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A Cross-Sectional Study on Diabetes Mellitus Awareness Among Pakistani Students: Implications for Primary Health Care Education

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Abstract

Background: Diabetes mellitus (DM) is a metabolic disorder affecting healthcare systems and health globally, and its early awareness can prevent disease development. The study aimed to explore students' awareness of DM, which had received little attention in developing countries like Pakistan.

Methods: A cross-sectional study in Bahawalpur, Pakistan, surveyed 658 participants using an online questionnaire to assess their understanding, knowledge, and attitudes towards DM, using a binary logistic regression model for statistical analysis.

Result: A total of 658 participants included 5.3% diabetic and 84.7 non-diabetic, with 62.3% of males and 37.7% of females being non-significantly associated with diabetes and having a 1.02-time high risk for it [crude odds ratio (COR)=1.02, 95% confidence interval (CI)=0.51-2.07]. Unmarried individuals, non-smokers, and those with higher education levels significantly increased their risk of developing diabetes by 15 times (p -value=0.001). The study found that over 76% of participants were aware of general diabetes information, especially "DM leads to foot problems and other organ issues," which are significantly associated with diabetes but have a lower risk of developing it. Fewer respondents (17.3%-68.7%) knew about diabetes complications and symptoms. Binary logistic regression analysis showed that students with a higher awareness of risk factors and preventive measures (62.9%-93.6%) had a lower risk of developing diabetes (COR= < 1).

Conclusion: Our study found that participants were aware of DM risk factors and preventive measures, but not its symptoms and complications, which highlighted the need for university-level awareness programs and primary health promotion interventions, especially in underprivileged areas like Bahawalpur, Pakistan.

Keywords: diabetes mellitus, primary health education, glucose, risk factors, awareness

1. Introduction

Diabetes mellitus (DM) is a metabolic and genetic disorder characterized by persistently raised blood glucose levels (hyperglycemia). Diabetes is classified into two types: insulin-dependent (Type 1: the destruction of pancreatic beta cells causes insulin insufficiency) and non-insulin-dependent (Type 2: where insulin resistance can result in hyperglycemia) ([1](#), [2](#)). DM is among the top four non-communicable diseases (NCDs) globally ([3](#)), causing impairment, death, and increasing healthcare system burden, economic growth, and overall health issues for a significant global population([4](#)). Risk factors for DM include environmental factors, genetics, lifestyle, weight, physical activity, and dietary habits, which can lead to insulin resistance and obesity ([5](#), [6](#)). The World Health Organization (WHO) reported that diabetes has increased from 1980 (108 million) to 2014 (422 million) ([7](#)), falling 9th for the cause of death worldwide ([2](#)). The International Diabetes Federation (IDF) found diabetic cases worldwide (537 million) and in Pakistan (19.4 million) in 2021, which may rise to 783 million (worldwide) and 37.1 million (Pakistan) in 2045 ([8](#)). The National Diabetes Survey of Pakistan (NDSP-2016–2017) revealed 207.77 million people living in Pakistan, around 27.4 million affected by diabetes, with a burden of 14.47% pre-diabetic rate ([9](#)). According to the IDF, 17% of Pakistanis are diabetics, placing the country third overall, following China and India. Pakistan has the greatest death rate (35.5%) from diabetes complications among those under 60 years of age in 2021 and the highest comparative diabetes

prevalence rate (30.8%). Sindh has the greatest diabetic militant prevalence (32.3%) among Pakistan's provinces, followed by Punjab (30.2%), Baluchistan (29.5%), and KPK (13.2%) ([10](#)).

Symptoms of DM include polyuria, polydipsia, polyphagia, fatigue, frequent infections, wounds, glazed vision, and digestive problems, which lead to the destruction of the kidneys, heart, blood vessels, and eyes, among other organs, resulting in diabetic neuropathy, lack of vision, cardiac issues, and kidney failure leading to death ([11](#), [12](#)). Lifestyle changes, regular checkups, and treatment of diabetes can minimize complications, but ideal glucose control can be achieved by regular exercise, eating a nutritious diet, reducing weight, and taking prescription medications ([13](#)). Therefore, early awareness of DM and its risk factors thus provides a chance to enable preventive measures to stop and delay the disease's development ([14](#), [15](#)).

Global studies highlight the significance of increasing public understanding of diabetes symptoms, risk factors, lifestyle choices, and regular blood sugar tests ([16](#)). Many studies focus on knowledge of diabetes in the Asian population ([17](#)). Most studies were often carried out with local or clinic-based specimens, with the primary focus being people diagnosed with diabetes ([18](#)). Up to now, several additional studies have been conducted related to evaluating diabetes knowledge among individuals with and without diabetes in Asia ([19](#)). This alarming situation is particularly concerning in low-income and developing countries like Pakistan. The number of DM cases has increased with each passing year. The earlier studies showed an association between HBA₁C level and DM knowledge due to proper care and DM management with adequate knowledge ([20](#)). Therefore, this study aims to assess diabetes knowledge and awareness of risk factors, symptoms, complications, and preventive measures of DM among participants.

2. Method And Materials

2.1 Study designs

This cross-sectional study was conducted among students at Bahawalpur in Pakistan from February 4th to May 4th, 2024. Data was collected through an electronic survey using a Google Form distributed through social media platforms via WhatsApp and Facebook. This survey included individuals >18 or both genders who can understand and read English and those willing to provide informed consent. Individuals who were not willing to engage or were less than 18 or more than 80 years old and had any mental disease were excluded. Slovin's formula was used to calculate the minimum sample number for a survey, which was 400, considering a 39.14 million population, 4 million students, and a 5% margin of error.

2.2 KAP Questionnaire and Validation

This study includes 27 questions divided into 6 sections covering socio-demographic information, general knowledge, symptoms, complications, risk factors, and preventive measures for DM. The questions included in the DM knowledge and risk factors sections were drawn from a study conducted in Pakistan ([21](#)) and India ([22](#)). This questionnaire was developed with the help of an expert with experience in designing surveys, and the accessibility of the questionnaire materials was verified ([23](#)). Demographic data include age (categorized

as 18-29 years, 30-39 years, 40-49 years, 50-60 years, and >60 years), gender (male and female), education (categorized as high school, college level, university level, and none), professional status (student, employed, unemployed, businessman, retired, and other), marital status (married, single/unmarried, and divorced), residence (rural and urban), and smoking status (categorized as a smoker, non-smoker, former smoker, and partially smoker). A pilot test was conducted with 10 individuals before starting this study. With the help of this pilot test, minor modifications (e.g., rephrasing) were made.

2.3 Awareness of diabetes

Participants responded to different questions related to nine questions for general knowledge (“Do you think, diabetes is a?”), six questions for risk factors such as (“Do you think, obesity is a risk factor for diabetes?”) one question for symptoms (“What are the main symptoms of diabetes?”) one question for complications (“What are the main complications associated with diabetes?”) or three questions for prevention (“Do you know that reducing sugar intake reduces diabetes?”). Respondents' answers to knowledge questions were mostly binary (yes/no).

2.4 Data analysis

The study used descriptive statistics for quantitative variables and frequency and percentage for categorical variables. Normality was checked using the Shapiro-Wilk test, and proportions were compared using the Chi-square test (non-significant = p -value > 0.05, *less significant = p -value $\leq$ 0.05, and **more significant = p -value $\leq$ 0.01). Binary logistic regression analysis explored factors affecting diabetes, including sociodemographic factors, risk factors, symptoms, complications, and preventive measures. Variables with p < 0.05 were entered into a backward stepwise logistic regression model, using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Sociodemographic data of respondents

Of a total of 658, males 62.3% ($n=410/658$) and females 37.7% ($n = 248/658$) were not significantly associated with diabetes (COR= 1.02, 95% CI= 0.51 – 2.07) one time more chances to develop diabetes, who were 18-29 years old (95.6%, $n = 629/658$). Unmarried 92.7% ($n = 610/658$) individuals responded more to our survey associated significantly with diabetes, followed by married 6.8% ($n = 45/658$) and divorced 0.5% ($n = 03/658$). Students 87.7% ($n = 577/658$) participated more, followed by employed 5.8% ($n = 38/658$), businessmen 2.3% ($n = 15/658$), unemployed 1.7% ($n = 11/658$), retired 1.1% ($n = 07/658$), and other 1.5% ($n = 10/658$) with (COR<1) were significantly associated with diabetes and low risk of developing diabetes. University-level education 91.9% ($n = 605/658$) of individuals enrolled higher than college level 5.9% ($n = 39/658$) and school level 1.4% ($n = 09/658$) were associated not significantly with diabetes (COR= 1.20, 95% CI= 0.13 – 11.05). Half of the respondents' 52.9% ($n = 348/658$) lived in rural areas, and 47.1% ($n = 310/658$) lived in urban areas with (COR<1) low risk of diabetes. Non-smokers, 92.7% ($n = 610/658$), are higher than smokers, 3.3% ($n = 22/658$), partial smokers, 2.9% ($n = 19/658$), and former smokers, 1.1% ($n = 07/658$) were not associated

significantly with diabetes (COR= 1.73, 95% CI= 0.27 – 10.97), Unmarried, non-smokers and those with higher education levels had significantly 15 times higher chances of developing diabetes (p -value= <0.001). Binary logistic regression analysis showed a significant association of diabetes with educational, marital, and smoking status, but not significantly with gender, age, professional status, and residence (**Table 1**).

Table 1: Binary logistic regression analysis for assessing sociodemographic factors associated with diabetic and non-diabetic individuals (N = 658).

Variables N (%)	Diabetic Status		N (%)	Crude COR (95% CI)	AOR (95% CI)	p -value
	Yes	No				
Gender						
Male	22 (3.3)	388 (59)	410 (62.3)	1	1	0.94
Female	13 (2)	235 (35.7)	248 (37.7)	1.02 (0.51 – 2.07)	0.68 (0.27 - 1.73)	
Age (years)						
18-29	21 (3.2)	608 (92.4)	629 (95.6)	1	1	<0.001**
30-39	1 (0.1)	11 (1.7)	12 (1.8)	0.38 (0.05 - 3.08)	0.81 (0.03 - 22.52)	
40-49	5 (0.8)	1 (0.1)	06 (0.9)	0.01 (0.00 - .06) [†]	0.02 (0.00 - 0.83)	
50-59	3 (0.5)	1 (0.1)	04 (0.6)	0.01 (0.00 - 0.12) [†]	0.02 (0.00 - 2.00)	
60 +	5 (0.8)	2 (0.3)	07 (1.1)	0.01 (0.00 - 0.07) [†]	0.034 (0.00 - 0.55)	
Education level						
High school	4 (0.6)	5 (0.8)	09 (1.4)	1	1	0.001**
College level	3 (0.4)	36 (5.5)	39 (5.9)	9.60 (1.64 - 56.08) [†]	1.18 (0.06 - 23.40)	
University level	26 (0.4)	579 (87.9)	605 (91.9)	17.81 (4.52 - 70.27) [†]	1.90 (0.11 - 31.89)	
None	2 (0.3)	3 (0.5)	05 (0.8)	1.20 (0.13 - 11.05)	1.63 (0.03 - 94.07)	
Professional status						
Student	18 (2.7)	559 (85)	577 (87.7)	1	1	0.001**
Employed	4 (0.6)	34 (5.2)	38 (5.8)	0.27 (0.09 - 0.85) [†]	2.83 (0.17 - 48.08)	
Unemployed	3 (0.5)	8 (1.2)	11 (1.7)	0.08 (0.02 - 0.35) [†]	0.39 (0.03 - 4.30)	
Businessman	3 (0.5)	12 (1.8)	15 (2.3)	0.13 (0.03 - .49) [†]	1.68 (0.08 - 34.64)	
Retired	5 (0.8)	2 (0.3)	07 (1.1)	0.01 (0.00 - 0.07) [†]	0.85 (0.01 - 51.96)	
Other	2 (0.3)	8 (1.2)	10 (1.5)	0.13 (0.03 - 0.65) [†]	0.26 (0.03 - 2.08)	
Marital status						
Married	15 (2.3)	30 (4.5)	45 (6.8)	1	1	0.001**
Single	19 (2.9)	591 (89.8)	610 (92.7)	15.55 (7.20 - 33.58) [†]	2.27 (0.42 - 12.13)	
Divorced	1 (0.1)	2 (0.3)	03 (0.5)	1.00 (0.08 - 11.93)	0.63 (0.01 - 39.56)	
Residence						
Rural	14 (2.1)	334 (50.8)	348 (52.9)	1	1	0.11
Urban	21 (3.2)	289 (43.9)	310 (47.1)	0.57 (0.28 - 1.15)	0.55 (0.21 - 1.44)	
Smoking status						
Smoker	9 (1.3)	13 (0.2)	22 (3.3)	1	1	0.001**
Non-smoker	23 (3.5)	587 (89.2)	610 (92.7)	17.67 (6.85 - 45.53) [†]	6.78 (1.74 - 26.33) [†]	
Former smoker	2 (0.3)	5 (0.8)	07 (1.1)	1.73 (0.27 - 10.97)	1.86 (0.09 - 35.01)	
Partially smoker	1 (0.1)	18 (2.7)	19 (2.9)	12.46 (1.40 - 110.86) [†]	14.14 (0.43 - 469.1)	

COR: crude odds ratio, AOR: adjusted odds ratios, CI: confidence interval, * $p < 0.05$ and ** $p < 0.01$ (derived from Chi-square tests), [†] p -value <0.05 , which is significant in multiple logistic regression.

3.2 Respondent's knowledge of DM

Most of the participants, 89.5% (n = 589/658) with (COR = 0.90, 95% CI = 0.30 – 2.64), were well aware of diabetes, and only 10.5% (n = 69/658) declared inferior knowledge of diabetes. 64.9% of the respondents (COR = 0.55, 95% CI = 0.28 - 1.09) know that living with a chronic disease is a part of life. Diabetes was recognized as a metabolic disorder by 23.7% (n = 156/658) respondents, a genetic disorder by 12.5% (n =

82/658) respondents, and both by 63.8% (n = 420/658) respondents were not associated significant with diabetes (COR = 1.58, 95% CI = 0.61 – 4.06), but also showed non-significant relation with diabetes (p -value = 0.615) having one time more risk to develop diabetes. In this study, respondents were well familiar with diabetes-association complications (80.4%, n = 529/658), that is not significantly associated with DM (COR = 1.19, 95% CI = 0.48 - 2.92) one time more chance to develop diabetes, but significant with other asking general knowledge questions of DM like “DM leads to foot problems (COR = 0.49, 95% CI = 0.19 -1.02)”, “diabetes can affect other organs (COR = 0.28, 95% CI = 0.13 - 0.62)”, “how to measure diabetes? (COR = 0.36, 95% CI = 0.18 - 0.73)”, and “What is a glucose tolerance test? (COR = 0.56, 95% CI = 0.27 - 1.16) [with (COR<1) low chances to develop diabetes] (Table 2).

Table 2. Binary logistic regression analysis for assessing general knowledge awareness among diabetic and non-diabetic respondents (N=658).

Variables N (%)	Diabetic Status		N (%)	Crude		p -value
	Yes	No		COR (95% CI)	AOR (95% CI)	
Did you hear about a condition called diabetes?						
Yes	31 (4.7)	558 (84.8)	589 (89.5)	1	1	0.852
No	4 (0.6)	65 (9.9)	69 (10.5)	0.90 (0.30 - 2.64)	1.26 (0.39 - 4.02)	
Did you know that living with a chronic disease is a part of life?						
Yes	18 (2.7)	409 (62.2)	427 (64.9)	1	1	0.086
No	17 (2.6)	214 (32.5)	231 (35.1)	0.55 (0.28 - 1.09)	0.55 (0.27 - 1.12)	
Do you know diabetes is a?						
Genetic disorder	6 (0.9)	76 (11.6)	82 (12.5)	1	1	0.615
Metabolic disorder	9 (1.4)	147 (22.3)	156 (23.7)	1.29 (0.44 - 3.77)	1.39 (0.45 - 4.29)	
Both	20 (3.0)	400 (60.8)	420 (63.8)	1.58 (0.61 - 4.06)	1.19 (0.44 - 3.28)	
Do you know any diabetes-associated-complication?						
Yes	29 (4.4)	500 (76)	529 (80.4)	1	1	0.706
No	6 (0.9)	123 (18.7)	129 (19.6)	1.19 (0.48 - 2.92)	3.32 (1.08 - 0.22) [†]	
Do you know diabetes can lead to foot problems?						
Yes	27 (4.1)	550 (83.6)	577 (87.7)	1	1	0.05*
No	8 (1.2)	73 (11.1)	81 (12.3)	0.49 (0.19 -1.02) [†]	0.67 (0.25 - 1.79)	
Do you think diabetes can affect other organs?						
Yes	25 (3.8)	559 (84)	584 (87.8)	1	1	<0.001**
No	10 (1.5)	64 (9.7)	74 (11.2)	0.28 (0.13 - 0.62) [†]	0.31 (0.12 - 0.76) [†]	
Do you know how to measure diabetes?						
Yes	21 (3.2)	501 (76.2)	522 (79.4)	1	1	0.004**
No	14 (2.1)	122 (18.5)	136 (20.6)	0.36 (0.18 - 0.73) [†]	0.42 (0.17 - 1.04)	
Do you know what a glucose tolerance test is?						
Yes	23 (3.5)	481 (73.1)	504 (76.6)	1	1	0.118
No	12 (1.8)	142 (21.6)	154 (23.4)	0.56 (0.27 - 1.16)	0.76 (0.31 - 1.89)	

COR: crude odds ratio, AOR: adjusted odds ratios, CI: confidence interval, * p <0.05 and ** p <0.01 (derived from Chi-square tests), [†] p -value<0.05, which is significant in multiple logistic regression.

3.3. Awareness of DM Symptoms

Unexpected weight loss 68.2% (n = 449/658) was a more recognized symptom of DM, followed by a slow healing process/wound 58.5% (n = 385/658), increased thirst/dry mouth 54.9% (n = 361/658), polyuria 37.7% (n = 248/658), and others 17.3% (n = 113/658). (**Figure 1**).

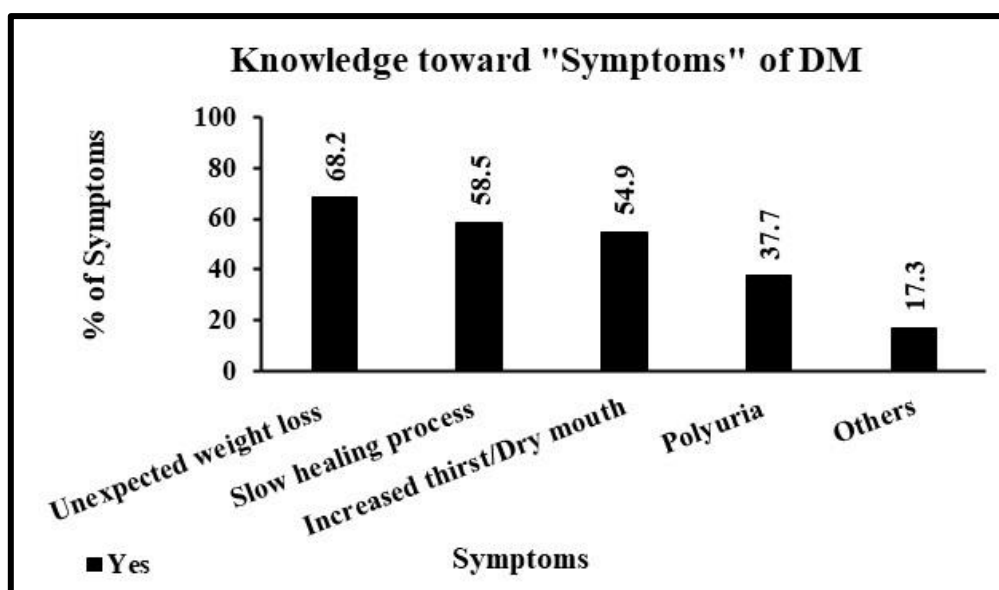


Figure 1: The study examined the public awareness of the question regarding “symptoms” of diabetes mellitus among participants at Bahawalpur. The data was significantly associated with both diabetic and non-diabetic individuals, with a p-value of <0.01 . * DM = Diabetes mellitus.

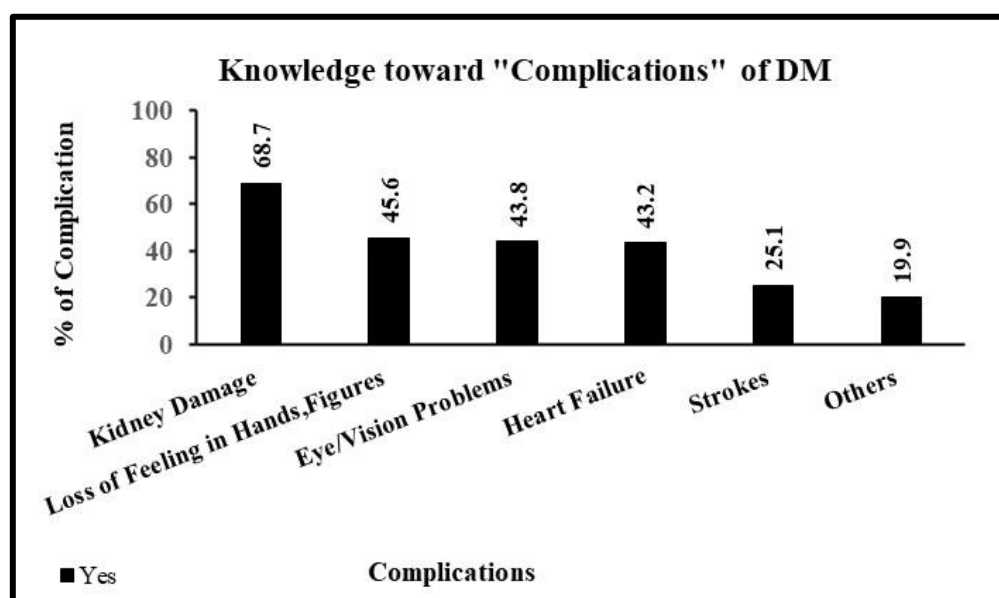


Figure 2: The study examined the public awareness of the question regarding “complications” of diabetes mellitus among participants at Bahawalpur. The data was significantly associated with both diabetic and non-diabetic individuals, with a p-value of <0.01 . * DM = Diabetes mellitus

3.5. Awareness of DM Risk Factors

Binary logistic regression analysis revealed a non-significant relationship between all risk factors such as high blood pressure and low physical activity for DM questioned in this research and diabetic and non-diabetic response. Obesity 89.7% (n=590/658) with (COR = 0.53, 95% CI = 0.21 - 0.33) was the most recognized risk factor for DM, followed by low physical activity 86.2% (n = 567/658) with (COR = 0.37, 95% CI = 0.17 -

0.80), high intake of alcohol 84.5% (n = 556/658) with (COR = 0.72, 95 CI = 0.31 - 1.69), high blood pressure 80.5% (n = 530/658) with (COR = 0.50, 95% CI = 0.24 - 1.06), and excess nutrients 76.7% (n = 505/658) with (COR = 0.87, 95% CI = 0.39 - 1.89) among the respondents. Excess protein intake of 63% (n = 414/658) with (COR = 0.99, 95% CI = 0.49 - 2.02) was the least recognized risk factor for diabetes. Low physical activity and high blood pressure as risk factors had a significant association with DM having (COR<1) less chances to develop diabetes (**Table 3**).

Table 3. Binary logistic regression analysis for assessing risk factors awareness among diabetic and non-diabetic respondents (N=658).

Variables N (%)	Diabetic Status		N (%)	Crude		p-value
	Yes	No		COR (95% CI)	AOR (95% CI)	
Do you know obesity is a risk factor for diabetes?						
Yes	29 (4.4)	561 (85.3)	590 (89.7)	1	1	0.174
No	6 (0.9)	62 (9.4)	68(10.3)	0.53 (0.21 - 0.33)	0.63 (0.23 - 1.74)	
Do you know high blood pressure is a risk factor for diabetes?						
Yes	24 (3.6)	506 (76.9)	530 (80.5)	1	1	0.066
No	11 (1.7)	117 (17.8)	128 (19.5)	0.50 (0.24 - 1.06) [†]	0.54 (0.23 - 1.30)	
Do you know low physical activity is a risk factor for diabetes?						
Yes	25 (3.8)	542 (82.3)	567 (86.1)	1	1	0.001**
No	10 (1.5)	81 (12.3)	91 (13.8)	0.37 (0.17 - 0.80) [†]	0.41 (0.18 - 0.92) [†]	
Do you know that a high intake of alcohol is a risk factor for diabetes?						
Yes	28 (4.3)	528 (80.2)	556 (84.5)	1	1	0.450
No	7 (1.1)	95 (14.4)	102 (15.5)	0.72 (0.31 - 1.69)	1.14 (0.42 - 3.08)	
Do you know that excess nutrients are a risk factor for diabetes?						
Yes	26 (3.9)	479 (72.8)	505 (76.7)	1	1	0.723
No	9 (1.4)	144 (21.9)	153 (23.3)	0.87 (0.39 - 1.89)	1.13 (0.47 - 2.70)	
Do you think excess protein intake is a risk factor for diabetes?						
Yes	22 (3.3)	392 (59.6)	414 (62.9)	1	1	0.994
No	13 (2.0)	231 (35.1)	244 (37.1)	0.99 (0.49 - 2.02)	1.31 (0.59 - 2.92)	

COR: crude odds ratio, AOR: adjusted odds ratios, CI: confidence interval, * $p < 0.05$ and ** $p < 0.01$ (derived from Chi-square tests), [†] p -value < 0.05 , which is significant in multiple logistic regression.

3.6. Awareness of DM Prevention

This research found no statistically significant association between DM “preventive measure” variables and diabetic and non-diabetic responders using binary logistic regression expect regular exercise. Regular exercise 93.6% (n = 616/658) with (COR 0.24, 95% CI = 0.09 - 0.58) was the most recognized preventive measure for DM, followed by reduced carbohydrate (sugar) intake of 87.7% (n = 577/658) with (COR= 0.66, 95% CI = 0.26 - 1.64) and least avoiding smoking of 76.9% (n = 506/658) with crude value (COR = 0.74, 95% CI =0.34

- 1.57). Regular exercise was found statistically significant association between DM with (COR<1) having less chance to develop diabetes and other preventive measures were not a statistically significant association between DM with p-value and COR value having more chance to develop diabetes. Both diabetic and non-diabetic were well aware of preventive measures including reducing sugar intake, regular exercise, and avoiding smoking towards DM (**Table 4**).

Table 4. Binary logistic regression analysis for assessing awareness of preventive measures among diabetic and non-diabetic respondents (N=658).

Variables N (%)	Diabetic Status		N (%)	Crude		<i>p-value</i>
	Yes	No		COR (95% CI)	AOR (95% CI)	
Do you know that reducing sugar intake, reduces diabetes?						
Yes	29 (4.4)	548 (83.3)	577 (87.7)	1	1	0.371
No	6 (0.9)	75 (11.4)	81 (12.3)	0.66 (0.26 - 1.64)	0.76 (0.29 - 1.96)	
Do you think the risk of diabetes is reduced with exercise?						
Yes	28 (4.2)	588 (89.4)	616 (93.6)	1	1	0.001**
No	7 (1.1)	35 (5.3)	42 (6.4)	0.24 (0.09 - 0.58) [†]	0.25 (0.10 - 0.62) [†]	
Do you know diabetes can be controlled by avoiding smoking?						
Yes	25 (3.8)	481 (73.1)	506 (76.9)	1	1	0.430
No	10 (1.5)	142 (21.6)	152 (23.1)	0.74 (0.34 - 1.57)	0.86 (0.39 - 1.89)	

COR: crude odds ratio, AOR: adjusted odds ratios, CI: confidence interval, * $p < 0.05$ and ** $p < 0.01$ (derived from Chi-square tests), [†] $p\text{-value} < 0.05$, which is significant in multiple logistic regression.

4. Discussion

Diabetes mellitus (DM) is a prevalent disease that may lead to severe health issues, including life-threatening complications, reduced life expectancy, and increased healthcare costs (24). This alarming situation is especially concerning in low-income and developing countries like Pakistan. The number of DM cases has increased with each passing year. Previous studies indicate a correlation between HBA1C level and DM knowledge, indicating that proper care and adequate knowledge are crucial for effective DM management (20). This study was conducted at Bahawalpur in Pakistan and found a majority of participants had heard about DM, but their knowledge about symptoms and complications was lacking. However, they were well aware of the risk factors and preventive measures associated with DM.

The current study revealed that only 5.3% of participants had diabetes, a number that is lower than previous studies conducted in India 8.6% (25), Sri Lanka 8.0% (26), China 9.6% (27), Bangladesh 9.2% (28), Iran 8.2% (29), Brazil 8.6% (30), Turkey 13.6% (31), Nepal 11.7% (32), India 15.7% (33), and in Kenya 2.4% (34), due to variations in their dietary patterns, physical activity, genetic factors, socio-economic factors, cultural practices, urbanization, public health initiatives, healthcare access, and awareness. Our study demonstrated that 89.7% of participants had heard about DM, which is almost similar to other studies conducted in Pakistan 87.2% (21), India 85.9% (22), Ethiopia 90.4% (35), and in southern India 90% (36), due to the same social and economic

culture. However, Uganda is at 99.2%, which is higher than our findings due to higher awareness among university-level participants, especially medical students (37). Our study revealed that more than half of the participants were aware that living with chronic diseases is a part of life. However, this level of awareness is lower than in a similar study conducted in India (85.7%), due to different age groups and variations in population size (22).

Our findings revealed that university students' recognition of DM as a genetic and metabolic disorder was comparatively lower than that of studies conducted at the Technical Institute of Karbala, Iraq (38), and China (39), likely due to a lower level of awareness. This study found that participants were well aware of diabetes-associated complications, which is higher than the study conducted in India at 55.3% (22), but their knowledge about "DM affects the body's organs" is similar to that of the Sri Lankan population at 85% (40), which is higher than the study conducted in India at 64.6% (22) and lower than the previous study in Pakistan at 23.7% (41), due to different education systems, awareness levels, social behavior, and economic status.

Due to the difference in population size, the present study revealed that more than half of the participants knew that DM can cause foot problems, which is higher than a study in India by 58.5% (22). Our study reported that respondents knew how to measure diabetes, which is dissimilar from other studies conducted in Bangladesh 9% (42), Pakistan 47% (21), Croatia 42% (43), and Pakistan 94% (44). This disparity may be due to their differences in sample size, population studied, study design, data collection methods, and temporal changes. Our findings demonstrated that most participants knew about glucose tolerance tests, which is higher than the study conducted in Bangladesh 4% (42) and Pakistan 30% (21), due to variations in the study population, education system, and backward village populations.

The current study found that respondents were not well aware of DM symptoms, including unexpected weight loss, the slow healing process, increased thirst or dry mouth, and polyuria, as the study conducted in Jordan (45), Ethiopia (35), and Cameroon (46), because of variations in the education system and economic status differences.

The present study showed an extraordinary level of awareness of DM complications, including kidney damage, loss of feeling in the hand or fingers, eye or vision problems, heart failure, and strokes, which are contradictory to other studies conducted in Pakistan (44), Singapore (47), Cameroon (46), and Jordan (45). This discrepancy could be attributed to education and literacy levels, healthcare infrastructure, cultural and social contexts, economic conditions, media and information dissemination, and healthcare provider training.

Our study found that respondents were well aware of DM risk factors, including obesity, low physical activity, high intake of alcohol, high blood pressure/hypertension, excess nutrient intake, and excess protein intake, which are higher than the study conducted in Telangana State, India (48), Poland (49), and Sri Lanka (40), because of their low-targeted public health campaigns, community engagement, media influence, access to information, population size differences, age factors, and variation in the economic states of the country. Our participants had a higher attitude and knowledge about preventive measures for DM, such as regular exercise,

avoiding smoking, and reducing sugar intake, compared to other studies conducted in Pakistan (21) and Bangladesh (42). We could attribute this to higher-targeted public health campaigns, community engagement, media influence, information access, population size differences, age factors, and country economic state variations. Our findings showed that significantly higher awareness levels about risk factors for DM were present among males, young people, those with higher education, students, non-smokers, and unmarried individuals. Obesity and high blood pressure were the highest awareness among males, students, and young people. Female and old-age individuals had the lowest awareness level about excess protein and nutrient intake as risk factors for DM.

Recent advancements in gene-editing technologies, particularly CRISPR-Cas9 and RNA interference (RNAi), have shown promise in treating diabetes mellitus. CRISPR-Cas9 has been utilized to precisely target and modify genes responsible for insulin production and glucose regulation, potentially correcting genetic defects associated with diabetes. RNAi, on the other hand, has been employed to silence specific genes that contribute to insulin resistance or pancreatic beta-cell dysfunction. Both approaches had offered a targeted and potentially long-lasting treatment option for diabetes, paving the way for future therapeutic strategies aimed at curing the disease at the molecular level (50).

5. Conclusion

The study shows that most participants have knowledge about diabetes, but they lack awareness of its symptoms, complications, and consequences. While most participants understand risk factors and prevention measures, interventions to develop diabetes require promoting healthy lifestyles and conducting university-level educational programs in Pakistan. To prevent diabetes, individuals should adopt a healthy lifestyle, reduce obesity, and maintain a healthy diet. Metformin is a preferred treatment for pre-diabetes. Diabetes mellitus (DM) is the leading global disorder, with Pakistan set to have the highest prevalence rate. Gene therapy using CRISPR technology and RNAi could treat DM.

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