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The study of socioeconomic status, hematological variations and biochemical analysis among diabetic patients

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Abstract

Diabetes Mellitus is a chronic metabolic disease marked by increased blood glucose level, leads to long-term hyperglycemia. Socioeconomic situation has crucial role in glycemic management. Hematological changes can be caused by several factors. Blood tests for biochemical analysis are simplest way to monitor kidney function. The work aimed to assess the socioeconomic status and hematological variations with the biochemical changes among patients. The questionnaire Performa was designed to collect data during interview. The blood samples was collected for hematological and biochemical analysis. The significant demographic and clinical features among diabetic patients, with middle-aged, between 41 to 60 years, and more females with non-significant differences. More people reside in rural areas, but gender distribution between rural and urban was similar. Income status shows most patients were from lower middle class, with a notable gender disparity in upper middle class. Male smokers were significantly more prevalent, indicating higher health risk in this group. Blood tests reveal lower hemoglobin levels, elevated white blood cell counts, and possible anemia in case group, with signs of macrocytic anemia and blood disorders. Biochemically, the case group shows higher urea, random blood glucose, and sodium levels, indicating potential kidney dysfunction, poorly controlled diabetes, and hypernatremia. To conclude, the most diabetic patients were middle-aged, with no significant gender or residency differences. Blood tests indicate anemia, inflammation, kidney issues, and poorly controlled diabetes in the case group. This suggested the need for targeted interventions, for at-risk groups like middle-aged, rural, and lower-income individuals, with focus on male smoking habits.

Keywords: Diabetes, Type I diabetes, Type II diabetes, Hematology, Biochemical changes

Introduction

Diabetes Mellitus is a long-lasting metabolic disorder categorized by persistently high blood glucose level, which can lead to damage and dysfunction in multiple organs, including the kidneys, retina, heart, neurons, and blood vessels (1). The important form is Type II diabetes, typically affecting adults, where the body develops resistance to insulin or fails to produce sufficient insulin (2). Type 2 diabetes is increasingly being diagnosed in younger populations. Heart failure frequently serves as an early indicator of cardiovascular disease in individuals with

Type 2 diabetes mellitus (T2DM) (3) and is associated with a high risk of mortality in both Type 1 and Type 2 diabetes (4). While diabetes is incurable, it can be managed with treatment and lifestyle changes to support a long, healthy life. Type 1 diabetes, often starting in childhood or adolescence, contrasts with Type 2 diabetes, which is becoming more prevalent in middle-class and low-income countries worldwide (5)

Socioeconomic status plays a crucial role in managing glycemic control (6). conomic factors significantly impact health, with those in poverty facing higher risks of diabetes-related complications. This study explores diabetes, prediabetes, and undiagnosed cases in Pakistan, highlighting the challenges posed by socioeconomic factors (7). Unlike wealthier nations, Pakistan faces difficulties in effective diabetes management (8). The World Health Organization reports that emerging nations have seen a 170% increase in diabetes incidence, with 228 million people, or 75% of the global total, affected (9)

Hematological changes in diabetes often stem from some factors, including more production of reactive oxygen species and development of advanced glycation end products due to long-term hyperglycemia. ROS-induced oxidative stress contributes to tissue damage and results in various hematological abnormalities, such as dysfunction of red blood cells (RBCs), hyperactivity of platelets (PLTs), and endothelial dysfunction (10). These blood changes can leads to difficulties like anemia and hypercoagulability, both contributed to increased risks of heart diseases in diabetic patients (11). Recent research has focused on hematology such as white blood cells (WBC) count, red blood cells distribution width (RDW), mean platelets volume (MPV), platelets distribution width, and platelets count as potential predictors of endothelial dysfunction and inflammation in type 2 diabetes mellitus (T2DM) (12). An elevated white blood cell (WBC) count is a well-established marker of inflammation and has been linked to an increased risk of diabetes (13). Platelets are crucial for maintaining normal hemostasis, with mean platelet volume (MPV) serving as a marker of platelet function (14). In diabetes, accelerated atherosclerosis and platelet activation contribute to inflammation and atherothrombosis, which are significant factors in the development of heart diseases in people with type II diabetes mellitus (15). Mean platelets volume indicates changes in either platelet activation or production rates, and elevated MPV was observed in diabetic patients with coronary heart diseases, nephropathy, and retinopathy (16). The most straightforward method for monitoring kidney function is through blood tests measure

blood urea nitrogen and creatinine. There is a strong correlation between blood sugar levels and blood urea levels (17). An increase in urea levels typically occurs when the kidneys are damaged or not functioning properly, so a simultaneous rise in both blood sugar and urea levels suggests that hyperglycemia may lead to renal impairment. Additionally, elevated uric acid levels have been linked to insulin resistance and established Type II Diabetes Mellitus (18). This research aimed to explore the relationship between Type 2 diabetes patients' socioeconomic status and hematological variations, as well as the associated biochemical changes, in the districts of Sahiwal and Okara.

Materials and Methods

Study Design

This study was aimed to investigate the prevalence and management of Diabetes Mellitus in both urban and rural areas of the Sahiwal and Okara districts in Pakistan, spanning from January 2023 to June 2024. The cross-sectional design was selected for its effectiveness in evaluating diabetes incidence within a defined population and timeframe.

Ethical concern and consent

The research approval from the Institutional Review Board of the University of Okara, was obtained and also adheres with the declarations of Helsinki. The consent form was gained from all patients who participated in the study.

Population and data collection

Data from approximately 624 patients were collected to assess socioeconomic status. The study employed a structured questionnaire and clinical evaluations for data collection. The questionnaire covered socio-demographic information, lifestyle factors, medical history, and diabetes management, while the clinical assessments included measurements of fasting blood glucose, HbA1c, blood pressure, BMI, and lipid profile (19).

A team of trained data collectors, including medical students and healthcare professionals, was assembled. Their training involved simulated sessions and interactive activities to improve their skills (20). Data collection was carried out in two stages. Initially, face-to-face interviews were

conducted using the structured questionnaire, with each interview lasting approximately 30 minutes and informed consent obtained beforehand (19). Subsequently, participants visited healthcare facilities for medical assessments, which included fasting blood samples and anthropometric measurements, all conducted according to standardized protocols (21).

Hematological analysis

For the hematological analysis, a six-milliliter venous blood sample was obtained from each Type 2 diabetes mellitus patient after overnight fasting. This included 2 ml in a serum separators tube and 4 ml in an EDTA tubes. For the control group (blood donors), 4ml of blood were also collected in EDTA tubes. Serum prepared from the serum separator tube was used to measure fasting blood glucose (FBG). FBG levels were measured by glucose oxidase technique with a Biosystems A25 automated chemistry analyzer (Costa Brava, Spain), following the manufacturer's instructions. Hematology was analyzed by a UniCel DxH 800 automated hematology analyzer, employing coulter counting, spectrophotometry, and VCSn equipment (22).

Biochemical analysis

Clinical characteristics of 624 diabetic patients, including random blood sugar (RBS), urea levels, and sodium, were extracted from their medical records. The cohort mainly comprised individuals aged 10 years and older, encompassing both males and females (23).

Statistical Analysis `

Statistical analysis was done with Microsoft Excel 2010. The descriptive statistics summarized socio-demographic factors, diabetes incidence, and treatment methods, with data reported as means, standard deviations, frequencies, and percentages (24). Correlations between diabetes prevalence and socio-demographic and lifestyle variables, using chi-square tests for categorical variables and t-tests for continuous variables was assessed (25, 26).

Results

Demographic and clinical characteristics of diabetic patients

The study comprises of 624 individuals who participated during the work. The demographic data reveals significant trends across age, gender, residence, income status, and smoking habits among the patient population. The majority of patients are between 41 to 60 years old, with a higher representation of females in this age group, though the difference is not statistically significant. This suggests that middle-aged individuals are the most affected by the studied condition. In terms of residence, a substantial portion of the patients live in rural areas, with females being more prevalent. However, there is no significant gender difference in rural and urban residency, indicating that both environments contribute similarly to the condition.

Income status analysis shows that most patients belong to the lower middle class, with a fairly even distribution between males and females. Interestingly, a significant gender difference is observed in the upper middle class, suggesting that income status may have a gender-specific impact, potentially linked to occupational or social factors. Smoking habits show a marked difference between genders, with a significantly higher percentage of male smokers compared to female smokers with diabetes type 2. This could indicate a greater health risk associated with smoking among males in this population. This is shown in table 1.

Table 1: The characteristics of diabetic patients

Age in years	Gender	No. of patients	Percentage %	Total %	P-value
10 to 40 years	**Male**	71	11.38	24.04	0.21
	Female	79	12.66		
41 to 60 years	**Male**	195	31.25	71.96	0.28
	Female	254	40.71		
61 to 80 years	**Male**	15	2.40	4.01	0.17
	Female	10	1.60		
Residence					
Rural	**Male**	196	31.41	77.24	0.21
	Female	286	45.83		
Urban	**Male**	104	16.67	22.76	

	Female	38	6.09		
Income status					
Lower middle class	**Male**	195	38.69	86.11	0.27
	Female	239	47.42		
Middle class	**Male**	49	9.72	25.00	0.20
	Female	77	15.28		
Upper middle class	**Male**	37	7.34	12.70	0.02
	Female	27	5.36		
Smoking					
Smokers	**Male**	137	27.18	29.17	0.02
	Female	10	1.98		
Non smokers	**Male**	144	28.57	94.64	
	Female	333	66.07		

Hematological variations and biochemical analysis

The blood test results for the case and control groups reveal several significant differences across various parameters. Hemoglobin levels in the case group (14.84 ± 3.69 g/dL) are lower compared to the control group (20.6 ± 4.11 g/dL), which could indicate potential anemia or other underlying conditions affecting red blood cell production in the case group. The white blood cell (WBC) count is notably elevated in the case group (26.99 ± 2.58 × 10^3/μL) compared to the control group (14.61 ± 1.652 × 10^3/μL), suggesting a possible infection or inflammatory response. The red blood cell (RBC) count is slightly higher in the control group (9.45 ± 1.66 × 10^6/μL) than in the case group (9.34 ± 0.41 × 10^6/μL), but both are above the normal range, which may indicate polycythemia or another condition leading to an increase in RBCs. Hematocrit (HCT) values are significantly higher in the control group (77.5 ± 9.11%) compared to the case group (61.36 ± 8.54%), pointing to potential dehydration or other factors leading to elevated HCT levels in the control group.

Mean corpuscular volume and mean corpuscular hemoglobin are both elevated in the case group (131.93 ± 12.07 μm³ and 36.46 ± 5.45 pg, respectively) than to control group (163.4 ± 13.42 μm³ and 52.9 ± 6.54 pg). This suggests macrocytic anemia or a related disorder in the control group. Mean corpuscular hemoglobin concentration (MCHC) is also higher in the case group (56.18 ± 15.64 g/dL) than to control group (64.8 ± 4.42 g/dL), further supporting the possibility of a blood disorder. Platelets count and mean platelet volume are slightly elevated in both groups, with the case group showing 471.62 ± 117 × 10³/μL for PLT and 21.94 ± 20.85 μm³ for MPV, and the control group showing 482.2 ± 111.6 × 10³/μL for PLT and 20.6 ± 3.6 μm³ for MPV. Platelet distribution width and plateletcrit are within normal ranges but slightly higher in the case group, which may reflect variations in platelet size and activity. Lymphocyte (Lym) percentages are elevated in both groups, with the control group showing higher levels (69.1 ± 13.57%) compared to the case group (62.54 ± 16.31%). Monocyte (MON) percentages are also higher in the control group (12.69 ± 3.34%) compared to the case group (8.63 ± 3.49%), suggesting a possible chronic inflammatory state or infection in the control group.

Biochemical analysis shows significantly elevated levels of urea, random blood glucose, and sodium in the case group. Urea levels (72.77 ± 21.814 mg/dL) are well above the normal range, indicating potential kidney dysfunction or dehydration. Random blood glucose levels (468.1 ± 39.894 mg/dL) are also alarmingly high, suggesting poorly controlled diabetes or severe hyperglycemia. Sodium levels (151.8 ± 7.76 mmol/L) are elevated, which may indicate hypernatremia, possibly due to dehydration or an endocrine disorder. This is shown in table 2.

Table 2: The blood and biochemical parameters

Blood Test	**Normal range**	**Unit**	**Case group**	**Control group**
			Mean± SD	**Mean± SD**
Hemoglobin	11.0-16.0	g/dl	14.84±3.69	20.6±4.11
WBC	4.0-10.0	10^3/ul	26.99±2.58	14.61±1.652
RBC	4.00-6.20	10^6/ul	9.34±0.41	9.45±1.66
HCT	35.0-55.0	%	61.36±8.54	77.5±9.11
MCV	80.0-100.0	um^3	131.93±12.07	163.4±13.42
MCH	26.0-34.0	p9	36.46±5.45	52.9±6.54

MCHC	31.0-35.5	g/dl	56.18±15.64	64.8±4.42
PLT	150-400	10^3ul	471.62±117	482.2±111.6
MPV	7,0-11,0	um^3	21.94±2085	20.6±3.6
PDW	10.0-18.00	%	32.38±4.18	30.4±3.97
PCT	0.200-0.500	%	0.46±1.05	0.4±2.46
lym	25.0-50.0	%	62.54±16.31	69.1±13.57
MON	2.0-10.0	%	8.63±3.49	12.69±3.34
Biochemical analysis				
Urea	7-20	mg/dL	72.77± 21.814	-
Random Blood Glucose	7-140	mg/dL	468.1± 39.894	-
Sodium	135-145	mmol/L	151.8± 7.76	-

The figure 1 depicts the biochemical analysis level including urea, random blood glucose and sodium in diabetes type 2 patients.

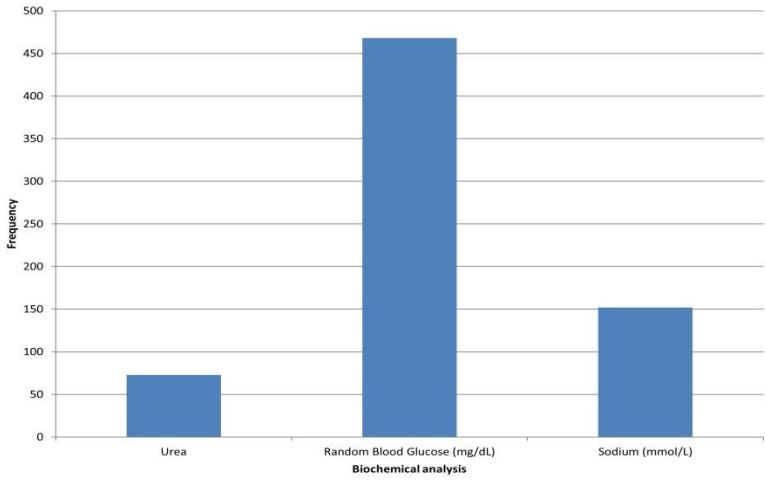

Figure 1: The biochemical analysis among diabetic patients

Discussion

This study aimed to evaluate the demographic profile, hematological alterations, and biochemical parameters in diabetes type II patients from Pakistan.

According to them, this was the first investigation exploring the link among socioeconomic status and Type II Diabetes Mellitus complications in young adults aged 20 to 40 years. The findings indicate that SES is significantly associated with T2DM complications in this age group, similar to patterns observed in middle-aged and older adults. It is crucial to address this among young adults since the complications can progress over time, and heart diseases appeared to be more common in those who develop complications at a younger age compared to those in middle age (27). Moreover, psychological stress seems to be more prevalent in young adults with disease complications than to their middle-aged and older counterparts. Previous research has suggested that the worsening of disease complications may lead individuals to quit stable jobs or negatively impact their professional lives (28). In this study, most patients fall within the 41 to 60 age range, with a higher proportion of females, although this difference is not statistically significant.

Their results are consistent with previous research on the connection between socioeconomic status and the prevalence of T2DM. Additionally, these results align with studies from Italy and France, which used poverty indices to demonstrate that individuals with lower SES were more likely to suffer from retinopathy and nephropathy (29). Similarly, research in the UK revealed a higher incidence of retinopathy in residents of economically disadvantaged areas, a trend also observed in Germany (30, 31). However, another UK study involving patients visiting general practitioners found no link between local poverty levels and the occurrence of retinopathy or nephropathy. A study from UK also did not identify any correlation between poverty indices and retinopathy (32, 33). In Japan, only 4 studies have explored the relationship between SES and T2DM. One study focused on public servants found a higher prevalence of T2DM among individuals with lower educational attainment and lower-ranking job positions, while another study on white-collar workers noted an increased incidence primarily among those in sales roles (34, 35).

In contrast, a study examining the general population found that individuals with lower incomes were more likely to receive treatment for T2DM. Another study, also focusing on the general people, indicated that the frequency of T2DM was high among those with lower incomes and

those working in blue-collar jobs (36, 37). In this study, an analysis of income status revealed that most patients were from the lower middle class, with a relatively balanced distribution between males and females. Notably, a significant gender difference emerged within the upper middle class, implying that income status might affect genders differently, potentially due to occupational or social influences.

Given the prevalence of diabetes and its significant association with renal complications, extensive efforts have been dedicated to evaluating and addressing issues related to this condition (17). In their study, researchers found significance in the total WBCs count, as well as in the absolute counts of neutrophils, lymphocytes, eosinophils, basophils, platelet count, (Hb) (RDW), and mean platelet volume (MPV) between T2DM patients and the control group. Although the mean RBCs count was low in T2DM cases than control group, the differences were not significant. This observation aligns with findings from studies conducted in India, Libya Sudan, and Addis Ababa, Ethiopia (38-41) .

One possible reason for the decreased RBC count could be that insistent hyperglycemia leads to enlarged production of reactive oxygen species and nonenzymatic glycosylation of hemoglobin and RBCs membrane proteins (42). These alterations are known to significantly increase blood viscosity, negatively impacting microcirculation in diabetes and contributing to microangiopathy (43). Contrary to these findings, studies conducted in Pakistan and Gondar, northwest Ethiopia, have reported high RBCs counts and hemoglobin concentrations in patients compared to control (44, 45). This discrepancy may be due to the effects of insulin resistance, which is linked to the stimulation of erythroid progenitors, thereby increasing RBC count and elevating hemoglobin and hematocrit levels (46). In this study, the RBC count is slightly higher in the control group ($9.45 \pm 1.66 \times 10^6/\mu L$) compared to the case group ($9.34 \pm 0.41 \times 10^6/\mu L$). However, both counts are above the normal range, potentially indicating polycythemia or another condition that leads to an increased RBC count.

Their study found that hemoglobin (Hgb), used as an indicator of anemia, was significantly lower in T2DM patients compared to the control group. This result aligns with earlier research from Bangladesh, India, Libya, and Nigeria, where T2DM patients also showed significantly lower Hgb levels than controls. The prevalence of anemia in their study was 17.9% (95% CI: 11.5–24.5), which is consistent with findings from studies in Saudi Arabia (22%), Australia

(17.8%), and Sudan (18.3%). However, this prevalence was lower than the rates reported in studies from India (71.4%), Nigeria (45.2%), and Dessie, northeast Ethiopia (26%) (28). The could be attributed to differences in the study population's characteristics and variations in sample size. In our study, most participants were adults, with a majority being male. It was observed that hemoglobin levels in the case group (14.84 ± 3.69 g/dL) were lower compared to the control group (20.6 ± 4.11 g/dL). This reduction in hemoglobin levels may suggest the presence of anemia or other conditions impacting red blood cell production in the case group.

In terms of WBC indices, this study found that the total WBCs count, along with neutrophils and lymphocytes count were elevated in T2DM group than control. These are related with previous work in Turkey, Bangladesh, Libya, and Gondar, northwest Ethiopia (28). Additionally, the eosinophils and basophils were significant in diabetic group, aligning with studies from Saudi Arabia and Bangladesh (47, 48). The literature on WBC disturbances in T2DM patients is limited; however, this study observed that 3.7% of participants had leukocytosis, 1.5% had neutrophilia, 4.5% had eosinophilia, and 5.2% had basophilia. Notably, the WBC count was markedly elevated in the case group (26.99 ± 2.58 × 10^3/µL) compared to the control group (14.61 ± 1.652 × 10^3/µL), indicating a potential infection or inflammatory response.

In the study, it was observed that the differential white cell counts revealed that the majority of T2DM patients, 127 (94.8%), had normal neutrophil counts, while 5 (3.7%) experienced neutropenia. Diabetic neutrophils are known to exhibit impaired deformability, chemotaxis, phagocytosis, and bactericidal activity, and they also tend to have a shorter lifespan compared to normal neutrophils (49). These factors may contribute to the occurrence of neutropenia observed in this study. Concerning the absolute monocyte count, non-significant difference was found between the diabetic and control groups, consistent with findings from a study in Ethiopia but in contrast to studies in Turkey and Bangladesh (41, 47). Additionally, monocytopenia was observed in 5 (3.7%) of the T2DM patients.

The peripheral blood count may not accurately reflect monocyte distribution in tissues (50). In this study, lymphocyte (Lym) percentages were found to be elevated in both groups, with the control group displaying higher levels (69.1 ± 13.57%) compared to the case group (62.54 ± 16.31%). Similarly, monocyte (MON) percentages were greater in the control group (12.69 ±

3.34%) than in the case group (8.63 ± 3.49%). These findings suggest the possibility of a chronic inflammatory state or infection in the control group.

The analysis of platelets revealed that both mean platelet volume and platelets count were significant in the T2DM group than controls. This was related with studies from Nigeria and Ethiopia, which also reported elevated platelet counts in diabetes patients. The increased MPV observed in this study corroborates several other research findings. Elevated MPV and platelet counts are considered indicators of thrombotic risk and potential vascular complications in diabetes (28). One possible explanation for these elevated levels is the release of S100A8/A9 by neutrophils, which stimulates the production of interleukin-6 (IL-6) and thrombopoietin from liver cells. This process can lead to increased bone marrow activity and the production of more reticulated platelets, which are linked to both atheroprogression and atherothrombosis (51). In this study, platelet count (PLT) and MPV were slightly elevated in both groups. The case group showed a mean platelet count of 471.62 ± 117 × 10^3/µL and an MPV of 21.94 ± 20.85 µm^3, while the control group had a mean platelet count of 482.2 ± 111.6 × 10^3/µL and an MPV of 20.6 ± 3.6 µm^3. Platelet distribution width (PDW) and plateletcrit (PCT) were within normal ranges but slightly higher in the case group, indicating potential variations in platelet size and activity.

In the data presented, serum urea and creatinine concentrations were significantly lower in diabetic patients compared to the control group. Urea, a byproduct of protein metabolism formed in the liver, is a key marker for assessing kidney function. The observed decrease in serum urea levels among diabetics might be attributed to impaired synthesis due to compromised liver function or disruptions in protein metabolism (52). Creatinine, a waste product typically filtered out by the kidneys and excreted in the urine, also showed reduced levels in diabetic patients. This lower creatinine level is challenging to interpret, as it may be influenced by hyperfiltration in the kidneys, a condition often seen in diabetes. This complexity in understanding the onset of such changes can lead to varying and sometimes controversial results (53, 54). In this study, the urea levels in the diabetic group were measured at 72.77 ± 21.814 mg/dL, which is significantly above the normal range. This suggested potential kidney dysfunction or dehydration, recommends the need for further investigation into the kidney health of diabetic patients.

In this study, fasting blood glucose levels were notably higher in females compared to males within the diabetic population. This disparity may be linked to hormonal changes associated with

menopause, which can disrupt glucose and insulin metabolism. Additionally, nutritional factors might contribute to elevated glucose levels in females, who generally have a higher body mass index than males (55). Diabetes mellitus encompasses a range of metabolic diseases categorized by chronic hyperglycemia results from either insufficient insulin production, ineffective insulin action, or both. A specific form, permanent neonatal diabetes, arises from a glucokinase deficiency, reflecting an inborn error in the glucose-insulin signaling pathways. Globally, the frequency of diabetes among adults was assessed at 285 million (6.4%) in 2010 and is projected to increase to approximately 439 million (7.7%) by 2030 (56). In the current study, random blood glucose levels were found to be alarmingly high at 468.1 ± 39.894 mg/dL, indicating poorly controlled diabetes or severe hyperglycemia. Furthermore, sodium levels were elevated at 151.8 ± 7.76 mmol/L, which may suggest hypernatremia, potentially due to dehydration or an underlying endocrine disorder.

Conclusion

To conclude, the study reveals that most diabetic patients are middle-aged, with a higher female representation, though not significantly. Rural residency and lower middle-class income are common, with males showing significantly higher smoking rates. Blood tests indicate anemia, inflammation, and possible kidney dysfunction in the case group, along with poorly controlled diabetes and elevated sodium levels. This suggested the need for targeted interventions, particularly in managing diabetes among middle-aged, rural, and lower-income individuals, with attention to gender-specific risks like smoking.

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Author’s contribution

All authors contributed equally in the manuscript.

Conflict of interest

None

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