Health Problems of Civilization
eISSN: 2354-0265, ISSN: 2353-6942

ORIGINAL PAPER

GLYCEMIC CONTROL AND COMORBIDITIES IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A GENDER-BASED STUDY IN HEALTH FACILITIES OF DUHOK, IRAQ

Hozan Qasim Hussein[1(A,B,C,D,E,F,G)], **Hileen Mustafa Haji**[1(A,B,C,D)], **Milat Hussein Mustafa**[1(A,B,C)]

[1]Department of Medical Laboratory, Cihan University – Duhok, Duhok, Kurdistan Region, Iraq

Hussein HQ, Haji HM, Mustafa MH. Glycemic control and comorbidities in patients with type 2 diabetes mellitus: a gender-based study in health facilities of Duhok, Iraq. Health Prob Civil. https://doi.org/10.5114/hpc.2025.155551

Tables: 1
Figures: 5
References: 33
Submitted: 2025 Aug 1
Accepted: 2025 Oct 22

Address for correspondence: Hozan Qasim Hussein, Department of Medical Laboratory, Cihan University – Duhok, Hawshke Street, 42001 Duhok, Kurdistan Region, Iraq, e-mail: hozan.hussein@duhokcihan.edu.krd, phone: +964 750 233 4573

ORCID: Hozan Qasim Hussein https://orcid.org/0009-0006-6626-0069, Hileen Mustafa Haji https://orcid.org/0009-0005-5717-6263, Milat Hussein Mustafa https://orcid.org/0009-0004-0265-8882

Summary

Background. This study aimed to investigate gender-related differences in glycemic control and the prevalence of comorbidities among diabetic patients attending healthcare facilities in Duhok, Iraq. It also examined associations between treatment regimens, lifestyle factors, and glycemic outcomes.

Material and methods. A cross-sectional study was conducted from October 2024 to April 2025, enrolling 200 diabetic patients from the Duhok Diabetes Center and Azadi Teaching Hospital. Data collected included patient demographics, HbA1c values, diabetes treatment modalities, comorbid conditions, and lifestyle factors. Glycemic control was categorized as poor (HbA1c ≥ 7%) or good (HbA1c < 7%) based on the American Diabetes Association criteria.

Results. Overall, 52% of patients achieved good glycemic control (HbA1c < 7%), with no statistically significant difference between males (49.52%) and females (54.74%) (p=0.4612). In contrast, patients on combined insulin and oral hypoglycemic therapy showed significantly poorer glycemic control, with 95.65% of males and 93.75% of females in this group having HbA1c ≥ 7% (p<0.0001).

Conclusions. The study found no significant gender differences in glycemic control or the prevalence of comorbidities. The poorer glycemic outcomes observed in patients receiving combination therapy likely reflect more advanced or difficult-to-control disease.

Keywords: glycemic control, HbA1c, gender differences, comorbidities, diabetes mellitus

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent elevation in blood glucose levels due to insufficient insulin secretion, impaired insulin action, or a combination of both [1]. It remains one of the most prevalent non-communicable diseases worldwide and poses a significant global health challenge. According to recent projections, the number of individuals living with diabetes is expected to reach approximately 783 million by the year 2045 [2]. This growing prevalence is particularly concerning in low- and middle-income countries, where access to timely diagnosis, effective treatment, and long-term management is often inadequate [3].

Glycemic control, most commonly measured using glycated hemoglobin (HbA1c), plays a central role in reducing the risk of diabetes related complications [4]. Poor regulation

of blood glucose levels is known to accelerate the development of both microvascular and macrovascular complications, including diabetic nephropathy, neuropathy, retinopathy, and cardiovascular disease. Although pharmacological advances and lifestyle interventions have improved the therapeutic landscape for type 2 diabetes mellitus (T2DM), many patients, especially in developing regions, continue to struggle to achieve recommended glycemic targets [5].

Emerging research suggests that gender may influence the clinical course and outcomes of diabetes [6]. Some studies have reported that female patients with diabetes are more likely to experience poor glycemic control, potentially due to hormonal fluctuations, psychological stress, sociocultural barriers, and disparities in healthcare access [7,8]. On the other hand, male patients often present with a higher risk of macrovascular complications, possibly due to higher rates of central obesity, tobacco use, and reluctance to seek early medical care [9,10].

In Iraq, particularly in the Kurdistan Region and the province of Duhok, there is limited published data on gender related differences in glycemic control and the burden of comorbid conditions among diabetic patients. Studies from neighboring regions have shown that a significant proportion of individuals with T2DM have uncontrolled blood glucose levels and frequently suffer from comorbidities such as hypertension, dyslipidemia, obesity, and cardiovascular disease [11]. These health challenges are compounded by systemic issues including low health literacy, poor adherence to treatment regimens, limited access to follow-up services, and economic barriers to care [12].

Aim of the work

This study aimed to assess the level of glycemic control among adult patients with type 2 diabetes mellitus attending healthcare facilities in Duhok, Iraq. Specifically, it sought to identify the most prevalent comorbid conditions affecting these patients and to examine gender-related differences in glycemic control and comorbidity profiles. In addition, the study investigated associations between treatment regimens, lifestyle factors, and glycemic outcomes.

The findings of this research are expected to provide valuable insights for healthcare providers and policymakers, supporting the development of gender-sensitive and context-appropriate strategies for improving diabetes management in resource-limited settings.

Material and methods

Study setting

This study was conducted in the Duhok Governorate, Kurdistan Region of Iraq, across two diabetes-focused healthcare facilities: the Duhok Diabetes Center and the inpatient wards of Azadi Teaching Hospital. These centers serve as primary referral institutions for diabetes care in the region and provide access to a diverse patient population.

Study design and patients

A cross-sectional study was carried out between October 2024 and April 2025. A total of 200 adult patients (≥ 18 years) with a confirmed diagnosis of DM were enrolled. Inclusion criteria required informed consent and complete medical records. Patients using anti-inflammatory medications or who declined participation were excluded. No a priori sample size calculation was performed; instead, all eligible patients who attended the study sites during the study period and met the inclusion criteria were consecutively enrolled.

Data collection

Data was collected via structured interviews using a standardized questionnaire administered by trained staff. Information included demographic characteristics, duration of diabetes, type of treatment (oral agents, insulin, or combination therapy), HbA1c levels, comorbidities (e.g. hypertension, cardiovascular disease, obesity, chronic kidney disease), and lifestyle behaviors (e.g. smoking, physical activity, diet adherence).

Laboratory investigations

Venous blood samples (5 mL) were collected in EDTA tubes for HbA1c analysis using the DCR1000 BioZek analyzer and BioZek HbA1c test kits. HbA1c levels were interpreted according to the American Diabetes Association (ADA) 2023 guidelines: HbA1c ≥ 6.5% confirmed diabetes; values ≥ 7% indicated poor glycemic control, and < 7% denoted good control [13].

Figure 1 illustrates the blood sampling process used to measure blood sugar levels and HbA1c concentrations across different genders.

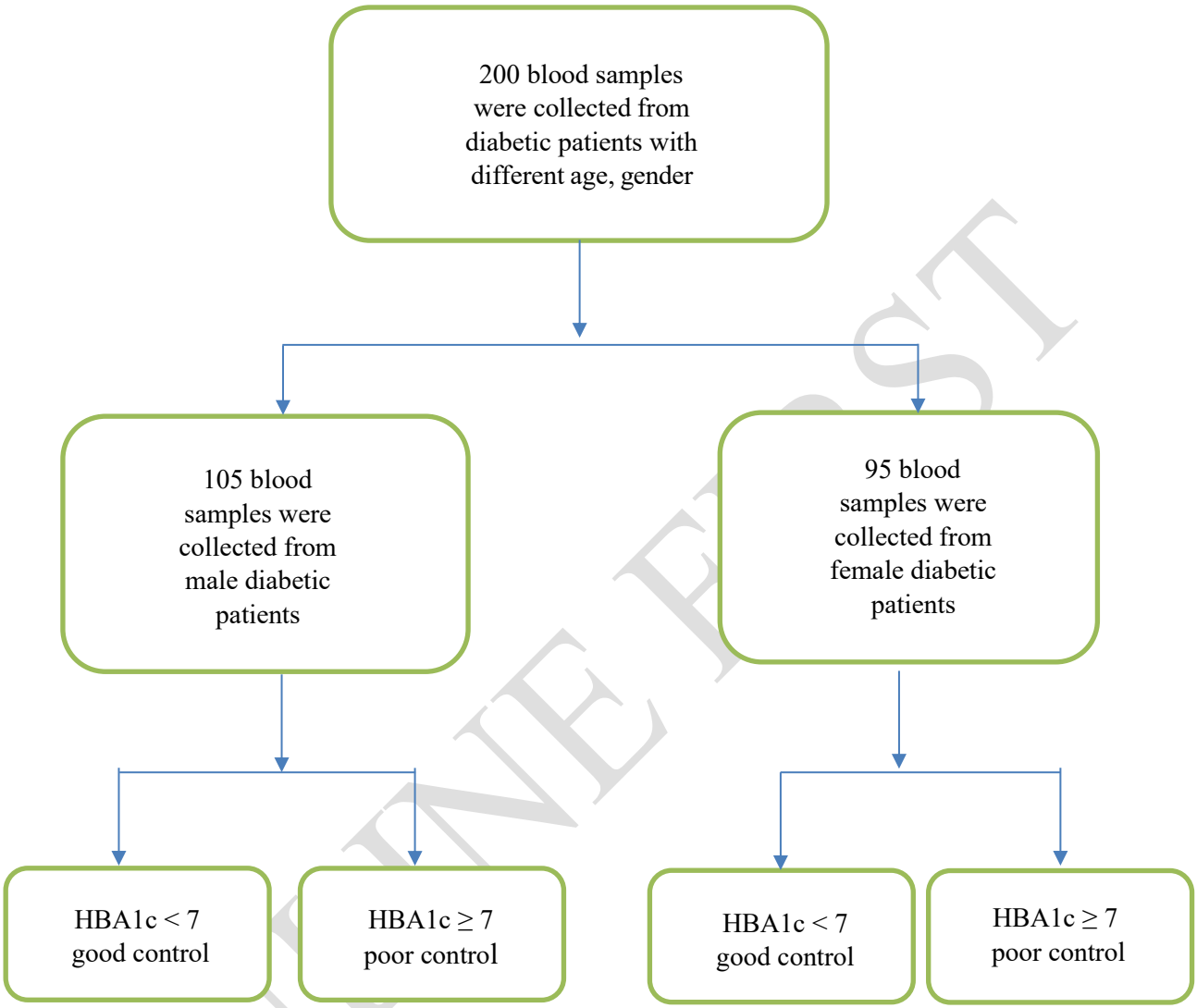

Figure 1. Blood sampling and methods used in this study

Statistical analysis

The general and medical characteristics of the patients with T2DM were presented in mean (SD) standard deviation for the continuous and number (%) for the nominal variables. The comparisons of the diabetes control between male and female patients and with different medical and general characteristics in male and female patients were examined using Pearson Chi-squared tests as appropriate. The significant level of difference was determined as $p<0.05$.

All analyses were performed using JMP® software (Version 18.0, SAS Institute Inc., Cary, NC, 1989-2023).

Results

A total of 200 adult patients with T2DM were included in the study, comprising 105 males (52.5%) and 95 females (47.5%). The mean age was 55.16±10.49 years, ranging from 21 to 79 years. Over half of the patients (55.5%) had been living with diabetes for more than 10 years, and 66.5% were treated with oral antidiabetic medications (Table 1).

Table 1. General and medical characteristics in patients with T2DM

General and medical characteristics (n=200)		Number	Percentage
Age (21-75 years)	**Std Err Mean: 0.74**	55.16	10.49
Age category	**20-29**	4	2.00
	30-39	7	3.50
	40-49	37	18.50
	50-59	82	41.00
	60-69	46	23.00
	70-79	24	12.00
Gender	**Male**	105	52.50
	Female	95	47.50
Antidiabetic type	**Insulin**	28	14.00
	Oral Medication	133	66.50
	Combined	39	19.50
HBA1c control	**Good**	104	52.00
	Poor	96	48.00
Comorbidities	**-**	149	74.50
Hypertension	**-**	105	52.50
Cardiovascular disease	**-**	48	24.00
Cerebrovascular disease	**-**	5	2.50
Chronic kidney disease	**-**	9	4.50
Chronic liver disease	**-**	4	2.00
Chronic pulmonary disease	**-**	3	1.50
Anemia	**-**	0	0
GIU laceration	**-**	6	3.00
Asthma	**-**	3	1.50
Thyroid disease	**-**	14	7.00
Obesity	**-**	12	6.00
Immunocompromised state	**-**	11	5.50
HIV infection	**-**	1	0.50
Malignancy	**-**	9	4.50
Smoking state	**-**	2	1.00
Diabetes duration	**Less than 1 year**	17	8.50
	1-5 years	36	18.00
	5-10 years	36	18.00
	More than 10 years	111	55.50
Medication adherence	**Rarely**	42	21.00

	Sometimes	98	49.00
	Always	60	30.00
Dietary management	**No**	39	19.50
	Yes	126	63.00
	Sometimes	35	17.50
Physical activity	**Never**	11	5.50
	Rare	104	52.00
	Sometimes	83	41.50
	Daily	2	1.00
Blood sugar monitoring	**Rarely**	73	36.50
	1-2 times per week	99	49.50
	3-4 times per week	27	13.50
	Daily	1	0.50
Family history	**No**	90	45.00
	Yes	108	54.00
	Unknown	2	1.00
Recent hospitalization	**-**	14	7.00

Table 2 and Figure 2 show the distribution of glycemic control among 200 diabetic patients based on HbA1c levels. Overall, 52% achieved good control. Good glycemic control was observed in 49.52% of males and 54.74% of females. The difference between genders was not statistically significant (p=0.4612).

Table 2. Level of glycemic control among different genders of diabetic patients using HbA1c levels

Gender (n=200)	**HBA1c Control no (%)**		***p***
	Good (n=104)	**Poor (n=96)**	
Male	52 (49.52)	53 (50.48)	0.4612
Female	52 (54.74)	43 (45.26)	

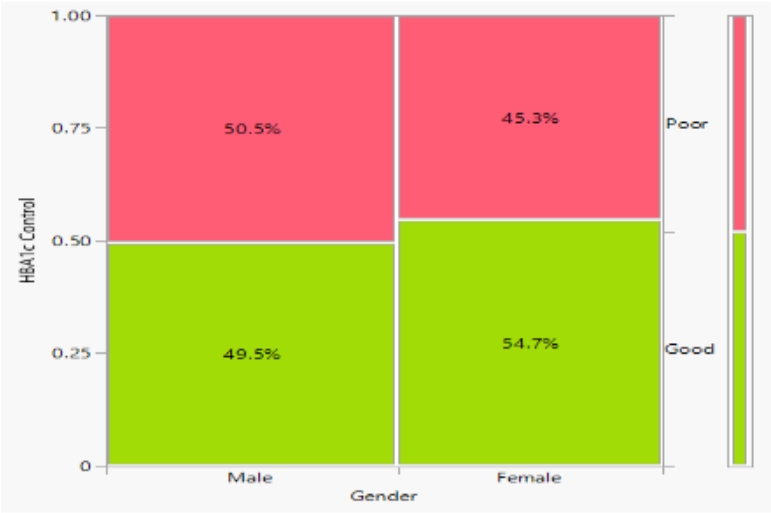

Figure 2. Mosaic plot of diabetes control between male and female patients

Comorbidities were highly prevalent, affecting 74.50% of the patients. Hypertension was the most common (52.50%), followed by cardiovascular disease (24.00%), thyroid disorders (7.00%), obesity (6.00%), and chronic kidney disease (4.50%). Table 3 presents the distribution of comorbidities among the study population.

Table 3. Comparisons of common comorbidities between male and female patients with T2DM

Comorbidities (n=200)	Gender		*p*
	Male	Female	
Comorbidities			
Yes	74 (70.48)	75 (78.95)	0.1699
No	31 (29.52)	20 (21.05)	
Hypertension			
Yes	50 (47.62)	55 (57.89)	0.1462
No	55 (52.38)	40 (42.11)	
Cardiovascular disease			
Yes	28 (26.67)	20 (21.05)	0.3532
No	77 (73.33)	75 (78.95)	
Cerebrovascular disease			
Yes	1 (0.95)	4 (4.21)	0.1928
No	104 (99.05)	91 (95.79)	
Chronic kidney disease			
Yes	3 (2.86)	6 (6.32)	0.3133
No	102 (97.14)	89 (93.68)	
Chronic liver disease			
Yes	3 (2.86)	1 (1.05)	0.6231
No	102 (97.14)	94 (98.95)	
Chronic pulmonary disease			
Yes	2 (1.90)	1 (1.05)	1.0000
No	103 (98.10)	94 (98.95)	
GIU laceration			
Yes	1 (0.95)	5 (5.26)	0.1039
No	104 (99.05)	90 (94.74)	
Asthma			
Yes	1 (0.95)	2 (2.11)	0.6051
No	104 (99.05)	93 (97.89)	
Thyroid disease			
Yes	4 (3.81)	10 (10.53)	0.0940
No	101 (96.19)	85 (89.47)	
Obesity			
Yes	3 (2.86)	9 (9.47)	0.0718
No	102 (97.14)	86 (90.53)	

When examining the association between treatment type and glycemic control, male patients on combined therapy (insulin and oral medications) had significantly poorer outcomes. Specifically, 93.55% of patients on combined therapy had poor control, compared to 49.62% on oral therapy and 46.43% on insulin alone ($p<0.0001$). Table 4 summarizes these findings.

Table 4. Differences in glycemic control and comorbidities in male patients

Characteristics (n=105)	HBA1c Control		*p*
	Good	Poor	
Age category			
20-29	1 (33.33)	2 (66.67)	
30-39	2 (50.00)	2 (50.00)	
40-49	5 (29.41)	12 (70.59)	0.4895
50-59	23 (51.11)	22 (48.89)	
60-69	11 (55.00)	9 (45.00)	
70-79	10 (62.50)	6 (37.50)	
Antidiabetic type			
Insulin	8 (53.33)	7 (46.67)	<0.0001
Oral medication	43 (64.18)	24 (35.82)	
Combined	1 (4.35)	22 (95.65)	
Comorbidities			
Yes	32 (43.24)	42 (56.76)	0.0467
No	20 (64.52)	11 (35.48)	
Hypertension			
Yes	24 (48.00)	26 (52.00)	0.7659
No	28 (50.91)	27 (49.09)	
Cardiovascular disease			
Yes	8 (28.57)	20 (71.43)	0.0096
No	44 (57.14)	33 (42.86)	
Cerebrovascular disease			
Yes	0 (0.00)	1 (100.00)	1.000
No	52 (50.00)	52 (50.00)	
Chronic kidney disease			
Yes	1 (33.33)	2 (66.67)	1.000
No	51 (50.00)	51 (50.00)	
Chronic liver disease			
Yes	1 (33.33)	2 (66.67)	1.000
No	51 (50.00)	51 (50.00)	
Chronic pulmonary disease			
Yes	0 (0.00)	2 (100.00)	0.4952
No	52 (50.49)	51 (49.51)	
GIU laceration			
Yes	1 (100.00)	0 (0.00)	0.4952
No	51 (49.04)	53 (50.96)	
Asthma			
Yes	0 (0.00)	1 (100.00)	1.000
No	52 (50.00)	52 (50.00)	
Thyroid disease			
Yes	2 (50.00)	2 (50.00)	1.000
No	50 (49.50)	51 (50.50)	
Obesity			
Yes	1 (33.33)	2 (66.67)	1.000
No	51 (50.00)	51 (50.00)	
Immunocompromised state			
Yes	2 (33.33)	4 (66.67)	0.6783
No	50 (50.51)	49 (49.49)	
Malignancy	0 (0.00)	4 (100.00)	0.1179

Yes **No**	52 (51.49)	49 (48.51)	
Smoking state **Yes** **No**	1 (50.00) 51 (49.51)	1 (50.00) 52 (50.49)	1.000
Diabetes duration **Less than 1 year** **1-5 years** **5-10 years** **More than 10 years**	7 (77.78) 9 (64.29) 8 (44.44) 28 (43.75)	2 (22.22) 5 (35.71) 10 (55.56) 36 (56.25)	0.1623
Medication adherence **Always** **Sometimes** **Rarely**	24 (80.00) 20 (37.74) 8 (36.36)	6 (20.00) 33 (62.26) 14 (63.64)	0.0004
Dietary management **No** **Yes** **Sometimes**	4 (17.39) 44 (67.69) 4 (23.53)	19 (82.61) 21 (32.31) 13 (76.47)	<0.0001
Physical activity **Never** **Rare** **Sometimes** **Daily**	1 (16.67) 16 (28.57) 33 (80.49) 2 (100)	5 (83.33) 40 (71.43) 8 (19.51) 0 (0.00)	<0.0001
Blood sugar monitoring **Rarely** **1-2 times per week** **3-4 times per week**	22 (51.16) 25 (50.00) 5 (41.67)	21 (48.84) 25 (50.00) 7 (58.33)	0.8407
Family history **No** **Yes** **Unknown**	28 (56.00) 24 (44.44) 0 (0.00)	22 (44.00) 30 (55.56) 1 (100)	0.3046
Recent hospitalization **Yes** **No**	4 (50.00) 48 (49.48)	4 (50.00) 49 (50.52)	1.0000

Lifestyle behaviors were found to strongly influence glycemic control in females. Among patients who reported always adhering to their medication regimen, 83.33% achieved good control. Similarly, those following dietary management and engaging in physical activity had significantly better glycemic outcomes (p<0.0001 for all). These results are shown in Table 5.

Table 5. Differences in glycemic control and comorbidities in female patients

Comorbidities (n=95)	**HBA1c control**		***p***
	Good	**Poor**	
Age category **20-29** **30-39** **40-49**	1 (100) 2 (66.67) 11 (55.00)	0 (0.00) 1 (33.33) 9 (45.00)	0.1885

50-59	16 (43.24)	21 (56.76)	
60-69	19 (73.08)	7 (26.92)	
70-79	3 (37.50)	5 (62.50)	
Antidiabetic type			
Insulin	7 (53.85)	6 (46.15)	<0.0001
Oral medication	44 (66.67)	22 (33.33)	
Combined	1 (6.25)	15 (93.75)	
Comorbidities			
Yes	38 (50.67)	37 (49.33)	0.1227
No	14 (70.00)	6 (30.00)	
Hypertension			
Yes	30 (54.55)	25 (45.45)	0.9649
No	22 (55.00)	18 (45.00)	
Cardiovascular disease			
Yes	11 (55.00)	9 (45.00)	0.9788
No	41 (54.67)	34 (45.33)	
Cerebrovascular disease			
Yes	2 (50.00)	2 (50.00)	1.000
No	50 (54.95)	41 (45.05)	
Chronic kidney disease			
Yes	2 (33.33)	4 (66.67)	0.4049
No	50 (56.18)	39 (43.82)	
Chronic liver disease			
Yes	0 (0.00)	1 (100)	0.4526
No	52 (55.32)	42 (44.68)	
Chronic pulmonary disease			
Yes	0 (0.00)	1 (100)	0.4526
No	52 (55.32)	42 (44.68)	
GIU laceration			
Yes	4 (80.00)	1 (20.00)	0.3731
No	48 (53.33)	42 (46.67)	
Asthma			
Yes	1 (50.00)	1 (50.00)	1.000
No	51 (54.84)	42 (45.16)	
Thyroid disease			
Yes	6 (60.00)	4 (40.00)	1.000
No	46 (54.12)	39 (45.88)	
Obesity			
Yes	2 (22.22)	7 (77.78)	0.0739
No	50 (58.14)	36 (41.86)	
Immunocompromised state			
Yes	4 (80.00)	1 (20.00)	0.3731
No	48 (53.33)	42 (46.67)	
HIV infection			
Yes	1 (100)	0 (0.00)	1.000
No	51 (54.26)	43 (45.74)	
Malignancy			
Yes	0 (0.00)	5 (100)	0.0166
No	52 (57.78)	38 (42.22)	
Diabetes duration			
Less than 1 year	2 (25.00)	6 (75.00)	
1-5 years	14 (63.64)	8 (36.36)	0.0375
5-10 years	6 (33.33)	12 (66.67)	
More than 10 years	30 (63.83)	17 (36.17)	

Medication adherence			
Always	25 (83.33)	5 (16.67)	
Sometimes	20 (44.44)	25 (55.56)	0.0006
Rarely	7 (35.00)	13 (65.00)	
Dietary management			
No	4 (25.00)	12 (75.00)	
Yes	42 (68.85)	19 (31.15)	<0.0001
Sometimes	6 (33.33)	12 (66.67)	
Physical activity			
Sometimes	35 (83.33)	7 (16.67)	
Rare	16 (33.33	32 (66.67)	0.0009
Never	1 (20.00)	4 (80.00)	
Blood sugar monitoring			
Rarely	13 (43.33)	17 (56.67)	
1-2 times per week	28 (57.14)	21 (42.86)	0.1724
3-4 times per week	11 (73.33)	4 (26.67)	
Daily	0 (0.00)	1 (100)	
Family history			
Yes	28 (51.85)	26 (48.15)	
No	23 (57.50)	17 (42.50)	0.5679
Unknown	1 (100)	0 (0.00)	
Recent hospitalization			
Yes	2 (33.33)	4 (66.67)	0.4049
No	50 (56.18)	39 (43.82)	

Discussion

T2DM represents a major global health burden with rising prevalence, particularly in low- and middle-income countries [14]. In Iraq, the reported prevalence of T2DM ranges from 8.5% (age-adjusted) to 13.9%, reflecting significant regional variation in risk factors, healthcare access, and diagnostic practices [15]. The present study examined gender-specific differences in glycemic control and associated comorbidities among adult T2DM patients attending healthcare facilities in Duhok, a province in the Kurdistan Region of Iraq. In the present cohort, 52.0% of participants achieved good glycemic control, defined as HbA1c < 7%. While females demonstrated a slightly higher proportion of control (54.74%) compared to males (49.52%), the difference was not statistically significant (p=0.4612). This gender-related pattern aligns partially with findings from the DiaCare survey conducted in Iran, where 28.74% of participants had controlled HbA1c, with females again showing a non-significant advantage (29.99% vs. 27.47%) [16]. Similarly, no significant gender differences in glycemic control among T2DM patients were reported in Türkiye, suggesting that sociocultural and healthcare delivery factors may influence diabetes management [17]. In contrast, a more recent study in Basrah, Southern Iraq, found that younger men (< 55 years) exhibited significantly higher HbA1c, fasting blood glucose, and triglyceride levels compared to women [18]. Moving farther

afield, a 2023 study in Debre Berhan, Ethiopia, involving 258 T2DM patients (129 males and 129 females), revealed that females had poorer glycemic control, with a mean HbA1c difference of 0.51% (95% CI: 0.04-0.97; p=0.032). Factors contributing to poor glycemic control in females included rural residence, diabetes duration > 5 years, and drug non-adherence [19].

Comorbidities were prevalent among our T2DM cohort, affecting 74.5% of patients, with a higher rate in females (78.95%) compared to males (70.48%), though not statistically significant (p=0.1699). This gender disparity may reflect gender-specific risk factors such as higher obesity prevalence, reduced physical activity, and hormonal influences that predispose females to metabolic complications [20]. Hypertension was the most common comorbidity (52.5%), consistent with regional estimates ranging from 50% to 60%, likely due to shared pathophysiological mechanisms including insulin resistance and vascular dysfunction [21]. Cardiovascular disease (24%) was the second most frequent comorbidity, comparable to findings from Türkiye, reflecting the vascular impact of chronic hyperglycemia [22]. Other comorbidities included thyroid disorders (7%), obesity (6%), and chronic kidney disease (4.5%). The relatively lower rates of chronic kidney disease and obesity may be due to underdiagnosis or reporting variation. Notably, obesity remains underrecognized despite its role in promoting insulin resistance and systemic inflammation. These findings underscore the importance of integrated care models to manage the multifactorial burden of T2DM [23].

Analysis of treatment strategies revealed that patients receiving combination therapy, comprising both insulin and oral hypoglycemic agents, exhibited significantly poorer glycemic control, with 93.75% (p<0.0001), compared to 46.15% and 33.33% of patients on insulin monotherapy and oral agents alone, respectively. This finding likely reflects the natural progression of disease severity necessitating intensified therapeutic regimens rather than a direct failure of the treatment itself. These observations are consistent with recent data from an East Asian observational cohort, which reported inferior glycemic outcomes among patients escalated to dual therapy compared to those maintained on monotherapy [24]. Furthermore, contemporary clinical guidelines advocate for early initiation of combination therapy to preserve β-cell function and enhance glycemic durability, particularly in individuals demonstrating suboptimal response to monotherapy [25,26].

Furthermore, lifestyle behaviors were found to exert a significant influence on glycemic outcomes. Patients adhering consistently to prescribed pharmacologic regimens, dietary recommendations, and physical activity demonstrated markedly improved glycemic control

(p<0.0001). Among adherent males and females, 80% and 83.33%, respectively, achieved target HbA1c levels. These findings align with a large-scale cohort study from China that underscored the role of self-care behaviors in achieving glycemic stability among T2DM patients [27]. A similar pattern was observed in a Kurdish population in Erbil, Iraq, where lifestyle modifications and medication adherence significantly correlated with improved glycemic profiles [28].

Although a trend toward poorer glycemic control was observed in patients with diabetes duration exceeding 10 years, this did not reach statistical significance. This trend aligns with extant literature documenting progressive β-cell dysfunction and increasing insulin resistance over time, which collectively complicate long-term glycemic management in T2DM patients [29].

Notably, the presence of malignancy was significantly associated with suboptimal glycemic control among female patients (p=0.0166). This association is in agreement with emerging evidence describing a bidirectional relationship between diabetes and cancer, wherein chronic hyperglycemia and systemic inflammation may exacerbate tumor progression and disrupt glucose metabolism [30,31]. Nonetheless, the limited sample size necessitates further investigation in larger cohorts to validate this finding.

This study has several limitations. First, no a priori sample size estimation was performed, which may have reduced the statistical power to detect some associations and limits the generalizability of the findings beyond the studied population. Second, some subgroup analyses, such as those involving malignancy, asthma, and HIV infection, were based on very small patient numbers (n=1-5). These findings should therefore be interpreted with caution and regarded as exploratory rather than confirmatory. Future studies with larger, adequately powered samples are needed to validate these observations.

In summary, these findings highlight the multifactorial drivers of glycemic control among patients with T2DM in Duhok, Iraq. While gender differences were minimal, several key factors were significantly associated with poorer outcomes: treatment regimen, behavioral adherence, disease duration, the presence of comorbidities especially malignancies and inadequate lifestyle modifications. Notably, emerging evidence underscores that suboptimal glycemic control in cancer patients is linked to higher mortality and treatment-related complications [32].These results support the need for personalized therapeutic strategies, structured lifestyle interventions, and proactive screening for comorbidities to align diabetes care with international guidelines while addressing region-specific challenges [33].

Conclusions

This study highlights key findings on glycemic control and comorbidities among T2DM patients in Duhok. Overall, 52% achieved good glycemic control (HbA1c < 7%), with no significant gender differences. However, patients on combined insulin and oral therapies had poorer control, indicating management difficulties in advanced cases. Comorbidities were prevalent (74.5%), particularly hypertension (52.5%). Better glycemic outcomes were associated with medication adherence and dietary management. Tailored treatment plans, especially for those on intensive therapies, and regular follow-up are essential. Integrating lifestyle education and routine comorbidity screening into care is recommended. Future research should address gender-specific trends and long-term outcomes to guide more effective, individualized diabetes management strategies.

Disclosures and acknowledgements

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Ethical approval was obtained from the General Directorate of Health in Duhok (Reference no. 144, dated January 27, 2025).

Artificial intelligence (AI) was not used in the creation of the manuscript.

References:

1. Chandrasekaran P. The role of obesity in type 2 diabetes mellitus – an overview. Mol Sci. 2024; 25: 1-21. https://doi.org/10.3390/ijms25031882
2. Murtaza G, Riaz S, Zafar M, Raza MA, Kaleem I, Imran H, et al. Examining the growing challenge: prevalence of diabetes in young adults (Review). Med Int. 2025; 5(1): 1-8. https://doi.org/10.3892/mi.2024.201
3. Kropp M, Golubnitschaja O, Mazurakova A, Koklesova L, Sargheini N. Diabetic retinopathy as the leading cause of blindness and early predictor of cascading

complications – risks and mitigation. EPMA J. 2023; 14: 21-42. https://doi.org/10.1007/s13167-023-00314-8

4. Amsalu H, Hailu M, Asefa A, Ayenew M. The effect of lifestyle factors on chronic complications of diabetes at public health hospitals in Southwest Ethiopia. Sci Rep. 2024; 14: 1-9. https://doi.org/10.1038/s41598-024-69527-9
5. Zhu XY, Shi MQ, Jiang ZM, Li X, Tian JW, Su FF. Global, regional, and national burden of cardiovascular diseases attributable to metabolic risks across all age groups from 1990 to 2021: an analysis of the 2021 global burden of disease study data. BMC Public Health. 2025; 25: 1-21. https://doi.org/10.1186/s12889-025-22702-7
6. Marassi M, Cignarella A, Russo GT, Nollino L, Strazzabosco M, Marzullo P, et al. Sex differences in the weight response to GLP-1RA in people with type 2 diabetes. A long-term longitudinal real-world study. Int J Mol Sci. 2025; 219(April): 1-9. https://doi.org/10.1016/j.phrs.2025.107866
7. Ciarambino T, Crispino P, Leto G, Mastrolorenzo E, Para O, Giordano M. Influence of gender in diabetes mellitus and its complication. Int J Mol Sci Rev. 2022; 23(16): 1-13. https://doi.org/10.3390/ijms23168850
8. Jaza H, Salh H, Aziz TA, Ahmed ZA. Association between albuminuria, glycated hemoglobin with comorbidities in type 2 diabetes patients: experience in Sulaimani City, Iraq. Al-Rafidain J Med Sci. 2024; 6(1): 1-8. https://doi.org/10.54133/ajms.v6i1.380
9. Alrubaiee GG. Prevalence of chronic diabetic complications and associated risk factors among follow-up diabetic patients: estimates from a referral national diabetes center in Yemen. BMC Endocr Disord. 2025 ;25(68): 1-11. https://doi.org/10.1186/s12902-025-01893-5
10. Zakir M, Ahuja N, Surksha MA, Sachdev R, Kalariya Y, Nasir M, et al. Cardiovascular complications of diabetes : from microvascular to macrovascular pathways. Cureus. 2023; 15(9): 1-14. https://doi.org/10.7759/cureus.45835
11. Caycho-Rodríguez T, Vilca LV, Corrales-Reyes IE, Hernández-García F, Pupo Pérez A, González Quintana P, et al. COVID-19 contagion concern scale (PRE-COVID-19): Validation in Cuban patients with type 2 diabetes. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2021; 15(5): 102245. https://doi.org/10.1016/j.dsx.2021.102245

12. Yedjou CG, Sims JN, Njiki S, Chitoh AM, Cherkos AS, Tchounwou PB. Health and racial disparities in diabetes mellitus prevalence, management, policies, and outcomes in the United States. PMC. 2024; 8(3): 1-27. https://doi.org/10.29011/2577-2228.100460
13. Care D, Suppl SS, Brown FM, Bruemmer D, Collins BS, Cusi K, et al. Introduction and methodology: standards of care in diabetes – 2023. Diabetes Care. 2023; 46(1): 1-4.
14. Rob A, Hoque A, Asaduzzaman M, Ali M, Khatoon A, Thomas D, et al. The global challenges of type 2 diabetes. Bangladesh J Med. 2025; 36(2): 92-98. https://doi.org/10.3329/bjm.v36i2.78406
15. Abusaib M, Ahmed M, Nwayyir HA, Alidrisi HA, Al-Abbood M, Al-Bayati A, et al. Iraqi experts consensus on the management of type 2 diabetes/prediabetes in adults. Clin Med Insights Endocrinol Diabetes. 2020; 13: 1-11. https://doi.org/10.1177/1179551420942232
16. Shafiee G, Gharibzadeh S, Panahi N, Razi F, Arzaghi SM, Haghpanah V, et al. Management goal achievements of diabetes care in Iran: study profile and main findings of DiaCare survey. J Diabetes Metab Disord. 2023; 22(1): 355-366. https://doi.org/10.1007/s40200-022-01149-2
17. Ali J, Muhammad S, Haider S, Ali SM, Haider T, Anwar A, et al. Overall clinical features of type 2 diabetes mellitus with respect to gender. J Diabetes Metab Disord. 2023; 15(3). https://doi.org/10.7759/cureus.35771
18. Alidrisi HA, Al-ibadi AA, Al-saidi JS, Alsawad MA, Jameel AA, Al-shati AW. Comparative analysis of glycemic and lipid profiles in newly diagnosed males and females with type 2 diabetes mellitus. Cureus. 2023; 15(12): 6-13. https://doi.org/10.7759/cureus.50101
19. Wondm SA, Zeleke TK, Dagnew SB, Moges A, Tarekegn GY, Belachew EA. Association between self-care activities and glycemic control among patients with type 2 diabetes mellitus in Northwest Ethiopia general hospitals: a multicenter cross-sectional study. Sci Rep. 2024; 14(1): 1-15. https://doi.org/10.1038/s41598-024-72981-0
20. Kautzky-Willer A, Leutner M, Harreiter J. Sex differences in type 2 diabetes. Diabetologia. 2023; 66: 986-1002. https://doi.org/10.1007/s00125-023-05891-x

21. Al-Rubaye AAH. Risk factors of hypertension in Basra governorate. Intern ional J Biosci Biochem. 2024; 6(1): 102-107. https://doi.org/10.33545/26646536.2024.v6.i1b.69
22. Ülgü MM, Gülkesen KH, Akünal A, Ayvalı MO, Zayim N, Birinci Ş, et al. Characteristics of diabetes mellitus patients in Turkey: an analysis of national electronic health records. Turkish J Med Sci. 2023; 53(1): 316-322. https://doi.org/10.55730/1300-0144.5587
23. Ruze R, Liu T, Zou X, Song J, Chen Y, Xu R, Yin X, et al. Obesity and type 2 diabetes mellitus: connections in epidemiology, pathogenesis. Front Endocrinol (Lausanne). 2023; 14: 1-23. https://doi.org/10.3389/fendo.2023.1161521
24. Xie X, Wu C, Hao Y, Wang T. Benefits and risks of drug combination therapy for diabetes mellitus and its complications: a comprehensive review. Front Endocrinol (Lausanne). 2023; 14: 1-17. https://doi.org/10.3389/fendo.2023.1301093
25. Kim JY, Kim NH. Initial combination therapy in type 2 diabetes. Endocrinol Metab. 2024; 39(1): 23-32. https://doi.org/10.3803/EnM.2023.1816
26. Davies MJ, Aroda VR, Collins BS, Gabbay RA, Green J, Maruthur NM, et al. Consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD) management of hyperglycemia in type 2 diabetes, 2022. Diabetes Care. 2022; 45(11): 2753-2786. https://doi.org/10.2337/dci22-0034
27. Che M, Zhou Q, Lin W, Yang Y, Sun M, Liu X, et al. Healthy lifestyle score and glycemic control in type 2 diabetes mellitus patients: a city-wide survey in China. Healthcare. 2023; 11(14): 1-12. https://doi.org/10.3390/healthcare11142037
28. Al-Chawishli S, Dizaye K, Azeez S. Measuring diabetic medication adherence and factors that lead to non-adherence among patients in Erbil. Cureus. 2024; 16(9): 1-20. https://doi.org/10.7759/cureus.70397
29. Reed J, Bain S, Kanamarlapudi V, Bain S. A review of current trends with type 2 diabetes epidemiology, aetiology, pathogenesis, treatments and future perspectives. Diabetes Metab Syndr Obes. 2021; 14: 3567-3602. https://doi.org/10.2147/DMSO.S319895
30. Andersson E, Brådvik G, Nilsson FOL, Arpegård J, Strambi A. Prevalence of diabetes and hospitalization due to poor glycemic control in people with bladder cancer or renal

cell carcinoma in Sweden. BMC Urol. 2024; 24: 1-12. https://doi.org/10.1186/s12894-024-01536-2

31. Szablewski L. Insulin resistance: the increased risk of cancers. Curr Oncol. 2024; 31(2): 998-1027. https://doi.org/10.3390/curroncol31020075
32. Yahaya JJ, Doya IF, Morgan ED, Ngaiza AI, Bintabara D. Poor glycemic control and associated factors among patients with type 2 diabetes mellitus: a cross-sectional study. Sci Rep. 2023; 13(1): 1-10. https://doi.org/10.1038/s41598-023-36675-3
33. Rosenfeld RM, Grega ML, Karlsen MC, Moain A, Dabrh A, Aurora RN, et al. Lifestyle interventions for treatment and remission of type 2 diabetes and prediabetes in adults: a clinical practice guideline from the American College of Lifestyle Medicine. American Journal of Lifestyle Medicine. 2025; 19(2 suppl): 10S-131S. https://doi.org/10.1177/15598276251325488