack of knowledge among healthcare workers in the syndromic management of STI [6] [7]. In addition, further studies conducted in Pakistan and six countries in West Africa showed decreased knowledge in syndromic management of STI [8] [9]. In another study conducted in Nepal, there is a low level of knowledge among healthcare workers during the management of STI/HIV [10].

Primary care providers orchestrate an important role in the management of STD since various patients with STD are asymptomatic and the infections are diagnosed during their visits in primary care setting. Previous study reports that nearly half of the diagnosed STD is from primary care clinics and nearly 80% of the STD cases are reported from non-STD clinics [11] [12].

The wide approach to STD/STI also includes some symptoms that may be related to maintenance of menstrual hygiene and adequate wash practices. Our study aimed to find such association, if any, and derive meaningful conclusions as recommendations to improve the syndromic management approach.

## 2. Materials and Methods

This was a cross sectional, observational study conducted in the Obstetrics and Gynecology outpatient department of Civil Hospital, Ahmadabad. Asarwa civil hospital in Ahmedabad is a government hospital tending to needs of the urban and rural population of Ahmedabad district, other parts of Gujarat and referred cases from parts of Rajasthan, Madhya Pradesh and Maharashtra. Our study population covers a broad spectrum of socio-demographic statuses. The patient recruitment was done from February 2019 to June 2019 (20 weeks). We recruited women visiting the gynecology section of the department by consecutive sampling.

Non-pregnant women of reproductive age (18 years and above) attending the OPD with vaginal symptoms (vaginal discharge, itching/irritation/burning, ulcer and lower abdominal pain) were included in the study. Pregnant women, puerperal women and repeating patients were excluded from the study.

### 2.1. Sample Size Calculation

A single proportion sample size estimation formula was used with the following assumptions was used:

$$n = \left[ \left( Z\alpha/2 \right)^2 * p\left(1-p\right) \right] \Big/ d^2$$

$Z\alpha/2$ is the standard normal variable value at 95% CI (confidence interval) ($\alpha$ is 0.05 with 95%CI, $Z\alpha/2 = 1.96$; an estimate of the prevalence ($p$) of RTI 50%, and 5% the margin of error ($d$). A design effect of 1.5 was used due to multistage sampling and a sample size correction formula was employed since the source population was less than 10,000 in the study area. A 10% non-response rate was used to obtain 602 as an adequate sample size.

### 2.2. Data Collection

After identification by the treating physician based on syndromic approach of STD management, all potential study participants underwent an informed consent process in the local language (Gujarati or Hindi) and those choosing to participate provided written consent. Female surveyors administered a comprehensive pre-tested (for validity and reliability) questionnaire immediately after their visit with the attending physician and through it examined risk factors.

The questionnaire was designed by the primary investigators of the study and consists of risk factors in groups of socio-economic characteristics, menstrual hygiene practices and accessibility and usability of toilets for maintaining menstrual hygiene, clinical history and sexual history of subjects. A similar framework was already used by the authors in other related work, as it captures aspects of the working definition of Menstrual hygiene management (MHM) by the Joint Monitoring Program of the WHO and UNICEF in 2012 (defining MHM as: Women and adolescent girls using a clean menstrual management material to absorb blood that can be changed in privacy as often as necessary for the duration of the menstruation period, using soap and water for washing the body as required and having access to facilities to dispose the used menstrual management materials) and also other important risk factors related to the STI identified in the literature.

### 2.3 Statistical Analysis

The data were coded, entered into Microsoft excel 2019, and exported to R statistical analysis software version 4.0.2 used with interface R studio software for analysis. Descriptive statistics such as frequency distribution and prevalence were computed. Associations between independent variables and STI were determined using a binary logistic regression model.

## 3. Results

Among the 603 patients who visited the gynecology OPD of the hospital during the study period, 558 were enrolled in the study, 13 patients were not willing to participate in the study and 32 patients were excluded from the study.

### 3.1. Socio-Demographic Characteristics

The demographic characteristics of the patients were shown in Table 1. Majority of the patients (67.56%), were in the age group between 20 - 40 years and the mean age was 32.13 ± 4.68 years. Majority of them were married women (73.66%), followed by unmarried (19.71%), divorced (5.20%) and widowed women (1.43%). The majority of women were literate (80.82%), Hindu women (62.16%), belonging to open (66.78%) category of caste-based reservation system, living in a nuclear family (53.41%) working as household help or homemaker

Table 1. Socio-demographic characteristics of the study participants.

| Variables | Frequency n (%) | STI Yes n | STI No n | COR (95%CI) | p-value |
|---|---|---|---|---|---|
| **Age in years** | | | | | |
| Less than 20 years | 66 (11.83%) | 47 | 19 | 1 | |
| 20 - 40 years | 377 (67.56%) | 266 | 111 | 2.21 (1.15 - 4.29) | 0.01* |
| More than 40 years | 115 (20.61%) | 60 | 55 | 1.01 (0.56 - 1.82) | 0.9723 |
| **Marital status** | | | | | |
| Single | 110 (19.71%) | 73 | 37 | 1.52 (0.28 - 8.170) | 0.618 |
| Married | 411 (73.66%) | 269 | 142 | 1.58 (0.31 - 8.21) | 0.576 |
| Divorced | 29 (5.20%) | 25 | 4 | 0.48 (0.06 - 3.39) | 0.453 |
| Widowed | 8 (1.43%) | 6 | 2 | 1 | |
| **Religion** | | | | | |
| Hindu | 345 (62.16%) | 237 | 108 | 1 | |
| Muslim | 179 (32.25%) | 104 | 75 | 0.631 (0.434 - 0.919) | 0.016* |
| Others | 31 (5.59%) | 29 | 2 | 6.607 (1.943 - 4.134) | 0.011* |
| **Educational status** | | | | | |
| Illiterate | 107 (19.18%) | 84 | 23 | 1 | |
| Primary | 176 (31.54%) | 107 | 69 | 1.235 (0.13 - 1.413) | 0.002* |
| Secondary | 164 (29.39%) | 87 | 77 | 0.323 (0.184 - 0.568) | <0.001* |
| Higher secondary | 95 (17.02%) | 81 | 14 | 0.631 (0.299 - 1.331) | 0.217 |
| Above that | 16 (2.87%) | 14 | 2 | 0.521 (0.107 - 2.541) | 0.411 |
| **Residence** | | | | | |
| Rural | 169 (30.29%) | 94 | 75 | 1 | |
| Urban | 389 (69.71%) | 279 | 110 | 0.494 (0.107 - 2.542) | <0.001* |
| **Occupation** | | | | | |
| Homemaker/Housemaker | 353 (63.37%) | 237 | 116 | 1 | |
| Laborer | 89 (15.98%) | 53 | 36 | 1.387 (0.85 - 2.26) | 0.179 |
| Other | 115 (20.65%) | 82 | 33 | 0.822 (0.513 - 1.316) | 0.405 |
| **Income of self** | | | | | |
| Less than Rs.5000 per month | 356 (63.80%) | 227 | 129 | 1 | |
| More than Rs.5000 per month | 202 (36.20%) | 146 | 56 | 0.675 (0.459 - 0.991) | 0.041* |
| **Family status** | | | | | |
| Nuclear | 298 (53.41%) | 193 | 105 | 1 | |
| Joint | 160 (28.67%) | 126 | 34 | 0.495 (0.314 - 0.783) | 0.002* |

**Continued**

| | | | | | |
|---|---|---|---|---|---|
| Others | 100 (17.92%) | 54 | 46 | 1.566 (0.979 - 2.502) | 0.0558 |
| **Caste** | | | | | |
| Open | 372 (66.78%) | 239 | 133 | 1 | |
| SC/ST/OBC | 125 (22.44%) | 80 | 45 | (0.103 - 0.546) | <0.001* |
| Others | 60 (10.77%) | 53 | 7 | 0.237 | 0.960 |

1: Reference category. Illiterate stands for not having attended both formal and informal education, primary education means Grade 1 - 8; secondary education means Grade 9 - 10, higher secondary means Grade = 10 - 12, and graduate education means having acquired a diploma, degree, masters and others.

(63.37%) earning less than 5000 per month (63.80%). The categories of housewife and household help were taken together in occupation as the objective of study was accessibility of an inhouse toilet or separate space dedicated to maintenance of hygiene.

The prevalence of sexually transmitted disease on basis of syndromic approach among reproductive-age women was 66.84% [CI: 62.76 - 70.74]. The most commonly reported symptoms were vaginal/cervical discharge (31.18%), followed by abdominal pain (17.92%) and urethral discharge/irritation/itching (12.90%) and ulcer (4.83%).The symptoms which were not considered as STD according to syndromic approach included gynecological symptoms like pain or discomfort during intercourse, bleeding between periods, frequent and urgent need to urinate, or a burning sensation during urination, abnormal vaginal bleeding, particularly during or after intercourse, pain or pressure in pelvis that differs from menstrual cramps etc. They were present in 33.15% of the patients.

### 3.2. Availability and Usage of Toilet

Among the patients recruited in the study, a clean, isolated, toilet facility with presence of water was available to 48.38%. No significant association of this parameter was obtained with chief complain of STD according to syndromic management, however stratified analysis of each of the complaints showed that there were higher odds of not having access to such a facility among women presenting with discharge (COR: 2.049 [CI: 1.343 - 3.146]; $p < 0.001$) and itching/irritation (COR: 1.426 [CI: 0.826 - 2.482]; $p = 0.204$). The results are shown in Table 2.

### 3.3. Past Clinical History

In our study, 79.75% women reported not having an invasive gynecological procedure (like abortion/dilation and curettage etc.) in the past 1 year. However, those who had undergone a procedure showed higher odds (COR-1.655 [CI: 1.046 - 2.683]; $p = 0.035$) of reporting an STD symptom as compared to reporting other symptoms. A positive history of similar illness was reported by 55.91% participants. Patients with STD symptoms were thrice as likely as other patients to have experienced similar illness (COR: 3.358 [CI: 2.291 - 4.988]; $p < 0.001$).

Among participants, 80.107% did not report per vaginal exam done in the last year and 68.41% of married women living with their husbands, denied concomitant presence of STD symptoms in their partners. The results were shown in Table 3.

Table 2. Availability and usage of toilet among study participants.

| Variables | Frequency n (%) | STI | | COR (95%CI) | p-value |
|---|---|---|---|---|---|
| | | Yes n | No n | | |
| Availability and usage of toilet | | | | | |
| Used | 270 (48.38%) | 174 | 96 | 1 | |
| Unused | 288 (51.61%) | 199 | 89 | 1.234 (0.867 - 1.757) | 0.244 |
| **Frequency of chief complain** | | **Availability and usage of toilet** | | | |
| | | **Used** | **Unused** | | |
| Vaginal/Cervical Discharge | 174 (31.18%) | 60 | 114 | 2.049 (1.343 - 3.146) | <0.001* |
| Abdominal pain | 100 (17.92%) | 68 | 32 | 0.507 (0.302 - 0.839) | <0.009* |
| Ulcer | 27 (4.83%) | 15 | 12 | 0.863 (0.376 - 1.940) | 0.722 |
| Urethral discharge/itching/irritation | 72 (12.90%) | 31 | 41 | 1.426 (0.826 - 2.482) | 0.204 |
| Other chief complain- not related to RTI | 185 (33.15%) | 96 | 89 | 1 | |

1: Reference category.

Table 3. Obstetrics and Gynecological history among the study population

| Variables | Frequency *n* (%) | STI | | COR (95%CI) | p-value |
|---|---|---|---|---|---|
| | | Yes *n* | No *n* | | |
| History of abortion/D and C/Other invasive procedures in year prior to data collection | | | | | |
| Yes | 113 (20.25%) | 85 | 28 | 1.655 (1.046 - 2.683) | 0.035* |
| No | 445 (79.75%) | 288 | 157 | 1 | |
| History of similar symptoms in year prior data collection | | | | | |
| Yes | 246 (44.08%) | 199 | 47 | 3.358 (2.291 - 4.988) | < 0.001* |
| No | 312 (55.91%) | 174 | 138 | 1 | |
| Per Vaginal exam in the past year | | | | | |
| Yes | 111 (19.892%) | 75 | 36 | 1.012 (0679 - 1.310) | 0.798 |
| No | 447 (80.107%) | 286 | 161 | 1 | |
| **Husband's illness of reproductive tract** | | **Multiple sexual partners** | | | |
| | | **Yes** | **No** | | |
| Yes | 145 (31.59%) | 80 | 28 | 0.752 (0.499 - 1.778) | 0.166 |
| No | 314 (68.41%) | 21 | 429 | 1 | |

1: Reference category.

### 3.4. Behavioral Factors

The majority (91.22%) of the study participants did not have multiple sexual partners during the previous year. The bivariate analysis showed that those respondents who had multiple sexual partners were at a higher risk for developing STD (COR: 1.136 [CI: 0.613 - 2.202]; p = 0.692) compared to those who did not have multiple partners. Majority of women reported having their first experience of sexual intercourse during ages 25 - 35 years (59.35%). The odds of presenting with an STD complain were significantly higher (three times) in women who had experienced sexual intercourse than those who had not. The women who had their first sexual intercourse at ages between 25 and 35 years had the highest odds of presenting with an STD (COR: 2.883 [CI: 1.754 - 4.762]; p < 0.001). The use of contraception, though seen only in 19.35% of women was significantly associated with having lesser odds of presenting with STD symptoms (COR: 0.546 [CI: 0.332 - 0.897]; p = 0.0149). The results were shown in Table 4.

### 3.5. Menstrual Hygiene Management (MHM) and Washing Practices

Unfortunately, the majority of women recruited in the study did not use sanitary napkins (66.13%). Out of all women, 31.69% denied re-using their menstrual absorbent material. 28.69% of women reused the material and changed the material twice a day, followed by once a day (26.23%) and more than twice a day (13.38%). However, 61.44% participants used only water to wash it. The use of sanitary napkins had lesser odds (COR: 0.742 [CI: 0.510 - 0.981]; p = 0.041) of presenting with STD symptoms in the OPD. As the frequency of washing increased, the odds of presenting with STD complain decreased. For those reusing

Table 4. Characteristics of behavioral factors among study participants.

| Variables | Frequency *n* (%) | STI | | COR (95%CI) | p-value |
|---|---|---|---|---|---|
| | | Yes *n* | No *n* | | |
| **Multiple sexual partners during the last year** | | | | | |
| Yes | 49 (8.78%) | 34 | 15 | 1.136 (0.613 - 2.202) | 0.692 |
| No | 509 (91.22%) | 339 | 170 | 1 | |
| **Age at first sexual intercourse** | | | | | |
| Not yet | 81 (14.56%) | 38 | 43 | 1 | |
| Less than 25 years | 106 (19.06%) | 70 | 36 | 2.200 (1.220 - 4.007) | <0.001* |
| 25 - 35 years | 330 (59.35%) | 227 | 103 | 2.883 (1.754 - 4.762) | <0.001* |
| More than 35 years | 39 (7.01%) | 21 | 18 | 2.880 (1.292 - 6.770) | 0.011* |
| **Use of any kind of contraception** | | | | | |
| Yes | 108 (19.35%) | 83 | 25 | 0.546 (0.332 - 0.897) | 0.0149* |
| No | 450 (80.64%) | 290 | 160 | 1 | |

1: Reference category.

Table 5. Menstrual hygiene management (MHM) practices among reproductive age women.

| Variables | Frequency *n* (%) | STI | | COR (95%CI) | p-value |
|---|---|---|---|---|---|
| | | Yes *n* | No *n* | | |
| **Nature of absorbent material used during menstruation** | | | | | |
| Cloth/cotton equivalent | 369 (66.13%) | 255 | 114 | 1 | 0.749 |
| Sterile sanitary pad/napkin | 189 (33.87%) | 118 | 71 | 0.742 (0.510-0.981) | 0.041* |
| **Frequency of washing the material** | | | | | |
| I do not wash it as I do not reuse it | 116 (31.69%) | 69 | 47 | 1 | |
| Once per day | 96 (26.23%) | 21 | 75 | 2.430 (1.339-4.505) | 0.004* |
| 2 times per day | 105 (28.69%) | 74 | 29 | 1.736 (0.940-2.45) | 0.054 |
| More than 2 times per day | 49 (13.38%) | 34 | 15 | 1.542 (0.759-3.929) | 0.229 |
| **Wash Material** | | | | | |
| Water and soap | 96 (38.55%) | 53 | 43 | 1 | |
| Water only | 153 (61.44%) | 131 | 22 | 4.618 (2.589-8.418) | < 0.001* |

the material, washing only with water had higher odds of presenting with an STD in OPD (COR: 4.618 [CI: 2.589 - 8.418]; $p < 0.001$). The results were shown in Table 5.

### 3.6. Multivariable Logistic Regression Analysis

The results of multivariable logistic regression analysis of demographic profile of patients are shown in Table 6. We found that socio-demographic factors like perimenopausal age (more than 40 years) had significantly lesser odds of presenting with STD complain (AOR: 0.420 [CI: 0.189 - 0.915]; $p = 0.03$), having a primary and secondary education had significantly lesser odds of presenting with STD complain ((AOR: 0.275 [CI: 0.144 - 0.510]; $p < 0.001$) and (AOR: 0.228 [CI: 0.119 - 0.424]; $p < 0.001$) respectively),living in hostels, dormitories or individually had lesser odds (AOR: 0.542 [CI: 0.309 - 0.944]; $p < 0.031$)) of presenting with STD symptoms and so did living in urban areas (AOR: 0.435 [CI: 0.686 - 2.733]; $p < 0.001$). Belonging to a religion other than Hinduism or Islam (AOR: 7.20 [CI: 1.866 - 48.251]; $p = 0.012$) and a caste other than open/ST/SC had a higher odd (AOR: 3.753 [CI: 1.587 - 10.144]; $p < 0.001$) of presenting with STD symptoms.

The results of multivariable logistic regression analysis of clinical profile of patients are shown in Table 7. Women who had similar illness in the past were 4 times more likely to present with STD symptoms (AOR: 4.205 [CI: 2.795 - 6.439]; $p < 0.001$). Having a history of an invasive gynecological procedure raised the odds to twice (AOR: 1.953 [CI: 1.184 - 3.295]; $p = 0.010$). Among those who had had sexual intercourse, the age group of less than 35 years was at higher odds of presenting with STD symptoms ($p < 0.001$).

Table 6. Factors associated with STDs among reproductive age women from multivariable logistic regression analysis - Demographics.

| Variable | COR (95%CI) | AOR (95%CI) | p-value of AOR |
|---|---|---|---|
| **Age** | | | |
| Less than 20 years | 1 | 1 | |
| 20 - 40 years | 2.21 (1.15 - 4.29) | 1.127 (0.569 - 2.199) | 0.727 |
| More than 40 years | 1.01 (0.56 - 1.86) | 0.420 (0.189 - 0.915) | 0.030* |
| **Education** | | | |
| Illiterate | 1 | 1 | |
| Primary | 1.235 (0.13 - 1.413) | 0.275 (0.144 - 0.510) | <0.001* |
| Secondary | 0.323 (0.184 - 0.568) | 0.228 (0.119 - 0.424) | <0.001* |
| Higher secondary | 0.631 (0.299 - 1.331) | 0.108 (0.047 - 0.255) | 0.844 |
| Graduate | 0.521 (0.107 - 2.541) | 0.258 (0.058 - 1.836) | 0.258 |
| **Residence** | | | |
| rural | 1 | 1 | |
| urban | 0.494 (0.107 - 2.542) | 0.435 (0.686 - 2.733) | <0.001* |
| **Income** | | | |
| Less than 5000 | 1 | 1 | |
| More than 5000 | 0.675 (0.459 - 0.991) | 0.846 (0.535 - 1.333) | 0.471 |
| **Family** | | | |
| nuclear | 1 | 1 | |
| Joint/extended | 1.566 (0.979 - 2.502) | 1.815 (1.094 - 3.094) | 0.052 |
| Others (dorms, hostels, individual) | 0.495 (0.314 - 0.783) | 0.542 (0.309 - 0.944) | 0.031* |
| **Caste** | | | |
| Open | 1 | 1 | |
| SC/ST | (0.546 - 0.103) | 1.105 (0.655 - 1.888) | 0.708 |
| OBC and other minorities | 0.237 | 3.753 (1.587 - 10.144) | <0.001* |
| **Religion** | | | |
| Hindu | 1 | 1 | |
| Muslim | 0.631 (0.434 - 0.919) | 0.433 (0.274 - 0.678) | <0.1 |
| Others | 6.607 (1.943 - 41.34) | 7.20 (1.866 - 48.251) | <0.012* |

1: Reference category.

The results of multivariable logistic regression analysis of sanitation practices among are shown in Table 8. Among the practices that determined hygiene, not having a toilet and using material other than sanitary napkin had higher odds of presenting with symptoms of STD ((AOR: 1.109 [CI: 0.745 - 1.647]; p = 0.611) and (AOR: 0.780 [CI: 0.516 - 1.180]; p = 0.293) respectively) however they were

Table 7. Factors associated with STDs among reproductive age women from multivariable logistic regression analysis—Clinical and Sexual history.

| Variable | COR (95%CI) | AOR (95%CI) | p-value |
|---|---|---|---|
| **Similar illness in the past 1 year** | | | |
| Yes | 3.358 (2.291 - 4.988) | 4.205 (2.795 - 6.439) | <0.001* |
| No | 1 | 1 | |
| **History of abortion/DNC/other invasive procedure** | | | |
| Yes | 1.655 (1.046 - 2.683) | 1.953 (1.184 - 3.295) | 0.010* |
| No | 1 | 1 | |
| **Contraception use** | | | |
| yes | 0.546 (0.332 - 0.897) | 0.531 (0.308 - 0.887) | 0.018* |
| no | 1 | 1 | |
| **Age at first sexual intercourse** | | | |
| Not yet | 1 | 1 | |
| Less than 25 years | 2.200 (1.220 - 4.007) | 2.941 (1.552 - 5.661) | <0.001* |
| 25 - 35 years | 2.883 (1.754 - 4.762) | 3.073 (1.791 - 5.320) | <0.001* |
| More than 35 years | 2.880 (1.292 - 6.770) | 2.307 (0.981 - 5.680) | 0.060 |

1: Reference category.

Table 8. Factors associated with STDs among reproductive age women from multivariable logistic regression analysis—MHM and toilet facility.

| Variable | COR (95%CI) | AOR (95%CI) | p-value of AOR |
|---|---|---|---|
| **Toilet availability and usage** | | | |
| Yes | 1 | 1 | |
| No | 1.234 (0.867 - 1.757) | 1.109 (0.745 - 1.647) | 0.611 |
| **Material used during menstruation** | | | |
| Cotton/Cloth | 1 | 1 | |
| Sanitary napkin | 0.742 (0.510 - 0.981) | 0.780 (0.516 - 1.180) | 0.293 |

1: Reference category.

not statistically significant (($p = 0.611$ and $p = 0.293$) respectively).

The results of multivariable logistic regression analysis of menstrual hygiene and wash practices of patients are shown in Table 9. As the frequency of washing increased the odds of presenting with an STD decreased however it was not a significant decrease. Usage of water only for washing reusable material was associated with four times greater odds of presenting with STD symptoms (AOR: 4.900 [CI: 2.701 - 9.116]; $p < 0.001$).

## 4. Discussion

The prevalence of STD symptoms in the present study is 66.84 which is

Table 9. Factors associated with RTIs among reproductive age women from multivariable logistic regression analysis—MHM and wash material.

| Variable | COR (95%CI) | AOR (95%CI) | p-value |
|---|---|---|---|
| **Wash frequency for women not using sanitary napkins** | | | |
| Do not reuse | 1 | Not included in multiple regression model | |
| Wash once a day | 2.430 (1.339 - 4.505) | 1 | |
| Wash twice a day | 1.736 (0.940 - 2.45) | 0.771 (0.387 - 1.520) | 0.454 |
| Wash more than twice a day | 1.542 (0.759 - 3.929) | 0.821 (0.359 - 1.906) | 0.641 |
| **Material used for wash** | | | |
| Water and soap | 1 | 1 | |
| Water only | 4.83 (2.606 - 8.9551) | 4.900 (2.701 - 9.116) | <0.001* |

1: Reference category.

comparatively higher when compared to other states and cities of India (Punjab: 45% [13], Bangalore: 29.15% [14], Surendranagar: 56.5% [15], Delhi: 43.9% [16], Uttar Pradesh: 46.76% [17] and Tamil Nadu: 55.5% [18]. The higher prevalence in the present study might be due to the reason that the study was carried out in the OPD in a community setting and thus, we received better responsiveness. In the present study, age more than 40 years, higher education, residing in urban surrounding and using contraception during sexual intercourse was associated with lesser odds of presenting with STDs [19]. On the other hand, belonging to backward castes, minority religious groups, having experienced similar illness and any invasive gynecological procedures in the past one year, having experienced sexual intercourse between 25 - 35 years and washing reusable material with only water had higher odds of presenting in the OPD with STD symptoms. [20]. Having access to a toilet facility and using hygienic sanitary napkins were also associated with lesser odds of presenting with STD symptoms but the results were not very significant. A stratified analysis of individual symptoms revealed that having presented with vaginal/cervical/urethral discharge with or without itching and irritation had higher odds of not having a toilet facility accessible to them which is line with previous study conducted in Odisha, India [21].

Mounting literature shows that a large proportion of older patients, visiting the healthcare facilities are affected with STD [22]. Married and single women had 1.58 (p = 0.576) and 1.52 (p = 0.618) times the odds of having STD symptoms in OPD than widowed women. We found that factors determining low socio-economic status like Illiteracy, minority religious groups, living in rural parts of the town and belonging to backward castes were significantly associated with higher chances of presenting with an STD complaint. A previous systematic review and meta-analysis reveals that low socioeconomic profile are associated with increased risk of STI [23]. Interestingly, in the present study an overlap exists as such low socioeconomic conditions are associated with both - higher chances of unhygienic menstrual hygiene and latrine usage and engaging in careless unprotective sex.

In the present study, women working as a laborer had a higher odd of presenting with an STD to the OPD (COR: 1.387; [CI: 0.85 - 2.26]; p = 0.179). This could be due to lesser access of toilet facility for women who work as laborer. Women presenting with vaginal/cervical discharge were twice more likely and others with urethral discharge with or without itching and irritation were 1.43 times more likely to not have accessibility to a usable toilet facility ($p < 0.001$ and $p = 0.204$). This finding highlights the magnitude of difference that can be achieved with the promotion of clean toilet facility in reducing the STD burden in households.

The fact that females presenting with similar symptoms in the past 1 year were more likely to present with STD symptoms shows that there is a possibility of presence of a habit/ chronically unchanging practice that contributed to STD symptoms significantly. We also found that a history of STI symptoms in the year before data collection was significantly associated with the development of STI. A similar study in an urban training health center of a tertiary care hospital in India showed that STI was significantly associated with a history of STIs in the previous year [12]. We found that women with invasive procedures done in the past one year were more likely to present with STI symptoms. A similar study among women in urban slums of India showed that participants who had a history of abortion had higher odds of STI symptoms than those who had no history of abortion [24].

Das *et al.* [25] reported that Indian women using disposable absorbent pads were less likely to develop infections than women using reusable material, consistent with our study suggesting that women who used sanitary napkins had lesser ((OR: 0.742); p = 0.041) odds of presenting with an STD and it was not significant. The literature reports that poor sanitation may facilitate transmission where genital contact is made with infected genital fluids on the latrine toilet seat [26]. A study conducted in Dehradun, India, reported an association between STI and poor menstrual hygiene as measured by washing the genitalia less often than twice per day during menstruation [27]. Among the women who did not use sanitary napkins, our study had women who used no-reusable/disposable cotton and women who used cloth and reused them after washing. The women who used cloth had higher odds of presenting with STD symptoms than women who used cotton.

## 5. Limitations

Our study had several limitations. Some of the crude associations when reanalyzed after stratification lost their significance which may be due to the decrease in stratified sample population. We did not report women who were laboratory confirmed cases of STDs. Furthermore, the results of this study may not be representative of the occurrence and underlying factors of STDs at the national level because it was conducted only in Ahmedabad.

Future studies should include a wider population sample and confirm the suspected STD cases with laboratory findings to better determine the cohort of women who may present with STD symptoms according to syndromic diagnosis but actually suffer from diseases related to improper menstrual and sanitary hygiene.

## 6. Conclusion

STI is a preventable illness that does affect the public health of the country. There still exists a barrier in the physician-patient discussion regarding sexual acts, safe sex practices and menstrual hygiene. Ever since the concept of treating STI based on syndromic approach has been proposed, the focus has shifted from eliminating the root cause of the disease to symptomatic management. Syndromic approach has effectively treated women from STI, however, it does not reduce incidence of STI as the factors that promote transmission still exist widely in the community. Although our study cannot conclude a causal relationship between unhygienic MHM practices and STI, it highlights the need for a safe, hygienic and comfortable environment for women for MHM practices, so as to reduce the colonization of sexually transmitted pathogens and thereby, reduce the risk of STI.

## 7. Recommendations

In low- and middle-income countries, for the ease of management of STDs, syndromic approach has been in place. Our study highlights important associations of STD symptoms with socioeconomic conditions and menstrual and sanitary hygiene. With small additions in the execution of syndromic management of STD a wider group of diseases can be dealt with.

In line with significant association of complains of discharge with toilet availability, we recommend ensuring hygienic places for women, particularly those belonging to low socioeconomic backgrounds and promoting its use to practice MHM. Since our study also found a crude association between the use of cotton/cloth as sanitary material and presentation with an STD symptom to OPD, we recommend that a menstrual hygiene education and if we may be too ambitious, a supply of sanitary pads should be made available to women presenting with STD symptoms. To arrest the spread of STI, it is necessary to educate the people regarding the factors that increase transmission and prevalence. Our study has stated the factors that affect the risk of acquisition of STI and the areas that our country's jurisdiction must prioritize while framing health policies. It is certainly every woman's right to practice safe MHM and it is the need of the hour to extend the public health rationale to also cover the reproductive and sexual health of the women.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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## Questionnaire

Sr. Number:

Initials:

Chief complaint:

1. Age (in years):

2. Residence:
   - Rural
   - Urban

3. Education:
   - Literate
   - Illiterate

If literate, level of education acquired or acquiring:
   - Primary
   - Secondary
   - higher secondary
   - Graduate
   - post graduate

4. Occupation:

5. Income: Monthly Income of the Patient:
   Total monthly income of the family:

6. Family:
   - Nuclear
   - Joint

7. Caste:
   - Open
   - SC
   - ST
   - OBC

8. Religion:

9. Marital Status:
   - Unmarried
   - Married
   - Separated
   - Divorced
   - Widow

If married:

For how many years have you stayed with your husband?:______

At present, are you staying with your husband?: Yes/No

10. Husband's occupation:

11. What was your age at first sexual intercourse:

12. Do you have more than one sexual partners: Yes/No

13. Do you use Contraception: Yes/No

If yes, Which one?: Condom /IUD/OC Pills/permanent sterilisation/others

14. During menstruation, which material do you use?
    - o Sanitary napkin
    - o Cloth
    - o Others _______________

    If cloth:

Do you reuse it? Yes/No

If Yes,

How do you wash it?

- o With water only
- o With water and soap

How frequently do you wash it? ______________

15. Is there a toilet in your home? Yes/No
16. How many times have you undergone per vaginal examinations in the past 1 year? ____
17. Did you have a delivery/ abortion in the past 1 year?: Yes/No

    If Yes—Delivery/Abortion
18. Have you experienced similar illness in the past 1 year? Yes/No

    If Yes,

    How many times? _____

    Did you visit a doctor immediately?: Yes/No

    If No?: Reason: ___________________________________________
19. Does your husband have a similar illness at present?
20. Has your husband experienced similar illness in the past 1 year? Yes/No

    If yes, what was it?: Ulcer/Discharge/others

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# The Impact of Severity of Periodontal Bone Loss and the Levels of Glycated Hemoglobin (HbA1c) on the Periodontal Clinical Parameters of the 2017 World Workshop among Type 2 Diabetic Patients in Saudi Arabia

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## Abstract

**Background:** Type-2 diabetic patients (uncontrolled levels of glucose blood) usually have periodontal diseases and alveolar bone loss. **Objectives:** The present study was designed to clarify the impact of severity of periodontal bone loss and the levels of glycated hemoglobin (HbA1c) on the periodontal clinical parameters of the 2017 World Workshop among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). **Material and Methods**: This study was done on 298 type 2 diabetic patients, selected from the internship clinics, College of Dentistry, King Khalid University, Abha, Saudi Arabia. The selection of patients was dependent on the levels of glycated hemoglobin (HbA1c), and they were categorized into controlled (<7% HbA1c) and uncontrolled type 2 diabetics (>7% HbA1c). All patients were divided according to the severity of periodontal bone loss into three groups, group I: mild periodontal bone loss, group II: moderate periodontal bone loss, and group III: severe periodontal bone loss. Clinical evaluation of periodontal diseases was carried out by clinical parameters according to the 2017 World Workshop. All data were collected and analyzed. A p-value of <0.05 was considered significant, and of <0.001 was considered highly significant. **Results**: The severity of periodontal bone loss were determined in controlled type 2 diabetics (<7% HbA1c) and compared to uncontrolled type 2 diabetics (>7% HbA1c). An increased percentage of patients with severe periodontal bone loss was observed in uncontrolled type 2 diabetics (>7% HbA1c) (42.9%), as compared to controlled type 2 diabetics (<7% HbA1c) (30.5%) without statistically significant ($p = 0.251$). An increased mean of age, clinical attachment loss (CAL), and percentage of radiographic bone loss (% RBL) were detected in controlled type 2 diabetics (<7% HbA1c), as compared to uncontrolled type 2 diabetics (>7% HbA1c). In contrast, we found an increased mean of plaque control record (PCR), gingival bleeding index (GBI), and periodontal pocket depth (PPD) in uncontrolled type 2 diabetics (>7% HbA1c) more than in controlled type 2 diabetics (<7% HbA1c) without statistically significant ($p > 0.05$). Moreover, the mean of age, PCR, CAL, % RBL, and PPD were more in the patients with severe periodontal bone loss, as compared to the patients with mild and moderate periodontal bone. Highly statistically significant differences were recorded ($p < 0.001$). **Conclusion:** This study demonstrates the role of uncontrolled diabetes as a risk factor for the increase in the severity of periodontal bone loss. Thus, we suggest including the glycated hemoglobin (HbA1c) levels with periodontal parameters in the evaluation of periodontal bone loss among type 2 diabetics.

## Keywords

Glycated Hemoglobin, Periodontal Bone Loss, Saudi Arabia, Type 2 Diabetic

## 1. Introduction

Periodontal diseases are multi-factorial inflammatory diseases of the surrounding dental structures, leading to clinical attachment loss and alveolar bone destruction [1]. The increase in the severity of periodontal bone loss occurs because of irregular inflammatory reactions during some systemic diseases [2].

Type 2 diabetes mellitus (DM) is a chronic systemic disease associated with many complications such as periodontal diseases [3]. The produced inflammatory mediators within the inflamed periodontal structures such as IL-6 and TNF-$\alpha$ interfere with the work of insulin receptors within the systemic circulation, resulting in diminishing sensitivity of insulin [4]. Furthermore, chronic hyperglycemia due to metabolism effect on periodontal tissues health and periodontal diseases severity [5]. Therefore, diabetes mellitus is not the direct cause of periodontal disease, but it is a predisposing factor that assists the local factors and bacterial plaque initiate and developing of periodontal diseases [6].

Periodontal diseases induce alteration of glycemic control in type 2 diabetics and nondiabetics, so periodontitis patients are more susceptible to developing diabetes three times compared to individuals of a healthy periodontium [7].

The destruction effect of type 2 diabetes on alveolar bone occurs due to the reduction of osteoblast formation and an increase of osteoclast formation in inflamed areas (an unbalance of osteoclast and osteoblasts) because of increasing the production of inflammatory cytokines and RANKL/osteoprotegerin (OPG) ratios, enhancing bone resorption [8] [9].

Glycosylated hemoglobin (HbA) is formed through a non-enzymatic irreversibly binding between glucose and hemoglobin. Hemoglobin A1c (HbA1c) is the main subpart of HbA as a beneficial indicator reflecting the glucose concentration in the blood through the last 2 - 3 months [10].

On the other hand, Diabetes mellitus (controlled and uncontrolled) influences approximately 285 million of the world population [11]. The United States has one of the highest percentages of diabetes, with more than 12.3% (29 million) population ≥ 20 years of age sufferance from diabetes [12]. Moreover, and according to the Saudi Arabian Ministry of Health reports, Saudi Arabia is one of the top ten countries in the world in the percentages of diabetes, with more than 23.9% population suffering from diabetes [13].

It is to be noted here that uncontrolled type 2 diabetics (>7% HbA1c) are more susceptibility to affect and developing of periodontal diseases than controlled (<7% HbA1c) as well as controlled type 2 diabetics respond to periodontal therapy, and uncontrolled type 2 diabetics (>HbA1c) are not a good response to periodontal treatment, with complications that may be developing after treatment in the long duration [14].

Previous studies have exhibited the relationship between diabetes and periodontal diseases [15] [16]. But, not considerable papers have been published on the association correlation between the severity of periodontal bone loss and the levels of glycated hemoglobin (HbA1c) among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). Additionally, there have been no studies conducted in the college of dentistry, King Khalid University to assess the impact of glycated hemoglobin levels on the severity of periodontal bone loss among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi).regarding the attachment between DM and the periodontal clinical parameters of the 2017 World Workshop. We hypothesized that HbA1c level is associated with the severity of periodontal bone loss. Therefore, the present study was designed to assist the impact of severity of periodontal bone loss and the levels of glycated hemoglobin (HbA1c) on the periodontal clinical parameters of the 2017 World Workshop among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). Consequently, this study will help to develop the health quality and guidelines of type 2 diabetics' medical care to include periodontal checkups as well as will help the physician to design a care plan for type 2 diabetics.

## 2. Material and Methods

### 2.1. Design of the Study and Collection of Data

This cross-sectional study was conducted in the internship clinics, College of Dentistry, King Khalid University, Abha, Saudi Arabia, from December 2020 to May 2021. The study patients included 298 type 2 diabetic patients presenting to the outpatient clinics, College of Dentistry, King Khalid University. Ranged between 35 - 55 years old with a mean age of 43.297 ± 16.510 among controlled type 2 diabetics and 42.571 ± 18.225 among uncontrolled type 2 diabetics, the characteristics of patients were collected, included age, gender, nationality, family history of type 2 diabetes mellitus, and smoking status. The patients were classified as either controlled type 2 diabetics (<7% HbA1c) or uncontrolled type 2 diabetics (>7% HbA1c). Severity periodontal bone loss was determined from the cement-enamel junction (CEJ) to the alveolar crest (mm). The severity of periodontal bone loss was divided into three groups: mild, moderate, and severe. The patients' selection depended on inclusion and exclusion criteria, as well as clinical examination of periodontal diseases and panoramic radiographic explanation to evaluate the periodontal diseases status and severity of the periodontal bone loss.

## 2.2. Ethical Statement

The study proposal was approved by the Institutional Review Board at College of Dentistry, King Khalid University (IRB/KKUCOD/ETH/2020-21/040). All patients were informed of the study's nature, and their consent was obtained. In the present study, all stages were conducted in conformity to the standards of the Helsinki Declaration

## 2.3. Inclusion Criteria

The inclusion criteria were resident patients in Saudi Arabia (Saudi and non-Saudi) older than 30 years who are being diagnosed with type 2 diabetes mellitus since at least two years ago according to the WHO criteria [17]. Every participant in this study should have At least 20 teeth remaining in the mouth.

## 2.4. Exclusion Criteria

All non-residents patients in Saudi Arabia were excluded as well as patients suffering from any systemic disease except type 2 diabetes and patients taking any medication except hypoglycemic drugs. Moreover, the patients who were undergoing periodontal treatment in the last 6 months and the patients who had local risk factors in the oral cavity as well as systemic complications of diabetes were also excluded.

## 2.5. Sample Size

Generally, 95% of type 2 diabetes patients suffer from periodontal disease, and we expected the same percentage in this study with a 5% margin of error. The present study was conducted on minimum sample size (298 patients) as required [18].

## 2.6. Glycated Hemoglobin (HbA1c) Levels Assessment

Patients were scanned for excluding the other systemic diseases other than T2DM depending on the patients provided medical reports before starting the study. Glycated hemoglobin (HbA1c) levels were recorded for all type 2 diabetes patients, according to the medical reports. The HbA1c rates are standardized according to the National Glycohemoglobin Standardization Program (NGSP) system [19]. When HbA1c is less than or equal 5.7% (HbA1c ≤ 5.7%), the patient is Nondiabetic, and the patient is at risk when HBA1c is less than or equal 6.4 (HBA1c ≤ 6.4) but when HBA1c is more than or equal 6.5% (HBA1c ≥ 6.5%), the patient is diabetic. Consequently, when the HbA1c level in the present study was less than 7% (<7% HbA1c), the patient was considered as controlled type 2 diabetics, and when HbA1c level was more than 7% (>7% HbA1c), the patient was considered as uncontrolled type 2 diabetics [20].

## 2.7. Periodontal Examination

Clinical evaluation of periodontal diseases was included all teeth, but class 3 mobility teeth, third molars, teeth with overhang restorations, and teeth with extensive carious lesions were excluded, where the untreatable teeth were indicted for extraction [21]. A manual periodontal probe (UNC-15, Hu-Friedy, Chicago, IL) was used in the assessment of plaque control record (PCR) [22] and bleeding on probing (BOP) [23], which was evaluated and classified as <10%, 11% - 30%, and >30%. In addition, the severity of periodontal disease was evaluated according to the 2017 World Workshop Periodontal diseases and conditions [24] by the assessment of periodontal pocket depth (PPD), clinical attachment level (CAL), which was calculated as 1 - 2 mm (mild), 3 - 4 mm (moderate) and ≥ 5 mm (severe) [25] and furcation involvement (FI). Clinical assessment of PCR, GBI, PPD, and CAL depended on four sites (buccal, mesial, distal, lingual) of all included teeth. Very severe periodontitis: (stage IV) clinical findings were recorded as follow: the number of missing teeth due to periodontal disease (>5 MTDP), trauma from occlusion (TFO), bite collapse (BC), at least 20 remaining teeth (20 RT), and tooth mobility (TM).

## 2.8. The Severity of Periodontal Bone Loss

The severity of alveolar bone in the present study was evaluated according to the American Academy of Periodontology (AAP) as mild (<15% bone loss), moderate (15% - 33% bone loss), and severe (>33% bone loss) [26]. Extraoral digital panoramic radiographs (Gendex Orthoralix 9200 DDE, Georgia-USA) were used to obtain the radiographic data, and the MiPACS Dental Enterprise Viewer Program (Medicor Imaging, Charlotte-USA) was applied to measure the radiographic bone level. The panoramic X-ray was screened for the calculation of percentage periodontal bone loss.

The distance between the cementoenamel junction (CEJ) and alveolar bone crest (ABC) and between CEJ and tooth apex (AP) was measured subtracted by 2 mm due to the histological distance between the alveolar bone crest to the base of the gingival sulcus was approximately 2 mm, and it was not visible on the radiograph. The distance between the CEJ and ABC subtracted by 2 mm divided by the distance between CEJ and AP subtracted by 2 mm multiplied by 100 was obtained for percentage radiographic bone loss assessment [27] [28].

### 2.9. Statistical Analysis

The findings of this study were collected and analyzed by ANOVA test and T-test to record the mean and standard deviation (±SD) of patients' age and the mean and standard deviation (SD) of some clinical and radiographic findings according to HbA1 and severity of radiographic bone loss as well as chi-square to record the percentage of patients in the groups, the smokers' percentage (number of cigarettes smoked per day) and the percentage of some clinical findings according to the severity of periodontal bone loss and the levels of glycated hemoglobin (HbA1c).

By the comparison between the results according to the study groups, the p values at ≤0.05 were considered statistically significant differences, and it was considered highly statistically significant differences at <0.001.

## 3. Results

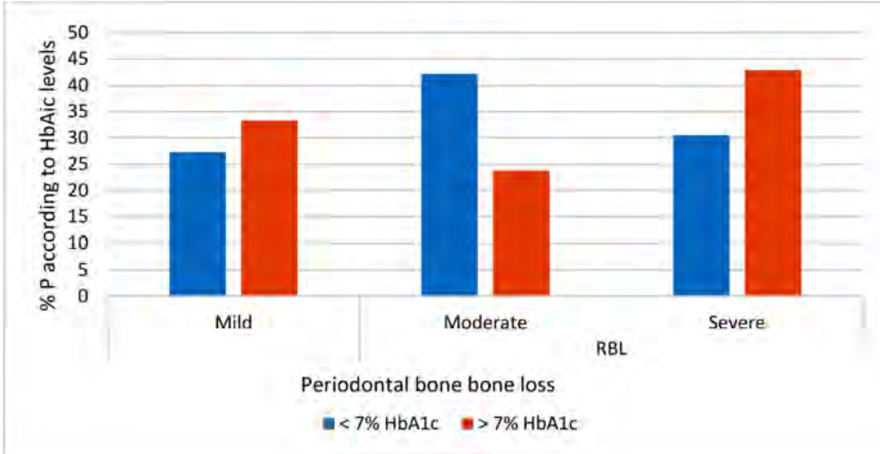
Three hundred adult male patients were obtained as the sample size in the present study, and all patients completed the study, except two patients who refused to continue in the study. The distributions of patient groups according to the severity of periodontal bone loss and the levels of glycated hemoglobin (HbA1c) are revealed in **Table 1** and **Figure 1**. According to the design of the present study, 256 patients have controlled type 2 diabetics (<7% HbA1c) exhibited the percentage of the affected patients with moderate radiographic bone loss patients was 42.2% more than the percentage of the affected patients with severe and mild radiographic bone loss patients 30.5%, 27.3%, respectively as well as 42 patients were uncontrolled type 2 diabetics (>7% HbA1c) showed the percentage of the affected patients with severe radiographic bone loss was 42.9% more than the percentage of the affected patients with mild and moderate radiographic bone loss patients 33.3%, 23.8%, respectively, but the differences were not statistically significant (p = 0.251).

Regarding distributions of smokers patients (number of cigarettes smoked per day) according to the severity of the radiographic bone loss, **Table 2** and **Figure 2** demonstrated that the percentage of the affected patients with severe

**Table 1.** Distributions of patient groups according to the severity of periodontal bone loss and the levels of glycated hemoglobin (HbA1c).

| | | HbA1c levels | | Total |
|---|---|---|---|---|
| | | **<7% HbA1c** | **>7% HbA1c** | |
| PBL | Mild N (%) | 70 (27.3%) | 14 (33.3%) | 84 (28.2%) |
| | Moderate N (%) | 108 (42.2%) | 10 (23.8%) | 118 (39.6%) |
| | Severe N (%) | 78 (30.5%) | 18 (42.9%) | 96 (32.2%) |
| | Total | 256 (100%) | 42 (100%) | 298 (100.0%) |
| Chi-square | $\chi^2$ (p-value) | | 2.767 (0.251) | |

N: Number of patients. PBL: Periodontal bone loss.



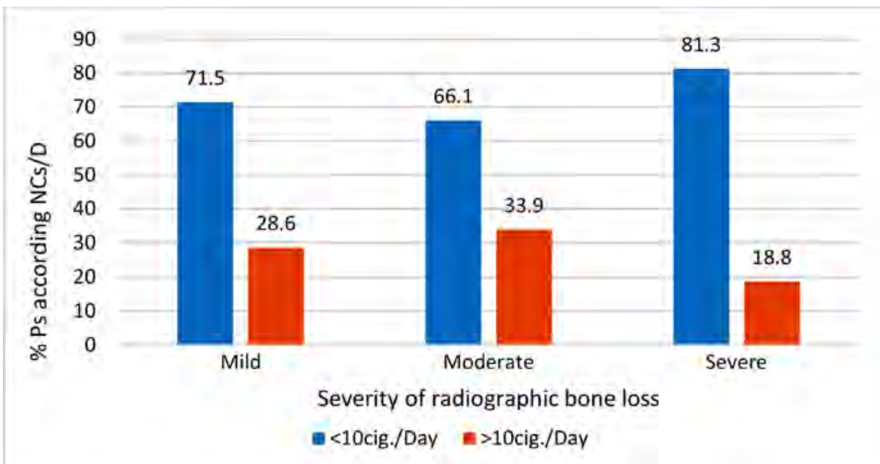

RBL: Radiographic bone loss, HbA1c: Glycated hemoglobin.

Figure 1. Severity of periodontal bone loss according to HbA1c levels.

Table 2. Distributions of smokers' patients (number of cigarettes smoked per day) according to the severity of the radiographic bone loss.

| | NCs/D | Severity of bone loss | | | Chi-square | |
|---|---|---|---|---|---|---|
| | | Mild N (%) | Moderate N (%) | Severe N (%) | $\chi^2$ | p-value |
| cigarettes Smokers | <10 cig./Day | 30(71.5%) | 39 (66.1%) | 39 (81.3%) | 6.305 | 0.178 |
| | >10 cig./Day | 12 (28.6%) | 20 (33.9%) | 9 (18.8%) | | |

NCs/D: Number cigarettes per day. Cig: Cigarettes.




Cig: Cigarettes. Ps: patients.

Figure 2. Smokers according to the severity of radiographic bone loss.

radiographic bone loss was (81.3%) more than mild and moderate radiographic bone loss (71.5%, 66.1%, respectively) among cigarettes smokers (<10 cig./day), whereas the percentage of the affected patients with moderate radiographic bone loss was (33.9%) more than mild and severe radiographic bone loss (28.6%, 18.8%, respectively) among cigarettes smokers (>10 cig./day).However, without significant differences (p = 0.178).

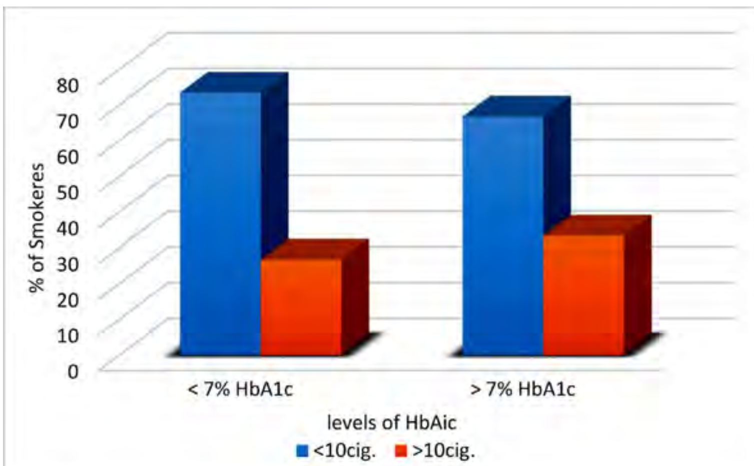
On the other hand, Table 3 and Figure 3 summarized distribution of smokers patients (number of cigarettes smoked per day) according to the levels of glycated hemoglobin (HbA1c) where the percentage of controlled type 2 diabetics (<7% HbA1c) were 73.4% more than uncontrolled type 2 diabetics (>7% HbA1c) (66.7%) among cigarettes smokers (<10 cig./day) and the percentage of uncontrolled type 2 diabetics (>7% HbA1c) were (33.3%) more than controlled type 2 diabetics (<7% HbA1c) (26.6%) among cigarettes smokers (>10 cig./day), but the differences were not statistically significant (p = 0.391).

Table 4 and Figure 4 displayed the mean and standard deviation (SD) of patients' age and some clinical and radiographic findings according to glycated hemoglobin (HbA1c) levels of the present study. There was a higher mean of ages (43.297), clinical attachment loss (7.453), and percentage of radiographic bone loss (32.438) among patients with less than 7% of glycated hemoglobin (< HbA1c) as compared to patients with more than 7% of glycated hemoglobin (>7% HbA1c) (42.571, 7.286, and 30.338, respectively). But the patients with more than 7% of glycated hemoglobin (>7% HbA1c) presented a higher mean of plaque control record (58.619), gingival bleeding index (44.190), and periodontal pocket depth (4.714) than patients with less than 7% of glycated hemoglobin (<HbA1c) (50.345, 38.347 and 4.422., respectively). No statistically significant

**Table 3.** Smokers patients (number of cigarettes smoked per day) distributions according to the levels of glycated hemoglobin (HbA1c).

| | | HbA1c | | Total | Chi-square |
|---|---|---|---|---|---|
| | | **<7% HbA1c** | **>7% HbA1c** | | |
| Smoking | <10 cig. | 188 (73.4%) | 28 (66.7%) | 216 (72.5%) | $\chi^2$ (p-value) |
| | >10 cig. | 68 (26.6%) | 14(33.3%) | 82 (27.5%) | 1.878 (0.391) |

Cig: Cigarettes.



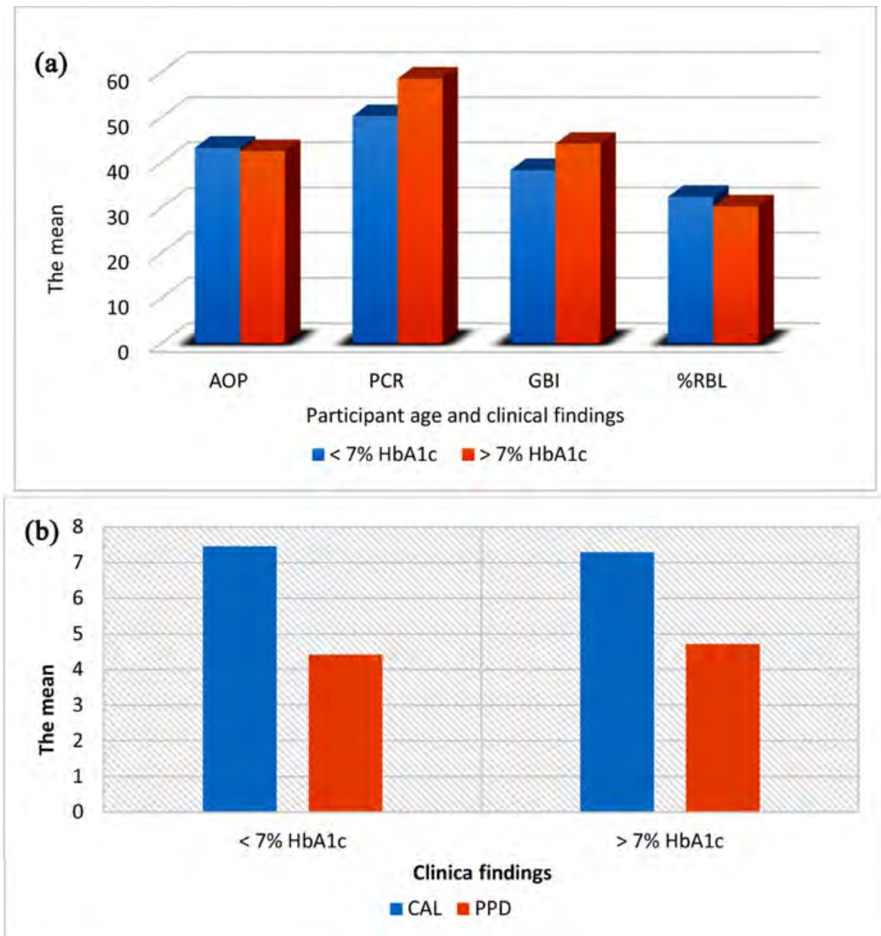

Cig: Cigarettes, HbA1c: Glycated hemoglobin.

**Figure 3.** Smokers distributions according to levels of HbA1c.

Table 4. The mean and standard deviation (SD) of patients' age and some clinical and radiographic findings according to HbA1c.

| | HbA1c | | T-test | |
|---|---|---|---|---|
| | <7% HbA1c<br>Mean ± SD | >7% HbA1c<br>Mean ± SD | t | p-value |
| AOP | 43.297 ± 16.510 | 42.571 ± 18.225 | 0.184 | 0.854 |
| PCR | 50.345 ± 19.158 | 58.619 ± 20.011 | −1.823 | 0.070 |
| GBI | 38.347 ± 16.205 | 44.190 ± 20.361 | −1.475 | 0.142 |
| CAL | 7.453 ± 2.872 | 7.286 ± 2.667 | 0.250 | 0.803 |
| %RBL | 32.438 ± 20.017 | 30.338 ± 13.985 | 0.462 | 0.645 |
| PPD | 4.422 ± 1.653 | 4.714 ± 1.793 | −0.742 | 0.459 |

AOP: Age of patients, PCR: Plaque control record, GBI: Gingival bleeding index, CAL: Clinical attachment loss, %RBL: % of radiographic bone loss, PPD: Periodontal pocket depth.



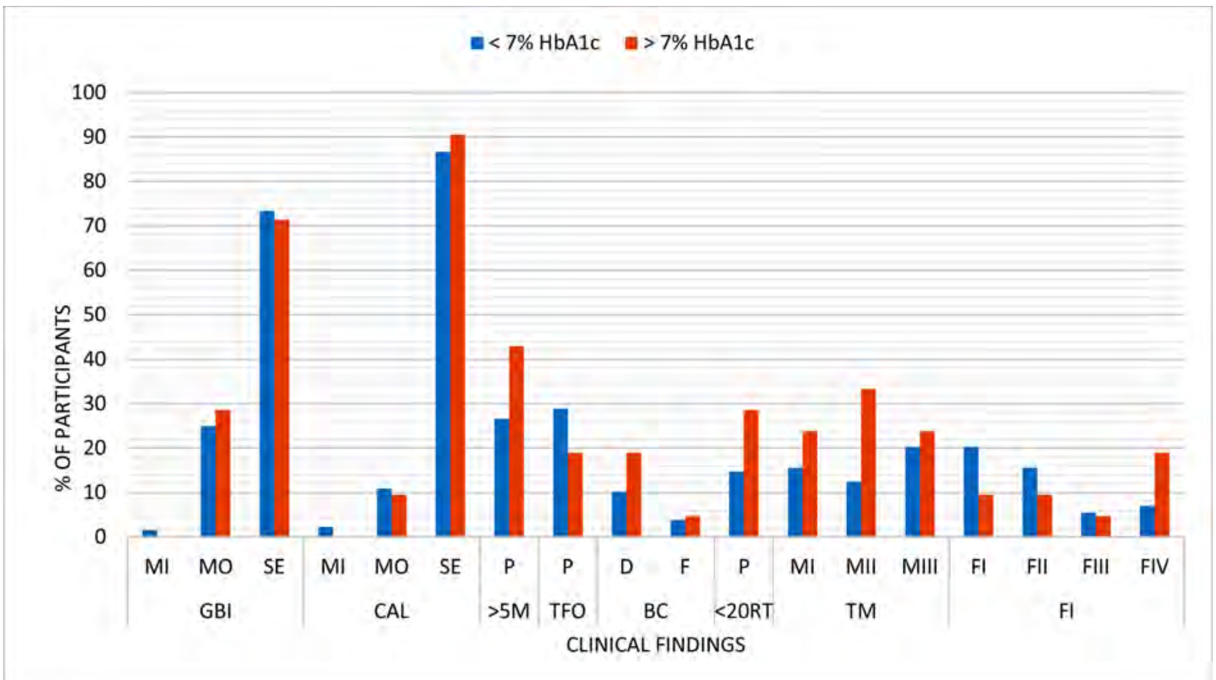

(a) AOP: Age of patients, PCR: Plaque control record, GBI: Gingival bleeding index, %RBL: % of radiographic bone loss; (b) CAL: Clinical attachment loss, PPD: Periodontal pocket depth.

Figure 4. (a) The mean of age and clinical and radiographic findings according to HbA1c levels. (b) the mean of CAL and PPD according to HbA1c levels.

difference is noticed between patients with less than 7% of glycated hemoglobin (<HbA1c) and patients with more than 7% of glycated hemoglobin (>7% HbA1c) according to the patients' ages, gingival bleeding index, clinical attachment loss, percentage of radiographic bone loss, and periodontal pocket depth ($p > 0.05$).

Table 5 and Figure 5 demonstrate the distribution of some clinical findings according to glycated hemoglobin (HbA1c) levels. The results showed that the patients with more than 7% of glycated hemoglobin (>7% HbA1c) were higher in percentage than patients with less than 7% of glycated hemoglobin (<HbA1c) among the patients who were affected with moderate (10% - 30%) gingival bleeding (28.6%), the affected patients of severe clinical attachment loss (>5 mm) (90.5%), the affected patients of 5 missing teeth and more due to periodontal diseases (42.9%), the affected patients of bite collapse (23.8%), the affected patients of less than 20 remaining teeth (28.6%), the affected patients of grade I (23.8%), II (33.3%) and III (23.8%)tooth mobility as well as the affected patients of grade IV (19.0%) furcation involvement.

On the other hand, there are an association between the percentage of patients with less than 7% of glycated hemoglobin (<7% HbA1c) and an increase in the patients who affected with mild (1.6%) and severe (73.4%) gingival bleeding, the affected patients of mild (2.3%) and moderate (10.9%) clinical attachment loss




GBI: Gingival bleeding index, CAL: Clinical attachment loss, >5 M: More than 5 missing teeth due to Perio. Diseases, D: Drifting, F: Flaring, P: Positive, TFO: Present of trauma from occlusion, BC: Bite collapse, <20 RT: Less than 20 remaining teeth, TM: Grade of tooth mobility, MI: Grade I tooth mobility, MII: Grade II tooth mobility, MIII: Grade III tooth mobility, FI: Grade of furcation involvement, FI: Grade I furcation involvement, FII: Grade II furcation involvement, FIII: Grade III furcation involvement, FIV: Grade IV furcation involvement.

Figure 5. Distributions of clinical findings according to % of HbAic participants.

**Table 5.** The distribution of some clinical findings according to HbA1c patients.

| | | HbA1c patients | | Total N (%) | Chi-square $\chi^2$ (p-value) |
|---|---|---|---|---|---|
| | | <7% HbA1c N (%) | >7% HbA1c N (%) | | |
| GBI | <10% (MI) | 4 (1.6%) | 0 (0.0%) | 4 (1.3%) | |
| | 10% - 30% (MO) | 64 (25.0%) | 12 (28.6%) | 76 (25.5%) | 0.705 (0.703) |
| | >30% (SE) | 188 (73.4%) | 30 (71.4%) | 218 (73.2%) | |
| CAL | 1 - 2 mm(MI) | 6 (2.3%) | 0 (0.0%) | 4 (1.3%) | |
| | 3 - 4 mm(MO) | 28 (10.9%) | 4 (9.5%) | 76 (25.5%) | 0.975 (0.614) |
| | >5 mm(SE) | 222 (86.7%) | 38 (90.5%) | 218 (73.2%) | |
| >5 MTDP | N | 188 (73.4%) | 24 (57.1%) | 212 (71.1%) | 2.194 (0.139) |
| | P | 68 (26.6%) | 18 (42.9%) | 86 (28.9%) | |
| TFO | N | 182 (71.1%) | 34 (81.0%) | 216 (72.5%) | 0.937 (0.333) |
| | P | 74 (28.9%) | 8 (19.0%) | 82 (27.5%) | |
| BC | N | 220 (85.9%) | 32 (76.2%) | 252 (84.6%) | |
| | D | 26 (10.2%) | 8 (19.0%) | 34 (11.4%) | 1.315 (0.518) |
| | F | 10 (3.9%) | 2 (4.8%) | 12 (4.0%) | |
| <20 RT | N | 218 (85.2%) | 30 (71.4%) | 248 (83.2%) | 2.158 (0.142) |
| | P | 38 (14.8%) | 12 (28.6%) | 50 (16.8%) | |
| TM | N | 132 (51.6%) | 8 (19.0%) | 140 (47.0%) | |
| | MI | 40 (15.6%) | 10 (23.8%) | 50 (16.8%) | 9.843 (0.02*) |
| | MII | 32 (12.5%) | 14 (33.3%) | 46 (15.4%) | |
| | MIII | 52 (20.3%) | 10 (23.8%) | 62 (20.8%) | |
| FI | N | 132 (51.6%) | 24 (57.1%) | 156 (52.3%) | |
| | FI | 52(20.3%) | 4 (9.5%) | 56 (18.8%) | |
| | FII | 40 (15.6%) | 4(9.5%) | 44 (14.8%) | 4.321 (0.364) |
| | FIII | 14 (5.5%) | 2 (4.8%) | 16 (5.4%) | |
| | FIV | 18 (7.0%) | 8 (19.0%) | 26 (8.7%) | |

GBI: Gingival bleeding index, CAL: Clinical attachment loss, >5 MTDP: More than 5 missing teeth due to Perio. Diseases, D: Drifting, F: Flaring, P: Positive, N: Negative, TFO: Present of trauma from occlusion, BC: Bite collapse, <20 RT: Less than 20 remaining teeth, TM: Grade of tooth mobility, MI: Grade I tooth mobility, MII: Grade II tooth mobility, MIII: Grade III tooth mobility, FI: Grade of furcation involvement, FI: Grade I furcation involvement, FII: Grade II furcation involvement, FIII: Grade III furcation involvement, FIV: Grade IV furcation involvement.

(>5 mm), the percentage of the affected patients of trauma from occlusion (28.9%) as well as the affected patients of grade I (20.3%), II (15.6%), and III (5.5%) furcation involvement (Table 5 and Figure 5).

According to the Chi-square test, there were no statistically significant differences in the comparison between the percentage of patients with less than 7% of glycated hemoglobin (<HbA1c) and the percentage of patients with more than 7% of glycated hemoglobin (>7% HbA1c) in the clinical findings within **Table 5** ($p > 0.05$) except the grade of tooth mobility, where there was a statistically significant difference in the comparison the percentage of patients with less than 7% of glycated hemoglobin (<HbA1c) and the percentage of patients with more than 7% of glycated hemoglobin (>7% HbA1c) in grade I, II and III tooth mobility ($p < 0.001$*) (**Table 5** and **Figure 5**).

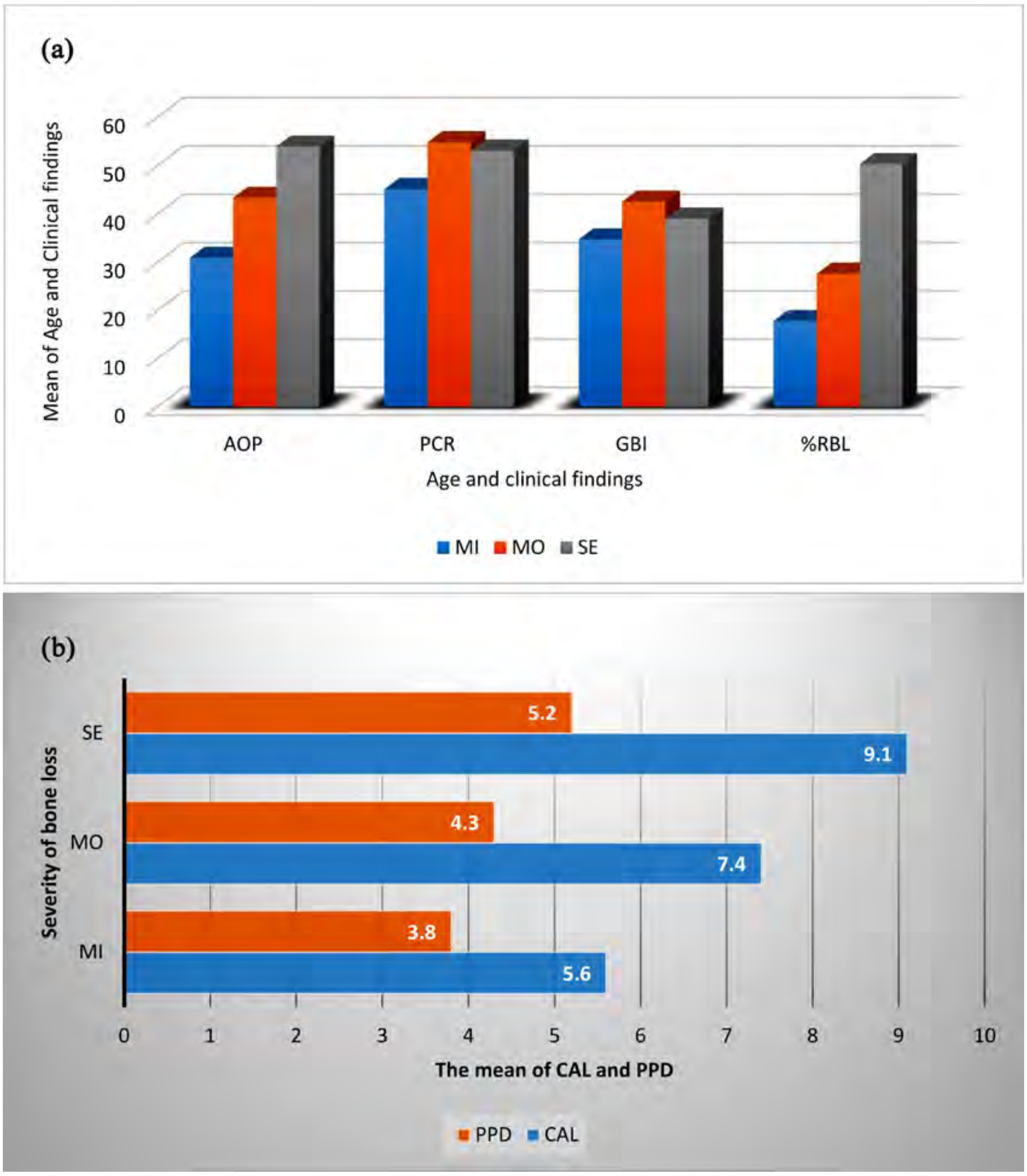
In the present study, there are associations between severity of radiographic bone loss (mild, moderate, and severe) and the mean of patients' ages, plaque control record, gingival bleeding index, clinical attachment loss, percentage of radiographic bone loss, periodontal pocket depth, where **Table 6** and **Figure 6** demonstrate a higher mean of ages (53.854) moreover an increase of clinical attachment loss (9.083), percentage of radiographic bone loss (50.290), and periodontal pocket depth (5.229) of affected patients with severe bone loss more than affected patients with moderate and mild bone loss whereas there was a higher mean of plaque control record (54.815) and gingival bleeding index (42.515) among patients with moderate bone loss more than affected patients with severe and mild bone loss. **Table 6** results showed statistically significant differences ($p < 0.001$*) except for plaque control record and gingival bleeding index ($p > 0.05$).

Results of patients' distribution according to clinical findings and severity of radiographic bone loss (mild, moderate, and severe) are demonstrated in **Table 7** and **Figure 7**. In evaluating the severity of radiographic bone loss, the results of the present study revealed that affected patients of severe clinical attachment loss (>5 mm) (100.0%), the affected patients of 5 missing teeth and more due to

**Table 6.** The mean and standard deviation (SD) of patients' ages and some clinical and radiographic findings according to severity of radiographic bone loss.

| | Bone loss | | | | | | ANOVA | |
|---|---|---|---|---|---|---|---|---|
| | Mild | | Moderate | | Severe | | | |
| | Mean | SD | Mean | SD | Mean | SD | F | p-value |
| AOP | 30.905 | 12.358 | 43.271 | 14.989 | 53.854 | 14.717 | 29.222 | <0.001* |
| PCR | 45.071 | 20.737 | 54.815 | 19.107 | 53.083 | 17.593 | 3.427 | 0.035* |
| GBI | 34.714 | 14.949 | 42.515 | 16.725 | 38.958 | 18.086 | 2.680 | 0.072 |
| CAL | 5.595 | 2.499 | 7.390 | 2.342 | 9.083 | 2.704 | 21.689 | <0.001* |
| %RBL | 17.845 | 7.654 | 27.554 | 13.918 | 50.290 | 18.222 | 63.992 | <0.001* |
| PPD | 3.786 | 1.389 | 4.322 | 1.265 | 5.229 | 2.024 | 9.738 | <0.001* |

AOP: Age of patients, PCR: Plaque control record, GBI: Gingival bleeding index, CAL: Clinical attachment loss, %RBL: % of radiographic bone loss, PPD: Periodontal pocket depth.




(a) AOP: Age of patients, PCR: Plaque control record, GBI: Gingival bleeding index, %RBL: % of radiographic bone loss. (b) CAL: Clinical attachment loss and PPD: Periodontal pocket depth.

**Figure 6.** (a) Mean of ages correlated to clinical and radiographic findings; (b) Mean of CAL and PPD according to severity of bone loss.

periodontal diseases (52.1%), the affected patients of trauma from occlusion (35.4%), the affected patients of bite collapse (27.1), the affected patients of less than 20 remaining teeth (31.3%), the affected patients of grade II (22.9%) and III (52.1%) tooth mobility as well as the affected patients of grade II (29.2%), III (8.3%), IV (20.8%) furcation involvement were categorized as having severe radiographic bone loss more than moderate and mild radiographic bone loss.

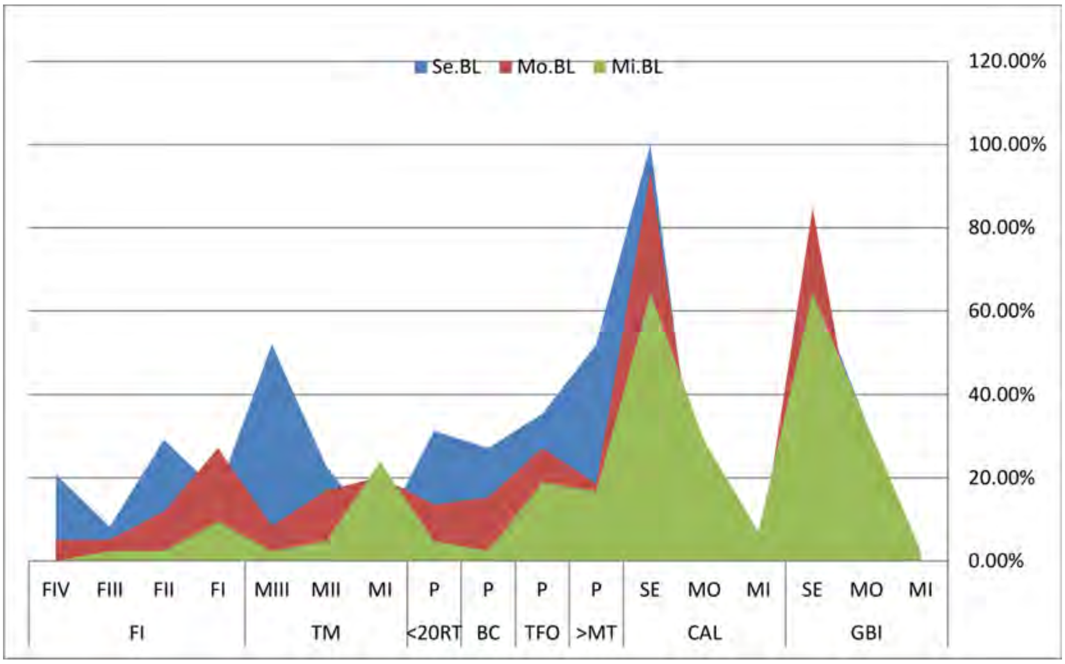
Moreover, the patients who were affected with mild (10%) gingival bleeding (2.4%), the affected patients of mild (1 - 2 mm) (7.1%) and moderate (3 - 4 mm)

(28.6%) clinical attachment loss, and the affected patients of grade I tooth mobility (23.8%) all were detected as having mild radiographic bone loss more than moderate and severe radiographic bone loss whereas the patients who affected

Table 7. Patients distribution according to clinical findings and severity of radiographic bone loss.

| | | Bone loss | | | Chi-square $\chi^2$ (p-value) |
|---|---|---|---|---|---|
| | | Mild N (%) | Moderate N (%) | Severe N (%) | |
| GBI | <10% (MI) | 1 (2.4%) | 1 (1.7%) | 0 (0.0%) | 9.356 (0.053) |
| | 10% - 30% (MO) | 14 (33.3%) | 8 (13.6%) | 16 (33.3%) | |
| | >30% (SE) | 27 (64.3%) | 50 (84.7%) | 32 (66.7%) | |
| CAL | 1 - 2 mm (MI) | 3 (7.1%) | 0 (0.0%) | 0 (0.0%) | 31.290 (<0.001*) |
| | 3 - 4 mm (MO) | 12 (28.6%) | 4 (6.8%) | 4 (6.8%) | |
| | >5 mm (SE) | 27 (64.3%) | 55 (93.2%) | 55 (93.2%) | |
| >5 MTDP | N | 35 (83.3%) | 48 (81.4%) | 23 (47.9%) | 17.997 (<0.001*) |
| | P | 7 (16.7%) | 11 (18.6%) | 25 (52.1%) | |
| TFO | N | 34 (81.0%) | 43 (72.9%) | 31 (64.6%) | 3.060 (0.217) |
| | P | 8 (19.0%) | 16 (27.1%) | 17 (35.4%) | |
| BC | N | 41 (97.6%) | 50 (84.7%) | 35 (72.9%) | 13.179 (0.01*) |
| | D | 1 (2.4%) | 6 (10.2%) | 10 (20.8%) | |
| | F | 0 (0.0%) | 3 (5.1%) | 3 (6.3%) | |
| <20 RT | N | 40 (95.2%) | 51 (86.4%) | 33 (68.8%) | 12.265 (0.002*) |
| | P | 2 (4.8%) | 8 (13.6%) | 15 (31.3%) | |
| TM | N | 29 (69.0%) | 32 (54.2%) | 9 (18.8%) | 59.112 (<0.001*) |
| | MI | 10 (23.8%) | 12 (20.3%) | 3 (6.3%) | |
| | MII | 2 (4.8%) | 10 (16.9%) | 11 (22.9%) | |
| | MIII | 1 (2.4%) | 5 (8.5%) | 25 (52.1%) | |
| FI | N | 36 (85.7%) | 30 (50.8%) | 12 (25.0%) | 48.480 (<0.001*) |
| | FI | 4 (9.5%) | 16 (27.1%) | 8 (16.7%) | |
| | FII | 1 (2.4%) | 7 (11.9%) | 14 (29.2%) | |
| | FIII | 1 (2.4%) | 3 (5.1%) | 4 (8.3%) | |
| | FIV | 0 (0.0%) | 3 (5.1%) | 10 (20.8%) | |

GBI: Gingival bleeding index, CAL: Clinical attachment loss, >5 M: More than 5 missing teeth due to Perio. Diseases, D: Drifting, F: Flaring, P: Positive, TFO: Present of trauma from occlusion, BC: Bite collapse, <20 RT: Less than 20 remaining teeth, TM: Grade of tooth mobility, MI: Grade I tooth mobility, MII: Grade II tooth mobility, MIII: Grade III tooth mobility, FI: Grade of furcation involvement, FI: Grade I furcation involvement, FII: Grade II furcation involvement, FIII: Grade III furcation involvement, FIV: Grade IV furcation involvement.




Mi.BL: Mild bone loss, Mo.BL: Moderate bone loss, Se.BL: Severe bone loss, GBI: Gingival bleeding index, CAL: Clinical attachment loss, >5 M: More than 5 missing teeth due Perio. Diseases, D: Drifting, F: Flaring, P: Positive, TFO: Present of trauma from occlusion, BC: Bite collapse, <20 RT: Less than 20 remaining teeth, TM: Grade of tooth mobility, MI: Grade I tooth mobility, MII: Grade II tooth mobility, MIII: Grade III tooth mobility, FI: Grade of furcation involvement, FI: Grade I furcation involvement, FII: Grade II furcation involvement, FIII: Grade III furcation involvement, FIV: Grade IV furcation involvement.

**Figure 7.** Participants distribution according to clinical findings and severity bone loss.

with severe gingival bleeding (>30) revealed moderate (84.7%) and severe (66.7%) radiographic bone loss more than mild (33.3%) radiographic bone loss.

The statistical analysis showed highly significant differences in the patients' distributions for all clinical and radiographic findings in the present study according to the severity of radiographic bone loss ($p < 0.001^*$) except the patients who were affected with mild, moderate, and severe gingival bleeding where there were no statistically significant differences in the patients' distributions ($p > 0.05$).

## 4. Discussion

The present study assessed the correlation between the severity of periodontal bone loss and the levels of glycated hemoglobin (HbA1c), presence of type 2 diabetes millets, and periodontal diseases in the clinical evaluation of periodontal diseases among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). There was a correlation between severity and progression of periodontal diseases among the individuals with levels of glycated hemoglobin (HbA1c) and between increases of occurrence of periodontal diseases with elevated HbA1c levels [29].

In the present study, there was a passive connection between the patients' ages and HbA1c levels as well as with the severity of periodontal bone loss where the mean of age was 53.854 years among affected patients of severe periodontal bone loss and 42.571 years among uncontrolled type 2 diabetic patients (>HbA1c).

This study displayed a relationship between the number of cigarettes smoked per day and HbA1c levels in type 2 diabetic patients where there was a positive relationship of an increase of the number of smoked cigarettes more than ten cigarettes per day with elevated HbA1c. This result was detected in other previous studies [30] [31]. These increases in HbA1c levels may be attributed to impaired glucose metabolism and secretion of insulin during cigarette smoking [32] [33].

In the present study, there was an increase of the periodontal bone loss severity with an increased number of cigarettes smoked per day (>10 cig./day) among type 2 diabetics, but these results were not significant. These findings confirm the results of previous demonstrated that the association between cigarette smoking and severity of periodontal bone loss be evidence of the potential risk factor of cigarette smoking on alveolar bone [34] [35]. Thus, the impact of cigarette smoking on periodontal bone and HbA1c levels among type 2 diabetes may be attributed to the inhalation of toxic substances in cigarette smoking where cytotoxic contents of tobacco such as nicotine and cotinine were detected in the gingival crevicular fluid and the saliva [36]. According to previous studies concerning cigarette smoking, there is an association between the severity of periodontal bone loss and the number of cigarettes smoked per day [37] [38]. This finding is in agreement with the results of the present study, which revealed that an increase in periodontal bone loss among cigarettes smokers (<10 cig./day).

Furthermore, the incidence of alveolar bone loss may be considered as the development of periodontal diseases [39]. Similar associations have been detected in the present study. A new study was conducted in 2018 revealed that hyperglycemia has a considerable role in periodontal diseases severity among type 2 diabetics [40]. These results confirmed the results of the present study, which exhibited that generalized severe gingivitis and generalized severe periodontitis are more prevalent in type 2 diabetics (controlled and uncontrolled). These results were not consistent with that of the previous study, which revealed that moderate periodontitis was more among type 2 diabetics [41].

The present study demonstrated that uncontrolled type 2 diabetics had more plaque and severe gingivitis, as evident by the higher scores of GBI and PCR. Similar findings were revealed in another study, which detected higher plaque index and gingival index among uncontrolled type 1 diabetics [42]. Thus, the present study detected that the oral hygiene status was moderate or poor. There were no significant differences in the level of oral hygiene between controlled and uncontrolled type 2 diabetics ($p = 0.070$), but there were significant differences in the level of oral hygiene between controlled and uncontrolled type 2 diabetics according to the severity of radiographic bone loss ($p = 0.035$). These findings may be due to the little knowledge of the risk for periodontal disease and the awareness of oral health among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi).

The results of the present study included comparing the HbA1c levels and periodontal bone loss in patients, which demonstrates the potent link between periodontal bone loss and HbA1c levels. These results are comparable with the Persson study that revealed if there is an increase in the levels of HbA1c; the periodontal bone loss will be severe among uncontrolled type 2 diabetics. [43].

In the present study, the percentage of the affected patients with moderate radiographic bone loss patients was more than the percentage of the affected patients with severe and mild radiographic bone loss patients among controlled type 2 diabetics (<7% HbA1c) whereas uncontrolled type 2 diabetics (>7% HbA1c) showed the percentage of the affected patients with severe radiographic bone loss was more than the percentage of the affected patients with mild and moderate radiographic bone loss patients. Thus and according to the present study results, uncontrolled type 2 diabetes has more alveolar bone loss more than controlled type 2 diabetics. These findings agree with Lorentz *et al.*'s results, which found an increase in clinical and bone attachment loss among type 2 diabetics [44]. Significantly more periodontal bone loss was in uncontrolled type 2 diabetics than controlled [45].

Moreover, this result is in agreement with the epidemiological study of Tsai *et al.* and Tylor *et al.*, who detected that uncontrolled diabetes type-2 have an increasingly severe clinical attachment loss and alveolar bone loss more than controlled diabetes type-2 where the results of the current study demonstrated that the mean of clinical attachment loss among uncontrolled diabetes type-2 more than controlled diabetes type-2 [46] [47]. Therefore, the results of the present study demonstrate that uncontrolled type 2 diabetics have severe periodontal disease more than controlled type 2 diabetics.

Several previous studies confirmed the correlation between hyperglycemia and periodontal diseases are given that periodontitis can cause hyperglycemia and also the impact of hyperglycemia on periodontal tissues integrity [48]. We found a similar intensity association between an increase of periodontal diseases and their severity with the rise of glycated hemoglobin (HbA1c) levels among type 2 diabetics. The patients with uncontrolled type 2 diabetes (HbA1c ≥ 7) in the present study revealed elevated periodontal diseases clinical parameters (mean of PCR, GBI, and PPD) as well as an increase in the affected patients of stage IV periodontitis (severe clinical attachment loss (>5 mm), 5 missing teeth and more due to periodontal diseases, bite collapse, less than 20 remaining teeth and grade I, II and III tooth mobility) which also was in agreement with the findings of other studies [49] [50].

The present study clarified clinical attachment loss exceeded the mean of 7 mm among controlled and uncontrolled type 2 diabetics, whereas some studies have revealed lesser clinical attachment loss (less than 4 mm) [51]. This study revealed that severe clinical attachment loss, as well as moderate and severe periodontal bone loss, were associated with uncontrolled type 2 diabetics.

## 5. Strength and Limitations

The authors believe that the small sample size of the current study and unequal distribution of patients according to the severity of periodontal loss are the main limitations where most of the data were collected from the outpatients' clinics, College of Dentistry, King Khalid University only. Therefore, we suggest expanding the study with an increase in the sample size to cover the other dental centers and colleges of dentistry in Saudi Arabia to determine as accurately the impact of HbA1c levels on the severity of periodontal loss among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). The results of the present study assist in identifying uncontrolled type 2 diabetics with periodontal diseases for the management of uncontrolled type 2 diabetics and periodontal diseases by endocrinologists and periodontists. And as we know that the present study may be from the first studies in the college of dentistry, King Khalid University, which was conducted to assess the correlation between HbA1c levels and severity of periodontal bone loss among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). At the level of the medical and dental practice, these results revealed that the importance of improving the guidelines of screening uncontrolled type 2 diabetics and periodontitis patients in medical primary care centers and dental clinics.

Therefore, in Saudi Arabia, the treatment of periodontal disease of uncontrolled type 2 diabetics is useful in the enhancement of type 2 diabetics' health status due to the negative impact of periodontitis–diabetes interaction on glycemic control of type 2 diabetics. Consequently, the treatment of periodontal diseases should be included in the protocol of type 2 diabetic patients' treatment. Early diagnosis of periodontal diseases among type 2 diabetics and prevention are essential to avoid periodontal tissue destruction. Furthermore, periodontal treatment may be improving HbA1c levels.

## 6. Conclusion

We conclude according to the results of the current study and the previous studies that demonstrated the association between glycated hemoglobin (HbA1c) levels and severity of periodontal diseases among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). There was an increase in periodontal clinical parameters among uncontrolled type 2diabetics more than controlled type 2 diabetics. We found that the severity of periodontal bone loss increased with decreasing control of type 2 diabetes. Thus, the Risk of aggravating periodontal disease is associated with a rise in glycated hemoglobin (HbA1c) levels among uncontrolled type 2 diabetics. Systematic oral screenings and periodontal therapy are essential to prevent periodontal diseases among type 2 diabetics. We need more periodontal studies to demonstrate the association between HbA1c levels and severity of periodontal bone loss among type 2 diabetic patients in Saudi Arabia (Saudi and non-Saudi). Emphasize that the awareness and knowledge of dental practitioners and oral public health specialists as well as the primary medical care clinicians that the monitoring of HbA1c levels and dental plaque with other systemic and local factors are more important to avoid the progression of periodontal destruction and other complications in the oral mucosa among type 2 diabetics.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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