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# Gender-Based Differences in CRP and HbA1c Levels and Their Association with Type 2 Diabetic Patients in Shekhan: A Cross-Sectional Study

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## *Abstract*

**Type 2 Diabetes mellitus (T2DM) is a chronic metabolic disorder defined by persistent hyperglycemia, and its progression is often evaluated through biomarkers such as glycated hemoglobin (HbA1c), which reflects glycemic control, and C-reactive protein (CRP), an indicator of inflammation. Gender-related differences in these biomarkers may influence the disorder patterns, especially in regions like Shekhan district, where healthcare challenges exist. This study focused on measuring CRP and HbA1c values among diabetic patients based on gender, through examining their correlation within male and female groups, and determining how the demographic factors, including age, smoking, and how diabetes medication affects these markers. A cross-sectional study was carried out on 100 diabetic patients (39 males and 61 females) in Shekhan district, Iraq, and the collected data included demographics, comorbidities, lifestyle factors, and treatment details. Poor glycemic control was defined as HbA1c ≥ 7%, while CRP > 6 mg/L was considered abnormal. Results indicated that 64% of participants had good glycemic control (HbA1c < 7%), with males showing better control (71.8%) than females (59%), although this difference was not statistically significant (p = 0.194). Elevated CRP levels were present in 18% of patients, also without a significant gender difference (p = 0.586), but females receiving combined insulin and oral therapy showed significantly higher CRP levels (p < 0.0001). Combined therapy was further associated with poor glycemic control in both genders (p = 0.020 in males; p < 0.0001 in females). Hypertension (41%) and cardiovascular disease (31%) were the most frequent comorbidities. Overall, the findings suggest that gender disparities in glycemic control and inflammation highlight the importance of personalized management and routine monitoring, while future research should continue to explore gender-specific diabetes strategies.**

***Keywords***: *Type 2 Diabetes Mellitus, CRP, HbA1c, Gender Differences, Inflammation, Glycemic Control.*
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## I. INTRODUCTION

Type 2 Diabetes mellitus is a complicated metabolic disorder marked by chronic hyperglycemia. If not effectively controlled, it can result in serious complications (Nadhiya *et al*., 2023). Among the various biomarkers associated with diabetes, C-reactive protein (CRP) and glycated hemoglobin (HbA1c) are commonly used indicators of systemic inflammation and long-term glycemic control, respectively (Utami *et al*., 2025). Although CRP is a non-specific inflammatory marker that can be elevated in various inflammatory or infectious conditions, persistently increased CRP levels reflect chronic low-grade inflammation that is strongly associated with insulin resistance and the development and progression of type 2 diabetes (Bashir *et al*., 2022). In parallel, HbA1c is widely recognized as a dependable marker for monitoring chronic glycemic control, reflecting the mean blood glucose levels over the preceding two to three months (Chauhan *et al*., 2024; Elbaruni *et al*., 2023).

Recent investigations have underscored the importance of gender-related differences in both CRP and HbA1c levels among individuals with diabetes. Evidence suggests that women frequently present with higher CRP concentrations than men, potentially contributing to the elevated risk of cardiovascular complications observed in female diabetic patients (Rana *et al*., 2022). Moreover, gender-specific determinants-including hormonal fluctuations, psychosocial stressors, and disparities in healthcare access-have been shown to affect glycemic regulation, thereby contributing to variations in HbA1c levels between men and women (Kaiafa *et al*., 2021).



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Within the context of Shekhan, which is a region distinguished by specific healthcare challenges and distinct cultural dynamics recognizing gender-based disparities is particularly important (Yameny, 2024). Previous research has demonstrated that a considerable proportion of individuals with diabetes in the Middle East encounter difficulties in attaining optimal glycemic control, frequently leading to elevated HbA1c levels and an increased burden of related comorbidities (El-kebbi *et al*., 2021).

Moreover, the relationship between systemic inflammation, as indicated by CRP levels, and glycemic regulation highlights the importance of developing targeted interventions that address gender-specific health determinants (Hussein *et al*., 2023).

The study aims to evaluate CRP and HbA1c levels in individuals diagnosed with diabetes mellitus, with a particular focus on gender-based stratification to delineate potential differences between males and females. In addition, to investigate the association between CRP and HbA1c within each gender group, thereby providing insight into gender-specific patterns of inflammatory status and glycemic regulation. Furthermore, the research examines the influence of risk factors, including age, smoking habits, and diabetes treatment, on CRP and HbA1c levels across both genders, offering a comprehensive understanding of the interplay between biological, clinical, and lifestyle determinants in diabetes management.

## II. Materials and Methods

### A. Study setting

The study was carried out in hospitals, clinics, and diabetes care centers across Shekhan district, Iraq. These settings were purposefully chosen due to their key role in the clinical management of diabetes, thereby providing access to a diverse and representative patient cohort.

### B. Study design

This cross-sectional study was conducted to assess and analyze gender-specific variations in CRP and HbA1c levels among individuals with diabetes. Data were collected over a three-month period, extending from November 2024 to January 2025.

### C. Inclusion and exclusion criteria

The study sample consisted of consenting adults (aged ≥ 18 years) who had received a confirmed clinical diagnosis of diabetes. Individuals were excluded if they were undergoing treatment with anti-inflammatory medications during the study period, had incomplete medical records, or declined to provide consent.

### D. Sample size

A total of 100 diabetic patients were enrolled in the study, comprising 39 males and 61 females.

### E. Data collection

Data were collected using a structured questionnaire specifically designed for this study. The questionnaire elicited information on participants' demographic variables (case number, date, age, and sex) and clinical indicators, including glycaemic control, categorized by HbA1c levels, and C-reactive protein (CRP) concentrations. Details regarding comorbidities-such as hypertension, cardiovascular disease, chronic kidney disease, obesity, and smoking status-were also recorded. In addition, information was obtained on the duration of diabetes (<1 year, 1–5 years, 5–10 years, or >10 years), lifestyle factors (smoking, physical activity, and dietary management), treatment modalities for diabetes (insulin, oral therapy, or combined therapy), and family history of diabetes.

### F. Clinical samples collection

For diagnosing diabetes, 5 mL of peripheral venous blood was collected to evaluate blood glucose and HbA1c concentrations. In accordance with the American Diabetes Association's Standards of Care (Butler *et al*., 2021). Individuals with HbA1c values ≥ 6.5% were classified as diabetic. Glycemic status was categorized based on HbA1c values, with levels below 7.0% reflecting adequate glycemic control and levels of 7.0% or higher indicating inadequate control, in line with established clinical recommendations (Wang *et al*., 2024). An additional 5 mL of peripheral blood were obtained from each participant for the assessment of biochemical and inflammatory markers, including C-reactive protein (CRP).

### G. Laboratory investigations

#### 1. HbA1c and blood sugar

Patients with type 2 diabetes mellitus were evaluated for glycaemic control and associated complications using HbA1c measurements. HbA1c was employed as an indicator of average blood glucose concentration over the preceding three months, corresponding to the lifespan of erythrocytes. Venous blood samples were collected in EDTA tubes, and HbA1c levels were determined using the DCR1000 BIOZEK system with Biozek test kits, following the manufacturer's guidelines.

#### 2. CRP Measurement

Serum concentrations of the inflammatory biomarker C-reactive protein (CRP) were quantified using the iChroma II system (Boditech Med Inc.), in accordance with the manufacturer's instructions. In adults, reference values for CRP are ≤ 6 mg/L.

### H. Statistical analysis

The demographic and clinical characteristics of patients with type 2 diabetes mellitus were summarized using means and standard deviations for continuous variables, and frequencies with percentages for categorical variables. The prevalence of normal and abnormal CRP values, as well as the distribution of patients across different T2DM levels, was reported in frequencies and percentages. Associations between smoking status, age, and disease duration with CRP levels and glycaemic categories in male and female patients were analyzed using Pearson's chi-squared test. Statistical

significance was set at $p < 0.05$. All analyses were conducted using SPSS version 27.0.

## III. RESULTS

### A. General and medical characteristics

Table 1 presents data on 100 patients with type 2 diabetes mellitus (T2DM), aged 18–77 years (mean 47.22 ± 14.14). Females constituted 61% of the sample. Comorbidities were frequent (61%), mainly hypertension (41%) and cardiovascular disease (31%). Obesity affected 28%, and 62% had a family history of diabetes. Disease duration ranged from less than one year (23%) to over ten years (21%).

Table 1. General and medical characteristics of the patients with type 2 diabetes mellitus.

| General and medical characteristics (n=100) | | Number | Percent |
|---|---|---|---|
| Age | min-max: 18-77 | Mean: 47.22 | SD: 14.14 |
| Age Category | ≤ 18<br>20-29<br>30-39<br>40-49<br>50-59<br>60-69<br>70-77 | 2<br>9<br>19<br>26<br>22<br>13<br>9 | 2.0<br>9.0<br>19.0<br>26.0<br>22.0<br>13.0<br>9.0 |
| Gender | Male | 39 | 39.0 |
| | Female | 61 | 61.0 |
| Comorbidities | Yes | 61 | 61.0 |
| | No | 39 | 39.0 |
| Hypertension | Yes | 41 | 41.0 |
| | No | 59 | 59.0 |
| Cardiovascular Disease | Yes | 31 | 31.0 |
| | No | 69 | 69.0 |
| Chronic Kidney Disease | Yes | 12 | 12.0 |
| | No | 88 | 88.0 |
| Obesity | Yes | 28 | 28.0 |
| | No | 72 | 72.0 |
| Chronic Liver Disease | Yes | 3 | 3.0 |
| | No | 97 | 97.0 |
| Diabetes Duration | < 1 year<br>1-5 Years<br>5-10 Years<br>>10 years | 23<br>31<br>25<br>21 | 23.0<br>31.0<br>25.0<br>21.0 |
| Smoking Status | Yes | 29 | 29.0 |
| | No | 71 | 71.0 |
| Physical Activity Level | Daily<br>Occasionally<br>Rarely<br>Never | 6<br>32<br>44<br>18 | 6.0<br>32.0<br>44.0<br>18.0 |
| Dietary Management | Yes | 63 | 63.0 |
| | No | 37 | 37.0 |
| Diabetes Medication | Insulin<br>Oral Medication<br>Combined | 8<br>75<br>17 | 8.0<br>75.0<br>17.0 |
| Family History of Diabetes | Yes | 62 | 62.0 |
| | No | 38 | 38.0 |
| CRP | min-max: 0.30-34.70 | Mean: 6.38 | SD: 5.97 |

### B. Glycaemic control and inflammatory status

#### 1. Glycemic Control (HbA1c Levels)

Table 2 shows the association between gender and HbA1c levels, where 64% achieved control. Males (71.8%) had better glycemic control than females (59%), without a significant difference ($p = 0.194$). Figures 1 and 2 illustrate these gender-based variations.

Table 2. Assessment of type 2 diabetes mellit8s for the CRP and HbA1c levels.

| Outcomes (n=100) | All patients (%) | Gender | | P-Value |
|---|---|---|---|---|
| | | Male | Female | |
| HBA1c Control<br>Good<br>Poor | 64 (64.0)<br>36 (36.0) | 28 (71.8)<br>11 (28.2) | 36 (59.0)<br>25 (41.0) | 0.194 |
| CRP<br>Normal<br>Abnormal | 82 (82.0)<br>18 (18.0) | 33 (84.6)<br>6 (15.4) | 49 (80.3)<br>12 (19.7) | 0.586 |

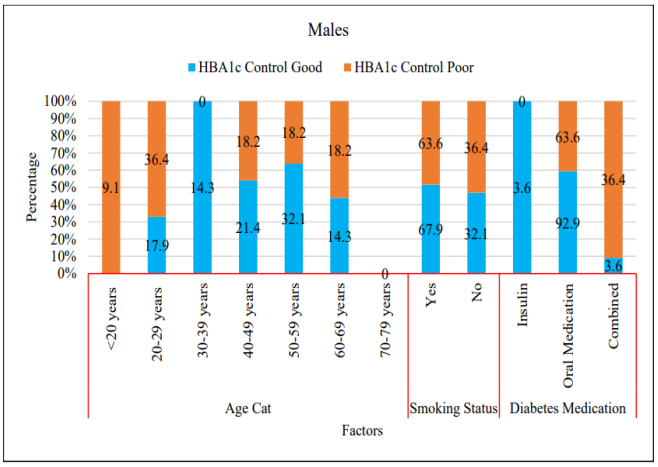


Figure 1. Illustrate the distribution of HbA1c control in males.

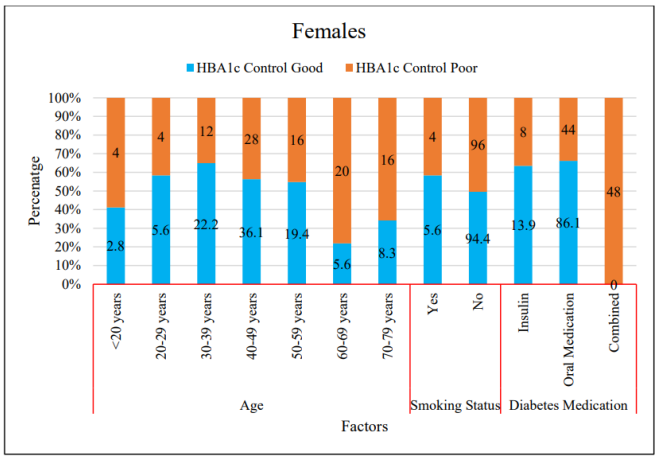


Figure 2. illustrates the distribution of HbA1c control of females.

#### 2. Inflammatory status (CRP Levels)

In the case of CRP levels with gender with 82% of participants were within the normal range. Both genders had similar distributions, and the difference between males and females was not statistically significant ($p = 0.586$) in Table 2. Figures 3 and 4 depict these overall and gender-specific distributions.

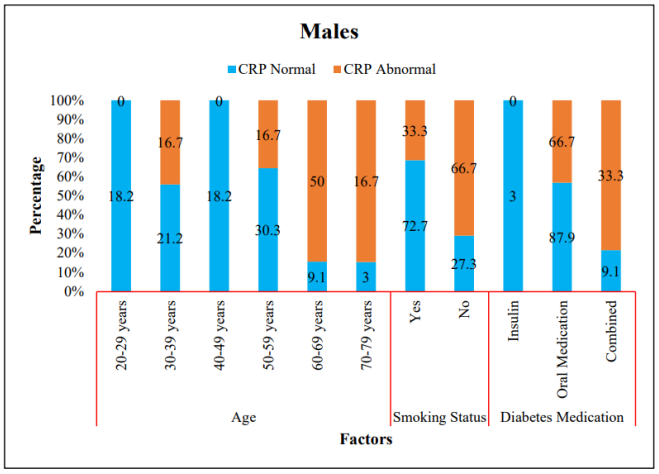


Figure 3. Show the overall and male-specific CRP distribution.

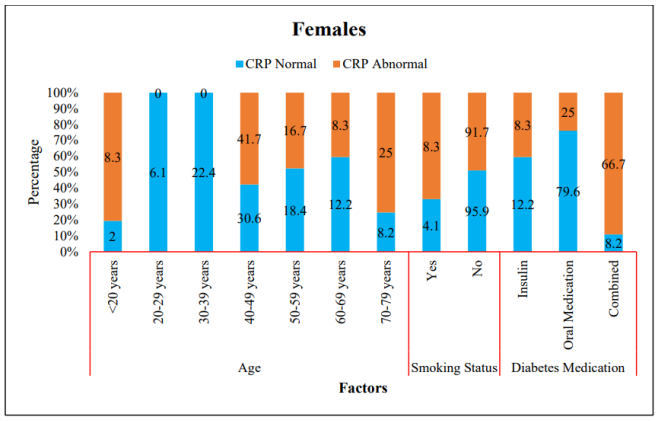


Figure 4. Show the overall and Females-specific CRP distribution.

## C. *Association of CRP and HbA1c levels with clinical variables*

### *1. CRP levels and clinical variables*

Table 3 presents a comprehensive analysis of CRP levels across different age groups, smoking habits, and categories of diabetes medication, with results stratified by sex.

- *Male patients*

Among male participants, CRP levels varied slightly with age and smoking status, showing higher values in certain age groups (notably 50–59 years) and among smokers; however, these differences were not statistically significant (age: p = 0.077; smoking: p = 0.060). Similarly, CRP levels showed no significant association with the type of diabetes medication used (p = 0.249).

- *Female patients*

In contrast, among female patients, CRP levels showed a significant association with the type of diabetes medication (p < 0.0001). Those receiving combined insulin and oral therapy were more likely to exhibit elevated CRP levels than those on oral agents alone, whereas age and smoking status showed no significant relationship with CRP levels in this group.

Table 3. Analyzing the correlation between CRP levels in male and female patients.

| **Male (n=39)** | **CRP** | | **P-Value** |
|---|---|---|---|
| | **Normal** | **Abnormal** | |
| Age Category | | | |
| 18-29 | 6 (18.2) | 0 (0.0) | |
| 30-39 | 7 (21.2) | 1 (16.7) | |
| 40-49 | 6 (18.2) | 0 (0.0) | |
| 50-59 | 10 (30.3) | 1 (16.7) | 0.077 |
| 60-69 | 3 (9.1) | 3 (50.0) | |
| 70-77 | 1 (3.0) | 1 (16.7) | |
| Smoking Status | | | |
| Yes | 24 (72.7) | 2 (33.3) | 0.060 |
| No | 9 (27.3) | 4 (66.7) | |
| Diabetes Medication Insulin | 1 (3.0) | 0 (0.0) | |
| Oral Medication | 29 (87.9) | 4 (66.7) | |
| Combined | 3 (9.1) | 2 (33.3) | 0.249 |
| Female (n=61) | CRP | | P-Value |
| | Normal | Abnormal | |
| Age Category | | | |
| ≤ 18 | 1 (2.0) | 1 (8.3) | |
| 20-29 | 3 (6.1) | 0 (0.0) | |
| 30-39 | 11 (22.4) | 0 (0.0) | |
| 40-49 | 15 (30.6) | 5 (41.7) | |
| 50-59 | 9 (18.4) | 2 (16.7) | 0.279 |
| 60-69 | 6 (12.2) | 1 (8.3) | |
| 70-77 | 4 (8.2) | 3 (25.0) | |
| Smoking Status | | | |
| Yes | 2 (4.1) | 1 (8.3) | 0.542 |
| No | 47 (95.9) | 11 (91.7) | |
| Diabetes Medication | | | |
| Insulin | 6 (12.2) | 1 (8.3) | |
| Oral Medication | 39 (79.6) | 3 (25.0) | <0.0001 |
| Combined | 4 (8.2) | 8 (66.7) | |

### *2. HbA1c levels and clinical variables*

Table 4 explores the association between HbA1c control and selected clinical variables, including age, smoking status, and type of diabetes medication, stratified by sex.

- *Male patients*

Among male patients, glycemic control showed a nonsignificant tendency to worsen with increasing age (p = 0.066), and smoking status had no significant impact on HbA1c levels (p = 0.801). However, the type of diabetes medication was significantly associated with glycemic control (p = 0.020), with males on combination therapy more likely to exhibit poor control.

- *Female patients*

Among female patients, glycemic control was not significantly associated with age (p = 0.566) or smoking status (p = 0.782). In contrast, the type of diabetes medication showed a strong association with HbA1c levels (p < 0.0001), with women receiving combination therapy more likely to exhibit poor glycemic control than those on oral agents alone.

Table 4. Analyzing the correlation between HbA1c levels in male and female patients.

| **Male (n=39)** | **HBA1c Control** | | **P-Value** |
|---|---|---|---|
| | **Good** | **Poor** | |
| Age Category | | | |
| ≤ 18 years | 5 (17.9) | 1 (9.1) | |
| 20-29 | 4 (14.3) | 4 (36.4) | |
| 30-39 | 6 (21.4) | 0 (0.0) | |
| 40-49 | 9 (32.1) | 2 (18.2) | |
| 50-59 | 4 (14.3) | 2 (18.2) | 0.066 |
| 60-69 | 0 (0.0) | 2 (18.2) | |
| 70-77 | | | |
| Smoking Status | | | |
| Yes | 19 (67.9) | 7 (63.6) | 0.801 |
| No | 9 (32.1) | 4 (36.4) | |
| Diabetes Medication | | | |
| Insulin | 1 (3.6) | 0 (0.0) | |
| Oral Medication | 26 (92.9) | 7 (63.6) | 0.020 |
| Combined | 1 (3.6) | 4 (36.4) | |
| Female (n=61) | HBA1c Control | | P-Value |
| | Good | Poor | |
| Age Category | | | |
| ≤ 18 | 1 (2.8) | 1 (4.0) | |
| 20-29 | 2 (5.6) | 1 (4.0) | |
| 30-39 | 8 (22.2) | 3 (12.0) | |
| 40-49 | 13 (36.1) | 7 (28.0) | |
| 50-59 | 7 (19.4) | 4 (16.0) | 0.566 |
| 60-69 | 2 (5.6) | 5 (20.0) | |
| 70-77 | 3 (8.3) | 4 (16.0) | |
| Smoking Status | | | |
| Yes | 2 (5.6) | 1 (4.0) | 0.782 |
| No | 34 (94.4) | 24 (96.0) | |
| Diabetes Medication | | | |
| Insulin | 5 (13.9) | 2 (8.0) | |
| Oral Medication | 31 (86.1) | 11 (44.0) | <0.0001 |
| Combined | 0 (0.0) | 12 (48.0) | |

## IV. DISCUSSION

Type 2 diabetes mellitus (T2DM) continues to pose a substantial global health burden, with disproportionately rising prevalence and complications in low- and middle-income countries due to rapid urbanization, lifestyle transitions, and constrained healthcare resources (Rob *et al*., 2025). Recent estimates indicate a persistent increase in diabetes-related morbidity across the Middle East, including Iraq, where regional disparities in access to care and disease management remain evident (Alrasheedi, 2024). Within this context, the present study examined glycaemic control and inflammatory status among adults with T2DM in Shekhan district, providing locally relevant evidence on gender-stratified metabolic outcomes.

In the current cohort, 64% of patients achieved adequate glycaemic control (HbA1c <7%), reflecting a moderate level of metabolic regulation. Although male patients demonstrated a higher proportion of good glycaemic control than females (71.8% vs. 59%), this difference was not statistically significant. This finding may be explained by the diminishing independent influence of gender on glycaemic outcomes once key clinical and therapeutic factors are considered (Gebeyaw and Lema, 2025). Recent evidence indicates that variables such as treatment intensity, medication adherence, duration of diabetes, and comorbidity burden exert a stronger effect on HbA1c levels than sex alone (Gebeyaw and Lema, 2025). Studies from comparable low- and middle-income settings have shown that apparent gender differences in glycaemic control often lose significance after adjustment for behavioural and disease-related determinants, suggesting that contemporary diabetes management outcomes are increasingly shaped by healthcare access and self-management practices rather than biological sex (Lema and Gebeyaw, 2025).

A notable finding of this study was the strong association between diabetes treatment modality and both glycaemic control and inflammatory status, particularly among female patients. Women receiving combined insulin and oral hypoglycaemic therapy exhibited significantly poorer glycaemic control and markedly higher CRP levels compared with those managed on oral agents alone ($p < 0.0001$). This pattern likely reflects more advanced disease and greater metabolic dysregulation rather than therapeutic inefficacy, as treatment escalation is commonly initiated in patients with prolonged disease duration, persistent hyperglycaemia, and progressive β-cell dysfunction (Li *et al*., 2023). In line with this, multicenter studies have reported that patients receiving combination therapy often present with elevated inflammatory markers, including CRP, consistent with advanced insulin resistance and chronic low-grade inflammation (Lim *et al*., 2024).

Among male patients, CRP levels did not demonstrate statistically significant associations with age, smoking status, or medication type, although non-significant elevations were observed among older individuals and smokers. However, glycaemic control among males was significantly associated with treatment modality, with poorer HbA1c outcomes observed in those receiving combined therapy. Similar patterns have been reported in large real-world cohorts, where treatment intensification reflects failure to achieve glycaemic targets and greater metabolic burden rather than an independent adverse effect of therapy (Zhang *et al*., 2025).

The majority of participants exhibited CRP levels within the normal range, supporting evidence that systemic inflammation is not uniformly present in all individuals with T2DM (Lee and Lee, 2023). Nevertheless, the identification of a subgroup-predominantly female patients receiving combined therapy-with significantly elevated CRP underscores the clinical relevance of inflammatory markers for cardiometabolic risk stratification. Recent studies have demonstrated that CRP provides incremental prognostic value beyond HbA1c, particularly in identifying patients at increased cardiovascular risk in resource-limited settings (Rolver *et al*., 2024).

Comorbidities were highly prevalent in this cohort, with hypertension and cardiovascular disease being the most frequently observed conditions. This clustering of cardiometabolic risk factors has been consistently reported in regional and global analyses of T2DM populations (Ferede *et al*., 2025). Such comorbidities contribute to systemic inflammation and complicate glycaemic control, thereby necessitating more intensive therapeutic strategies, as

emphasized in recent international diabetes management guidelines (Care and Suppl, 2022; Marx *et al*., 2023).

## V. Conclusions

Importantly, the findings of this study do not indicate uniform gender disparities in glycaemic control or inflammatory status. Rather, they reveal gender-specific patterns in the interaction between disease severity, treatment intensity, and inflammatory burden. Contemporary evidence suggests that gender influences diabetes outcomes indirectly through biological susceptibility, behavioral factors, healthcare utilization, and therapeutic pathways rather than through glycaemic indices alone (Consolazio and Giampiero, 2025).

## VI. Recommendations

Personalized diabetes management should consider individual characteristics such as comorbidities, medication response, and inflammatory status to optimize glycemic control and reduce complications. Patients on combined insulin and oral therapy require close monitoring, with medication adjustments as needed to improve outcomes. Lifestyle modifications, including a balanced diet, regular exercise, and smoking cessation, should be emphasized alongside medical treatment. Routine monitoring of HbA1c and CRP levels is essential for early detection of poor glycemic control and inflammation, allowing timely intervention. Further research is needed to explore gender differences, long-term effects of treatment regimens, and strategies to enhance diabetes management.

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