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# Urban-Rural Disparities in Glycaemic Control and Cardiometabolic Risk Among Patients with Type 2 Diabetes Mellitus.

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**Name of Author:**
Bibi Hajira Ishaq[1],Natasha Junaid[2],Zahid Sarfaraz Khan[3],Sobia Ali[4],Shah Nawaz[5],Rab Nawaz[6]

***Affiliation:***.
*[1]Assistant Professor, Department of Biochemistry, Khyber Medical College, Peshawar*
*[2]Assistant Professor, Khyber Medical College, Peshawar*
*[3]Associate Professor, Department of Anatomy, Khyber Girls Medical College, Peshawar*
*[4]Assistant Professor, Department of Biochemistry, Khyber Medical College, Peshawar*
*[5]Prof Department of Biochemistry, Nowshera Medical College, Nowshera*
*[6]Prof Community Medicine, PIMC Peshawar.*

***Corresponding Author:***
Dr. Shah Nawaz
Email:sudaiskhattak68@gmail.com

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***Abstract:*** **Objectives:** To compare glycaemic control and cardiometabolic risk factors between patients with type 2 diabetes mellitus from urban and rural areas and identify factors that were associated with poor glycaemic control. **Study Design:** A comparative cross-sectional study. **Place and Duration of the Study:** Jan 2025 to June 2025 six months. **Methodology:** A comparative cross-sectional study was carried out among 100 patients with Type 2 Diabetes Mellitus at Khyber Medical College/Khyber Teaching Hospital, Peshawar. A consecutive sampling technique was used to select participants, and they were divided into urban and rural residents. Demographic and clinical data were collected, such as age, sex, diabetes duration, BMI, blood pressure, and treatment history. Laboratory tests performed included fasting blood glucose, glycated hemoglobin (HbA1c), lipid profile, and other biochemical tests as appropriate. We assessed poor glycaemic control and used the following parameters to assess cardiometabolic risk: obesity, hypertension, dyslipidemia, and glycaemic status. Data were analyzed using SPSS, and a p-value $< 0.05$ was considered statistically significant. **Results:** Of the 100 patients, 50 were from urban areas and 50 from rural areas. The overall mean age of participants was 52.8 ± 10.6 years. Urban patients had a mean age of 51.9 ± 10.2 years, compared with 53.7 ± 11.0 years among rural patients (p=0.39). Poor glycaemic control was observed more frequently among rural participants than urban participants. The mean HbA1c was 8.4 ± 1.6% in rural patients compared with 7.7 ± 1.4% in urban patients (p=0.028). Similarly, rural participants had higher mean fasting blood glucose levels (178.6 ± 48.7 mg/dL) than urban participants (161.3 ± 43.5 mg/dL; p=0.071). Hypertension was present in approximately 60% of participants, while obesity and dyslipidemia were also common. Rural patients demonstrated a higher prevalence of uncontrolled hypertension (64% vs. 48%; p=0.101) and dyslipidemia (58% vs. 40%; p=0.071). Overall cardiometabolic risk was significantly greater among rural patients (p=0.032). Longer diabetes duration was also associated with poorer glycaemic control (p=0.018). These findings indicate clinically important urban-rural differences, particularly regarding HbA1c and overall cardiometabolic risk. **Conclusion:** Poor glycaemic control among patients with type 2 diabetes mellitus was observed in rural patients compared to urban patients, along with a higher burden of cardiometabolic risk factors. The findings indicate a high prevalence of elevated HbA1c levels, hypertension, and dyslipidemia, which emphasizes the need for targeted diabetes care in rural areas. Enhancing screening, health education, frequent biochemical monitoring, and access to appropriate treatment can help reduce geographical disparities and improve long-term diabetes outcomes for underserved populations.

***Keywords:*** Type 2 Diabetes; Glycaemic Control; Cardiometabolic Risk; Urban-Rural Disparities

## INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic condition in which blood glucose is continually increased due to reduced insulin production, insulin resistance, or a combination of both. It is one of the most significant non-communicable diseases globally and is linked to significant morbidity, premature mortality, and healthcare costs. Rapid urbanization, alteration of dietary patterns, physical inactivity, population aging, and socioeconomic inequalities are leading to an ever-increasing burden of T2DM, especially in low- and middle-income countries. Diabetes has become a significant public health issue in Pakistan, impacting urban and rural regions alike, and straining health systems to capacity [1]. A key part of diabetes management is achieving good glycaemic control, as long-term hyperglycemia increases the risk of microvascular and macrovascular complications. Glycated hemoglobin (HbA1c) is a good indicator of long-term glycaemic control, which reflects the average blood glucose level over the past few months. However, although it is known which patients with T2DM should receive which drugs and the recommended targets for glycaemic control, a significant portion of patients do not achieve the targets, poor glycaemic control can be due to inadequate treatment, poor adherence to treatment, late seeking of health care services, low level of disease awareness, food habits, physical inactivity, and lack of regular monitoring and follow-up [2,3]. Patients with T2DM are also likely to have other cardiometabolic risk factors such as obesity, hypertension, dyslipidemia, and central adiposity. These all add significantly to the risk of cardiovascular disease, one of the most common causes of death among people with diabetes. In addition to clinical factors, socioeconomic, environmental, and health system factors also impact cardiometabolic risk. Hence, the broader cardiometabolic profile of individuals with diabetes needs to be assessed in addition to HbA1c [4]. Differences between urban and rural areas could be important in predicting diabetes-related outcomes. Urban populations may also be more exposed to a sedentary lifestyle, calorie-rich foods, obesity, and other metabolic risk factors. On the other hand, rural people may face greater challenges accessing health care, less access to specialist services, poorer laboratory capabilities, lower health literacy, difficulty obtaining medications, and fewer opportunities for routine diabetes monitoring. Contrasting effects can lead to significant differences in glycaemic control and cardiometabolic risk between urban and rural populations. The size and direction of these differences can, however, vary depending on local socio-economic and health care circumstances [5]. Pakistan is an interesting context for exploring these differences. Most health facilities are found in urban centers, but rural communities make up a significant percentage of the nation's population. In rural areas, tertiary health care may be far from patients, causing delays in diagnosis, limited follow-up, and poor control of chronic diseases. At the same time, urban dwellers may also be more likely to adopt sedentary lifestyles and unhealthy food consumption patterns. Understanding how these factors affect diabetes outcomes is important for developing context-specific approaches to prevention and management [6].In contrast, relatively little research has directly compared glycaemic control and cardiometabolic risk between urban and rural patients in the same clinical context, particularly in T2DM. This gap is particularly relevant when comparing glycaemic control and cardiometabolic risk between urban and rural populations within the same clinical setting, particularly in T2DM. Identifying disparities can help clinicians and health planners determine the need for additional support and allocate resources. Differences can be assessed by considering demographic and clinical factors in addition to HbA1c, blood glucose, blood pressure, body mass index, and lipid parameters [7,8]. Hence, the current study aimed to assess the urban-rural differences in glycaemic control and cardiometabolic risk among people with T2DM. This study aimed to identify whether clinically significant differences in glycaemic control and cardiometabolic risk factors exist between groups of patients when compared by place of residence. The results could offer locally relevant data to support intensified diabetes screening, monitoring, health education, and targeted interventions for diabetes management, especially for those with higher barriers to optimal diabetes management [9].

## Material and Methods

This comparative cross-sectional study, conducted at the Department of Biochemistry, Khyber Medical College, Peshawar, from January to June 2025, included 100 patients with type 2 diabetes mellitus (T2DM) to evaluate differences in glycaemic control and cardiometabolic risk between urban and rural patients. The study was carried out at Khyber Medical College/Khyber Teaching Hospital, Peshawar, after approval from the Institutional Research and Ethical Review Board (IREB), Khyber Medical College. This protocol received ethical approval on 03 September 2024 with approval number 608/DME/KMC. Adult patients (18 years or older) with a confirmed diagnosis of T2DM were included using consecutive sampling. Patients were divided into two groups based on place of residence: urban (n=50) and rural (n=50). Excluded were type 1 diabetes mellitus, gestational diabetes, pregnancy, acute severe illness, malignancy, severe hepatic disease, end-stage renal disease, and diseases with a significant effect on metabolic parameters.

Demographic and clinical data were collected via a structured questionnaire, with written informed consent obtained. Collected data included age, sex, residential status, duration of diabetes, family history, medication use, smoking status, physical activity, and pertinent medical history. Weight, height, and Body Mass Index (BMI) were measured. Blood pressure was obtained after a proper rest period using a well-standardized apparatus. Venous blood samples were obtained after an appropriate fast. Laboratory tests performed included fasting blood glucose, glycated hemoglobin (HbA1c), total cholesterol, triglycerides, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol. HbA1c was the main indicator of glycaemic control; high cardiometabolic risk: urban 42%, rural 64%, p=0.032. We used SPSS version 26.0 for data entry and analysis. Continuous variables were expressed as mean ± SD, and categorical variables as frequencies and percentages. We used an independent-samples t-test to compare continuous variables between urban and rural groups, and the chi-square or Fisher's exact test for categorical variables. Results were statistically significant at $p < 0.05$. Study participants were kept anonymous throughout the study.

## Results

We included 100 patients with type 2 diabetes mellitus, comprising 50 urban and 50 rural residents. The overall mean age of participants was 52.8 ± 10.6 years. The mean age was 51.9 ± 10.2 years among urban patients and 53.7 ± 11.0 years among rural patients, with no significant difference between groups (p=0.39). Rural patients had poorer glycaemic control than urban patients. The mean HbA1c was 8.4 ± 1.6% in rural participants compared with 7.7 ± 1.4% in urban participants (p=0.028). Mean fasting blood glucose was also higher among rural patients (178.6 ± 48.7 mg/dL) than among urban patients (161.3 ± 43.5 mg/dL), although this difference was not statistically significant (p=0.071). Hypertension was observed in 64% of rural and 48% of urban participants (p=0.101). Dyslipidemia was more frequent among rural patients (58% vs. 40%; p=0.071). Overall cardiometabolic risk was significantly higher among rural participants (p=0.032). Longer duration of diabetes was also significantly associated with poorer glycaemic control (p=0.018). These findings demonstrate important urban-rural disparities, particularly in HbA1c and overall cardiometabolic risk among patients with T2DM.

**Table 1. Demographic and Clinical Characteristics of Patients with Type 2 Diabetes Mellitus**

| Variable | Urban (n=50) | Rural (n=50) | Total (n=100) | p-value |
|---|---|---|---|---|
| Age (years), mean ± SD | 51.9 ± 10.2 | 53.7 ± 11.0 | 52.8 ± 10.6 | 0.390 |
| Male sex, n (%) | 29 (58.0) | 27 (54.0) | 56 (56.0) | 0.689 |
| Duration of diabetes (years), mean ± SD | 7.1 ± 4.2 | 8.3 ± 4.7 | 7.7 ± 4.5 | 0.184 |
| BMI (kg/m²), mean ± SD | 27.8 ± 4.1 | 28.6 ± 4.5 | 28.2 ± 4.3 | 0.356 |
| Hypertension, n (%) | 24 (48.0) | 32 (64.0) | 56 (56.0) | 0.101 |
| Current smoking, n (%) | 11 (22.0) | 13 (26.0) | 24 (24.0) | 0.640 |
| Family history of diabetes, n (%) | 31 (62.0) | 35 (70.0) | 66 (66.0) | 0.398 |
| Physical inactivity, n (%) | 22 (44.0) | 31 (62.0) | 53 (53.0) | 0.071 |

BMI = body mass index; SD = standard deviation. Data are presented as frequency (%) or mean ± SD. Comparisons were performed using the independent-samples t-test or chi-square test, as appropriate. A p-value <0.05 was considered statistically significant.

**Table 2. Comparison of Glycaemic and Cardiometabolic Parameters Between Urban and Rural Patients**

| Parameter | Urban (n=50) | Rural (n=50) | Total (n=100) | p-value |
|---|---|---|---|---|
| Fasting blood glucose (mg/dL), mean ± SD | 161.3 ± 43.5 | 178.6 ± 48.7 | 169.9 ± 46.6 | 0.071 |
| HbA1c (%), mean ± SD | 7.7 ± 1.4 | 8.4 ± 1.6 | 8.05 ± 1.5 | 0.028 |
| Total cholesterol (mg/dL), mean ± SD | 192.4 ± 38.6 | 201.7 ± 42.1 | 197.1 ± 40.4 | 0.255 |
| Triglycerides (mg/dL), mean ± SD | 174.8 ± 65.2 | 190.6 ± 71.4 | 182.7 ± 68.5 | 0.249 |
| LDL-C (mg/dL), mean ± SD | 112.5 ± 29.4 | 119.8 ± 32.6 | 116.2 ± 31.1 | 0.242 |
| HDL-C (mg/dL), mean ± SD | 44.1 ± 9.2 | 41.7 ± 8.7 | 42.9 ± 9.0 | 0.180 |
| Dyslipidemia, n (%) | 20 (40.0) | 29 (58.0) | 49 (49.0) | 0.071 |
| Poor glycaemic control, n (%) | 27 (54.0) | 36 (72.0) | 63 (63.0) | 0.047 |
| High cardiometabolic risk, n (%) | 21 (42.0) | 32 (64.0) | 53 (53.0) | 0.032 |

HbA1c = glycated hemoglobin; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; SD = standard deviation. Data are presented as frequency (%) or mean ± SD. Statistical comparisons were performed using the independent-samples t-test or chi-square test, as appropriate. p<0.05 was considered statistically significant.

## DISCUSSION

This study shows significant differences in glycaemic control and cardiometabolic risk between urban and rural patients with type 2 diabetes mellitus (T2DM). Among these 100 patients, the rural group had significantly higher mean HbA1c than the urban group (8.4 ± 1.6% vs. 7.7 ± 1.4%, p=0.028). Rural patients also exhibited higher fasting blood glucose, hypertension, dyslipidemia, and overall cardiometabolic risk. The results indicate that residential neighborhood and access to health care could be associated with diabetes management and metabolic outcomes [10]. These findings align with recent studies showing that geographical disparities remain a key factor in diabetes outcomes in LMICs. Studies published in the past five years reported that patients in rural or underserved areas may have less access to physicians, lab testing, diabetes education, and ongoing monitoring [11]. These barriers can hinder treatment adjustments and adherence to prescribed treatments. Across Pakistan, these differences could be especially important since specialist diabetes services and diagnostic services are more likely to be available in large cities [12]. The average HbA1c difference reported between the two groups is clinically significant. The absolute difference was less than 1%, but a higher proportion of patients with poor glycaemic control were rural patients. More recent studies have also highlighted the importance of socioeconomic disadvantage, health literacy, medication accessibility, and health care utilization in the inability to reach target HbA1c levels [13]. Poor glycaemic control is especially significant as hyperglycemia leads to an increased risk of diabetic complications and cardiovascular morbidity. Thus, improving access to routine HbA1c testing and optimizing treatment in rural communities may improve long-term outcomes [14]. This study also found a greater burden of cardiometabolic risk among rural participants. 64% of rural patients and 48% of urban patients had hypertension, whereas 58% and 40% of them had dyslipidemia, respectively [15]. There were no significant differences between groups for hypertension and lipid abnormalities, but the overall cardiometabolic risk was significantly higher in the rural group (p=0.032). Recent research has shown that the presence of clustering of hyperglycemia, hypertension, obesity, and dyslipidemia significantly elevates cardiovascular risk in T2DM patients [16]. Our results thus corroborate the notion that diabetes management should be based on assessing cardiovascular risk factors, not only on glucose levels. Interestingly, the urban group did not have consistently better metabolic features. Increased sedentary behavior, increased consumption of energy-dense foods, obesity, and other metabolic risk factors are often linked to urbanization. So, there can be significant cardiometabolic problems for urbanites as well. This may explain why BMI changes were not as significant between groups in our study as they might have been. But rural participants were more physically inactive, which may have led to their poorer glycaemic profile. These results emphasize that diabetes control is complex, and residents' living conditions are linked to lifestyle, socioeconomic factors, access to care, and diabetes duration [17,18]. Another finding was that diabetes duration correlated with poor glycaemic control (p=0.018), which is also reported in recent literature [19]. As the disease progresses, it may become harder to control glycemia because of progressive deterioration of pancreatic β-cell function, increasing treatment needs, and the development of diabetes-related complications. This highlights the need for early diagnosis and ongoing disease management [20]. A few caveats should be noted. However, the cross-sectional design does not allow causal conclusions, and the relatively small sample of 100 patients at one center may limit generalizability. Residential and lifestyle self-report may also cause reporting bias. The study, however, offers clinically relevant evidence of disparities in diabetes outcomes between urban and rural areas, supporting targeted intervention. Further multicenter research involving more individuals and longer follow-up is needed to understand which socioeconomic, behavioral, and health-care-access factors drive these differences [21,22].

## CONCLUSION

Patients with type 2 diabetes mellitus in rural areas were less well controlled and had higher overall cardiometabolic risk compared to those in urban areas. The results suggest a need for better diabetes services in rural areas, more frequent metabolic monitoring, patient education, access to medication, and targeted interventions to help reduce the urban-rural divide and improve long-term clinical outcomes.

**Declarations**

**Ethical Approval**

Ethical approval was obtained from the Institutional Review and Ethics Board (IREB) of Khyber Medical College, Peshawar, Pakistan, in September 2024. The Board reviewed and approved the research protocol titled “Urban-Rural Disparities in Glycemic Cardiometabolic Risk Among Patients with Type 2 Diabetes Mellitus.” Written informed consent was obtained from all participants.

**Informed Consent**

We obtained written informed consent from all participants before enrollment. Participants were informed about the study objectives, procedures, potential benefits, and their right to participate voluntarily or withdraw at any time without affecting their medical care. Confidentiality and privacy of all

participants were strictly maintained, and personal identifying information was not disclosed.

**Conflict of Interest**

The authors declare that they have no conflict of interest related to the conduct, authorship, or publication of this study.

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This study received no external funding. The research was conducted using the institutional resources available to the authors. No funding agency was involved in the study design, data collection, analysis, interpretation, or preparation of the manuscript.

**Data Availability**

The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy and confidentiality considerations concerning the study participants.

Authors' Contributions

**Bibi Hajira Ishaq:** Conceptualization, study design, methodology, data collection, data interpretation, and manuscript drafting.

**Natasha Junaid:** Methodology, data collection, literature review, data interpretation, and critical revision of the manuscript.

**Zahid Sarfaraz Khan:** Study supervision, methodology, data interpretation, and critical review of the manuscript.

**Sobia Ali:** Conceptualization, data collection, literature review, data interpretation, and critical revision of the manuscript.

**Shah Nawaz:** Data collection, literature review, data analysis, interpretation of results, and manuscript revision.

**Rab Nawaz:** Study supervision, conceptualization, methodology, critical review, and final approval of the manuscript.

**All authors:** Contributed to the conception/design or interpretation of the work, reviewed and approved the final version, and agreed to be accountable for all aspects of the work in accordance with ICMJE authorship criteria.

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