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Holistic Factors Affecting Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Analysis

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Abstract:

Background: Diabetes mellitus is a significant risk factor for various degenerative diseases, the prevalence of which is rising due to changes in environmental factors and lifestyle behavior. This trend indicates that diabetes affects not only the elderly but also individuals in their prime working years. The disease can lead to both acute and chronic complications, impacting multiple organ systems.

Objective: This study aimed to investigate the principal factors influencing the behavior of patients with type 2 diabetes mellitus regarding blood glucose management.

Methods: A quantitative study employing a cross-sectional approach was conducted in Padang City in 2023, with a sample size of 204 individuals. Proportional sampling techniques were employed during the sampling procedure. Direct measurements of fasting blood glucose and interview techniques were employed to gather data through questionnaire tools. The logistic regression test was carried out for multivariate analysis, while the chi-squared test was conducted for bivariate analysis.

Results: The findings of this study indicated a substantial correlation between blood glucose management in patients with diabetes mellitus and factors, such as education, knowledge, attitude, diet, psychological state, family support, health worker assistance, and the availability of information facilities and infrastructure. The two important components were informational resources and infrastructure, as well as support for healthcare personnel.

Discussion: These results suggest that successful blood glucose management is not solely determined by individual behavior or knowledge but is also significantly influenced by external support systems. Enhancing access to reliable health information and strengthening the role of healthcare workers could play a critical role in empowering patients to manage their condition effectively.

Conclusion: The behavior of patients with type 2 diabetes mellitus in maintaining their blood glucose levels is significantly affected by the accessibility of informational resources and infrastructure, together with the help of healthcare professionals. To avert complications from diabetes and improve quality of life, healthcare providers must offer maximal support and expand infrastructure and informational resources.

Keywords: Holistic factors, Blood glucose levels, Diabetes mellitus, Type 2 DM, Behavior, Degenerative diseases, Healthcare Professionals.

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1. INTRODUCTION

The prevalence of diabetes mellitus (DM), especially type 2 DM, has increased in many countries, both developed and developing countries. According to the International Diabetes Federation, Indonesia has approximately 19.5 million individuals living with diabetes, making it the country with the fifth-highest diabetes prevalence globally [1]. If there is no effective handling action, this figure is expected to increase to 28.6 million by 2045. In addition, the American Diabetes Association (ADA) [2] estimated that in 2020, there were more than 500 million people worldwide with diabetes. This figure is expected to triple by 2030, and by 2045, this figure could reach 16.7 million cases. By 2023, the prevalence of diabetes in people over the age of 15 increased from 10.9 percent in 2018 to 11.7 percent. This indicates that diabetes affects not only the elderly but also individuals in the productive age group. The primary contributing factors include an unhealthy diet, physical inactivity, and obesity [1, 3].

Indonesia faces a similar situation, with high prevalence rates contributing to high healthcare costs. To reduce morbidity and mortality, early diagnosis of diabetes and its comprehensive management are essential. The results of the 2023 Indonesian Health Survey (SKI) showed an increase in the prevalence of diabetes and the potential for undiagnosed diabetes within the community. This is different from the results of the 2018 Riskesdas, where the percentage of type 2 diabetes increased to 52.1% in the productive age group and 48.8% in the age group over 15 years [4].

In 2023, the prevalence of diabetes in West Sumatra was recorded at 1.6% of the population, ranking the province 21st out of 34 provinces in Indonesia, based on data from the 2023 Indonesian Health Survey. The West Sumatra Provincial Health Office reported that in 2018, there were 44,280 cases of diabetes, which increased to 59,024 cases in 2019 and 63,112 cases in 2023, with the highest cases reported in Padang City at 2,056 in 2022, which increased rapidly in 2023 to 13,733 cases [5].

According to a previous study [6], the factors causing diabetes mellitus include age (p-value = 0.001, OR = 2.160), body mass index (p-value = 0.015, OR = 8.346), physical activity (p-value = 0.026, OR = 2.455), and level of knowledge (p-value = 0.021, OR = 2.256), all of which are risk factors associated with type 2 diabetes mellitus. Diabetes can cause acute and chronic complications that affect various body systems. Coronary heart disease accounts for approximately 30% of diabetes-related deaths, with kidney failure contributing an additional 30%. Key risk factors for the development of diabetes mellitus include dietary habits, levels of physical activity, age, and genetic predisposition. These factors are crucial for preventing diabetes resulting from uncontrolled blood glucose levels and are also significant contributors to the etiology of type 2 diabetes mellitus. Patients with diabetes mellitus have a statistically higher risk of developing heart failure and heart valve disease compared to non-diabetic patients [7].

Controlling blood glucose levels is an important step in preventing complications [8]. Effective blood glucose management in diabetic patients is as important as managing other chronic diseases. A study [9] emphasized the importance of both global and national interventions in supporting diabetes management by integrating family and cultural frameworks with health education in diabetic patients to improve their health status.

Efforts to prevent diabetic consequences include regulating blood glucose levels in individuals with diabetes, as well as identifying and forecasting advanced disease to avert and treat hyperglycemia and its associated problems [10]. Regulating blood glucose levels in individuals with diabetes is crucial. A study conducted in Nepal indicated that healthcare providers, particularly nurses, should prioritize the evaluation of social determinants and implement interventions for individuals with low income, illiteracy, and lack of health insurance, as well as those with insufficient health literacy, to enhance diabetes prevention [11]. Diabetes is a disease that leads to severe macrovascular complications (cardiovascular disease) and microvascular complications (including diabetic kidney disease, diabetic retinopathy, and neuropathy), resulting in increased mortality, blindness, renal failure, and diminished overall quality of life in affected individuals. Genetic variables contribute to problems and occurrences in individuals with diabetes mellitus [12].

Wronka *et al*. [13] stated that a crucial component of diabetes management involves adopting a healthy lifestyle, which includes regular physical activity, cessation of smoking, a balanced diet rich in antioxidant-rich foods, such as fruits and vegetables, and the utilization of hypoglycemic pharmacotherapy. Tobacco smoke is a modifiable risk factor for diabetes, with the risk of the

disease escalating by the severity of smoking. Physical activity, as an adjunct to therapy, can significantly mitigate the rise in blood glucose, with high-intensity interval training demonstrating the greatest advantageous impact on reducing blood glucose levels. The appropriate diet enhances cellular sensitivity to insulin and mitigates inflammation and stress [10].

Based on the background and identified problems, researchers realize the need to conduct research to determine the causal factors of uncontrolled blood glucose in diabetes mellitus patients. This study also aims to contribute to improving and maintaining the health of individuals, especially those with diabetes mellitus, while improving the quality of health services in handling diabetes mellitus cases and reducing mortality and morbidity rates for chronic disease sufferers, especially diabetes mellitus.

2. MATERIALS AND METHODS

2.1. Study Design

This study employs a quantitative research design, involving data collection, data analysis, and interpretation of the analytical results to draw conclusions, along with a cross-sectional approach [14, 15]. This research design is intended to identify the factors and indicators that influence the behavior of individuals with type 2 diabetes mellitus in controlling their blood glucose levels.

2.2. Study Location

This study was conducted in the Andalas Health Center, Ambacang Kuranji Health Center, and Lubuk Buaya Health Center in Padang City. This study area was selected based on data from the Padang City Health Office in 2022, which indicated that the Andalas Health Center had the highest number of diabetes mellitus patients, followed by the Lubuk Buaya Health Center and the Ambacang Kuranji Health Center.

2.3. Population and Sample

2.3.1. Research Population

The population in this study were individuals diagnosed with diabetes mellitus in the working areas of Andalas Health Center, Ambacang Kuranji Health Center, and Lubuk Buaya Health Center in Padang City, with a total of 2056 diabetes patients recorded in 2022.

2.3.2. Sample Selection

The sample selection method used was purposive sampling. In this study, a sample of 204 diabetes patients was selected using the proportional sampling method, which involves choosing subjects from each health center while ensuring the distribution of participants is proportional to the number of people with diabetes at each center. The selection of a sample size of 204 was based on previous studies using similar samples in the same population (Table **1**).

2.3.2.1. Inclusion Criteria

The inclusion criteria were as follows:

1) People with diabetes, who are actively registered in the working areas of Andalas Health Center, Lubuk Buaya Health Center, and Ambacang Kuranji Health Center.

2) Declare their willingness to become research respondents by signing a letter of consent to become respondents and being able to communicate well and fluently.

3) Age over 18 years.

2.3.2.2. Exclusion Criteria

The exclusion criteria are as follows:

1) Respondents who experienced serious complications that required treatment.

2) On three visits, the respondent was not found.

3) Respondents who were taking long-term corticosteroids or other drugs known to increase blood glucose levels.

2.4. Data Collection

Data collection was carried out from August to December 2023, following the acquisition of several necessary permits. The process began with obtaining a research permit from the Public Health Doctoral Study Program at Andalas University, which was then submitted to the Padang City Investment and One-Stop Integrated Service Office. The permit issued by this office was subsequently forwarded to the respective health centers involved in the study. Following the completion of administrative procedures, data collection was carried out, focusing on both the dependent and independent variables of the research. The independent variables were gender, employment status, education level, knowledge, attitude, body mass index/BMI, type of financing, medication taken, economic status, saturation factors, dietary habits, psychological conditions, family support, information facilities and infrastructure, and access to health facilities. In contrast, the dependent variable was fasting blood glucose levels, which were measured directly by researchers and assisted by laboratory experts.

2.5. Research Instruments, Validity, and Reliability of Tests

The research instrument consisted of a questionnaire for independent variables that was carefully prepared and reviewed by competent and experienced language experts. The knowledge variable consisted of 14 questions, attitude 14 questions, saturation variable 11 questions, diet variable 8 questions, psychological condition 9 questions, family support 12 questions, health worker support 8 questions, information infrastructure facilities 7 questions, and access to health facilities 4 questions. The dependent variable, *i.e.*, fasting blood glucose levels, consisted of 4 questions. All these questions were considered appropriate and correct to use after a thorough review. Validity and reliability tests were conducted on a sample of thirty diabetes mellitus patients from two health centers, Belimbing Health Center and Kuranji Health Center. The validity test was based on Pearson's product moment correlation coefficient, and the

critical value for the Pearson correlation coefficient (r) for both samples was 0.361 (at α = 5%). After the validity test, each questionnaire item was found to have a correlation value higher than 0.361. In addition, the questionnaire was evaluated using Cronbach's alpha coefficient, which is a commonly used measure of internal consistency. A Cronbach's alpha value of the questionnaire higher than 0.60 indicates that the questionnaire is highly reliable, indicating that the measured items are consistent and stable in capturing the intended construct. This study was approved by the Research Ethics Committee of the Faculty of Medicine, Andalas University (Approval No. 34/UN.16.2/KEP-FK/2023, dated January 27, 2023). All participants provided written informed consent prior to participation.

2.6. Data Analysis

2.6.1. Bivariate Analysis

In this study, a Chi-Square test was carried out to find the relationship between 2 categorical variables. Additionally, the odds ratio was calculated to assess the strength and direction of the association between variables. These analyses were employed to describe the data distribution, test for significant differences, measure associations between variables, and identify potential candidate variables for subsequent multivariate analysis [14].

2.6.2. Multivariate Analysis

Multivariate analysis was conducted in this study using binary logistic regression to control for potential confounding variables. This approach allowed us to identify candidate variables that have the most significant or dominant influence on the dependent variable. The analysis was performed in several stages, including variable selection, model fitting, and evaluation of the model's goodness of fit. The following are the stages of analysis:

1) Bivariate analysis was conducted using the Chi-square test to examine the association between each independent variable and the dependent variable. Variables with a *p*-value <0.25 were identified as candidates for multivariate analysis.

2) Candidate variables were selected based on the results of the bivariate analysis or theoretical relevance. Variables with *p*-value <0.25 or deemed clinically important were retained for inclusion in the multivariate logistic regression model.

3) Logistic regression analysis was performed using the backward elimination method. All candidate variables were initially entered into the model, and the variable with the highest *p*-value (>0.05) was removed at each step. The regression process was repeated until only statistically significant variables remained.

4) A confounding analysis was performed by calculating the change in odds ratios (ORs) between models. If removing a variable resulted in a ≥10% change in the OR of another variable, the removed variable was considered a confounder and retained in the model. Otherwise, it was excluded.

5) Steps 3 and 4 were repeated iteratively until the final model consisted of statistically significant variables ($p<0.05$) and confirmed confounders. Model adequacy was evaluated using the Hosmer-Lemeshow goodness-of-fit test. Final results were presented as adjusted odds ratios (AORs) with 95% confidence intervals (CIs).

3. RESULTS

In this study, the univariate analysis was carried out to describe the distribution of both the dependent variable, namely blood glucose levels, and independent variables, which include gender, employment status, education level, knowledge level, attitude, body mass index or BMI, type of financing, medication taken, use of alternative therapy, economic status, saturation factors, dietary habits, psychological conditions, family support, and the presence of other health problems. The details of this analysis are presented in Table **2**.

According to Table **2**, 58.3% of respondents had uncontrolled blood glucose levels. Additionally, 79.4% of respondents identified as female, while 52.9% were employed, as shown by their educational background. However, 51.5% of respondents had a high school education, and 61.3% of respondents exhibited inadequate expertise in blood glucose management. It was found that 59.3% of participants exhibited negative attitudes, 55.4% were classified as having mild obesity, and 89.7% received treatment through BPJS. Moreover, 67.2% of participants utilized metformin in the management of diabetes, and 52.9% of respondents, in addition to prescribed medications, also utilized herbal remedies. It was found that 64.7% of respondents belonging to a family income category exceeded the poverty threshold, and 56.9% of participants experienced monotony in dietary management while dealing with diabetes. In this study, 64.2% of participants were found to maintain an unhealthy diet, 59.8% of respondents reported experiencing adverse psychological effects when managing diabetes, 55.4% of respondents reported inadequate family support, 54.9% indicated insufficient assistance from health personnel, 63.7% perceived the facilities and infrastructure for diabetes information as inadequate, and 34.8% stated that access to health facilities was challenging.

Table 1. Distribution of samples in each health center.

No.	Health Center	Calculation (Population count)	Sample (10% of Population)
1	Andalas Health Center	835	83
2	Lubuk Buaya Health Center	673	67
3	Ambacang Health Center	548	54
Total 2.056 204			

Table 2. Frequency distribution of variables affecting blood glucose levels in diabetes mellitus patients in padang city, based on data collected from August to December 2023.

No.	Variable	Category	f	%
1	Blood glucose levels	Uncontrolled	119	58.3
		Controlled	85	41.7
2	Gender	Male	42	20.6
		Female	162	79.4
3	Employment status	Working	108	52.9
		Not working	96	47.1
4	Level of education	Did not finish school	8	3.9
		Elementary school or equivalent	35	17.2
		Junior high school or equivalent	33	16.2
		High school or equivalent	105	51.5
		College	23	11.3
5	Level of knowledge	Less	125	61.3
		Enough	79	38.7
6	Attitude	Negative	121	59.3
		Positive	83	40.7
7	Body Mass Index/BMI	Obesity	79	38.7
		Mild obesity	113	55.4
		Normal	12	5.9
8	Types of financing	Personal	6	2.9
		Insurance	15	7.4
		BPJS	183	89.7
9	Medication taken	Metformin	137	67.2
		Metformin and combinations	67	32.8
10	Use of alternative therapies	Using	108	52.9
		Not using	96	47.1
11	Economic status/family income	Below the poverty line	72	35.3
		Above the poverty line	132	64.7
12	Saturation factor	Saturated	116	56.9
		Not Saturated	88	43.1
13	Eating habits	Not healthy	131	64.2
		Healthy	73	35.8
14	Psychological conditions	Not Good	122	59.8
		Good	82	40.2
15	Family support	Not Good	113	55.4
		Good	91	44.6
16	Support for health workers	Not Good	112	54.9
		Good	92	45.1
17	Information facilities and infrastructure	Not Good	130	63.7
		Good	74	36.3
18	Access to health facilities	Difficult	71	34.8
		Easy	133	65.2

Bivariate analysis was also carried out to examine the link between the independent and dependent variables. The Chi-square test was conducted for bivariate analysis, categorizing variables as independent and dependent. Table **3** displays the outcomes of the bivariate analysis, revealing that out of 17 independent variables, 11 exhibited a significant relationship. These variables included education level, knowledge level, attitude, BMI, saturation factor, eating habits, psychological conditions, family support, health worker support, access to information facilities and infrastructure, and access to health facilities. Six variables showed no significant correlation with blood glucose regulation. They were gender, employment status, type of finance, medication administered, utilization of alternative therapy, and family income.

Of the respondents who did not graduate from elementary school, six (75.0%) exhibited uncontrolled blood glucose levels. In contrast, 62 (59.0%) of those with a high school education or equivalent also displayed uncontrolled blood glucose levels, as indicated by the cross-tabulation results in Table **2**. The statistical test findings indicated a significant link between blood glucose management and education level, as evidenced by a *p*-value of 0.005 (<0.05). The research revealed an odds ratio (OR) of 1.9, signifying that individuals aware of their incomplete elementary education were 1.9 times more likely to expe-

rience difficulties in regulating their blood sugar compared to those who completed high school or its equivalent.

Data pertaining to the relationship between blood glucose levels and knowledge level revealed that 37 (46.8%) of respondents with adequate knowledge had uncontrolled blood glucose, compared to 82 (65.6%) of respondents with less knowledge. The findings of the statistical test showed a substantial correlation between blood glucose management and knowledge level, with a *p*-value of 0.012 (<0.05). The findings of the analysis also revealed an odds ratio (OR) value of 2.1, indicating that respondents with less knowledge were 2.1 times more likely to have uncontrolled blood glucose than those with adequate knowledge.

Table 3. Results of analysis of variables affecting blood glucose levels in diabetes mellitus patients using the chi-square statistical test.

No.	Variables	Blood Glucose Levels				Total		*p*-value	OR
		Uncontrollable		Controlled					
		f	%	f	%	f	%		
1	**Gender**								
	Male	29	69.0	13	31.0	42	100	0.160	1.7 (0.8-3.6)
	Female	90	55.6	72	44.4	162	100		
2	**Employment Status**								
	Working	60	55.6	48	44.4	108	100	0.477	0.7 (0.4-1.3)
	Not working	59	61.5	37	38.5	96	100		
3	**Level of education**								
	Did not graduate from elementary school	6	75.0	2	25.0	8	100	0.005	1.9 (1.4-3.9)
	Elementary school/equivalent	20	57.1	8	42.9	35	100		
	Junior high school/equivalent	25	75.8	43	24.2	33	100		
	High school/equivalent	62	59.0	17	73.9	105	100		
	College	6	26.1	85	41.7	23	100		
4	**Level of Knowledge**								
	Less	82	65.6	43	34.4	125	100	0.012	2.1 (1.2-3.8)
	Enough	37	46.8	42	53.2	79	100		
5	**Attitude**								
	Negative	79	65.3	42	34.7	121	100	0.022	2.0 (1.1-3.5)
	Positive	40	48.2	43	51.8	83	100		
6	**Body Mass Index/BMI**								
	Obesity	4	33.3	8	66.7	12	100	0.009	2.2 (1.8-5.2)
	Mild obesity	76	67.3	37	32.7	113	100		
	Normal	39	49.4	40	50.6	79	100		
7	**Types of financing**								
	Personal	5	83.3	1	6	16.7	100	0.343	0.8 (0.3-1.9)
	Insurance	10	66.7	5	15	33.3	100		
	BPJS	104	56.8	79	183	43.2	100		
8	**Medication taken**								
	Metformin	81	59.1	56	40.9	137	100	0.860	1.1 (0.6-1.9)
	Metformin and combinations	38	56.7	29	43.3	67	100		
9	**Use of alternative therapies**								
	Using	63	58.3	45	41.7	108	100	1.000	1.0 (0.5-1.7
	Not using	56	58.3	40	41.7	96	100		
10	**Economic status/family income**								
	Below the poverty line	45	62.5	27	37.5	72	100	0.458	1.3 (0.7-2.3)
	Above the poverty line	74	56.1	58	43.9	132	100		
11	**Saturation factor**								
	Saturated	78	67.2	38	32.8	116	100	0.005	2.3 (1.3-4.1)
	Not saturated	41	46.6	47	53.4	88	100		

(Table 3) contd.....

No.	Variables	Blood Glucose Levels				Total		*p*-value	OR
		Uncontrollable		Controlled					
		f	%	f	%	f	%		
12	**Eating habits**								
	Not healthy	84	64.1	47	35.9	131	100	0.035	1.9 (1.0-3.4)
	Healthy	35	47.9	38	52.1	73	100		
13	**Psychological conditions**								
	Not Good	81	66.4	41	33.6	122	100	0.007	2.2 (1.2-4.0)
	Good	38	46.3	44	53.7	82	100		
14	**Family support**								
	Not good	75	66.4	38	33.6	113	100	0.014	2.1 (1.1-3.7)
	Good	44	48.4	47	51.6	91	100		
15	**Support for health workers**								
	Not good	75	67.0	37	33.0	112	100	0.009	2.2 (1.2-3.9)
	Good	44	47.8	48	52.2	92	100		
16	**Information facilities and infrastructure**								
	Not good	87	66.9	43	33.1	130	100	0.002	2.6 (1.4-4.7)
	Good	32	43.2	42	56.8	74	100		
17	**Access to health facilities**								
	Difficult	34	47.9	37	52.1	71	100	0.039	0.5 (0.2-0.9)
	Easy	85	63.9	48	36.1	133	100		

Data from an analysis of the association between attitudes and blood glucose levels revealed that 40 respondents (48.2%) had uncontrolled blood glucose, whereas 79 respondents (65.3%) had unfavorable attitudes and uncontrolled blood glucose. The statistical test revealed a substantial correlation between attitudes and blood glucose control, with a *p*-value of 0.022 (<0.05). Additionally, the analysis's findings revealed an odds ratio (OR) value of 2.0, indicating that individuals with negative views are 2.0 times more likely than those with good attitudes to have uncontrolled blood glucose.

Data from the analysis of BMI and blood glucose levels revealed that 39 respondents (49.4%) in the normal weight category and 76 (67.3%) in the mild obesity category had uncontrolled blood glucose levels. The statistical test yielded a *p*-value of 0.009 (<0.05), indicating a strong correlation between uncontrolled blood glucose levels and body mass index. The results of the analysis also showed an odds ratio (OR) value of 2.2, indicating that mild obesity respondents had a 2.2 times greater chance of uncontrolled blood glucose compared to respondents with normal weight. Data from an analysis of the link between saturation and blood glucose levels revealed that 41 respondents (46.6%) who were not saturated had uncontrolled blood glucose during diabetes, compared to 78 respondents (67.2%) who were saturated. The statistical test revealed a substantial correlation between the saturation variable and blood glucose management, with a *p*-value of 0.005 (<0.05). The analysis's findings also revealed an odds ratio (OR) value of 2.3, indicating that respondents with diabetes who were saturated were 2.3 times more likely to experience uncontrolled blood glucose than those who were not saturated.

Data on the relationship between blood glucose levels and eating habits revealed that 84 respondents (64.1%) had uncontrolled blood glucose due to unhealthy eating habits, while 35 respondents (47.9%) had uncontrolled blood glucose despite having healthy eating habits. The statistical test revealed a significant correlation between blood glucose control and eating pattern variables, with a p-value of 0.035 (<0.05). The findings also revealed an odds ratio (OR) value of 1.9, indicating that individuals with bad eating patterns were 1.9 times more likely to experience uncontrolled blood glucose than those with a good diet. Interestingly, the findings showed that 47.9% of respondents had uncontrolled blood glucose levels despite reporting healthy eating habits. This result suggests that while diet plays a crucial role in blood glucose regulation, it is not the only influencing factor. Other contributing factors, such as physical inactivity, stress, genetic predisposition, medication adherence, or comorbidities, may have impacted glycemic control. This highlights the importance of a comprehensive approach to diabetes management, which considers multiple lifestyle and physiological factors beyond diet alone.

Next, the analysis of the psychological condition variable in relation to blood glucose levels revealed that 81 respondents (66.4%) with poor psychological conditions had uncontrolled blood glucose while managing their diabetes. In contrast, 38 respondents (46.3%) with good psychological conditions also had uncontrolled blood glucose. The results of the statistical test showed a *p*-value of 0.007 (<0.05), which indicated a significant relationship between the psychological factor variable and blood glucose control. The results of the analysis also revealed an odds ratio (OR) value of 2.2, indicating that respondents with poor psychological conditions had a 2.2 times greater chance of uncontrolled blood glucose compared to respondents with good psychological conditions.

Data from an analysis of the link between blood glucose levels and family support revealed that 75

respondents (66.4%) had uncontrolled blood glucose and poor family support, while 44 respondents (48.4%) had uncontrolled blood glucose despite high family support. The statistical test revealed a significant correlation between blood glucose control and family support, with a *p*-value of 0.014 (<0.05). The findings also revealed an odds ratio (OR) value of 2.1, indicating that respondents with inadequate family support were 2.1 times more likely to have uncontrolled blood glucose levels than those with adequate family support.

Next, the relationship between health worker support and blood glucose levels demonstrated that 75 respondents (67.0%) who received poor support from healthcare workers had uncontrolled blood glucose, while 44 respondents (47.8%) who received good support from healthcare workers also had uncontrolled blood glucose. The results of the statistical test showed a *p*-value of 0.009 (<0.05), which indicated a significant relationship between health worker support and blood glucose levels. The findings also revealed an odds ratio (OR) value of 2.2, indicating that respondents with inadequate health worker support were 2.2 times more likely to have uncontrolled blood glucose levels than those with adequate help.

Analysis of the relationship between information facilities and infrastructure and blood glucose levels revealed that 87 respondents (66.9%) who reported poor facilities and infrastructure had uncontrolled blood glucose, while 32 respondents (43.2%) who reported good facilities and infrastructure also had uncontrolled blood glucose. The results of the statistical test showed a *p*-value of 0.002 (<0.05), which indicated a significant relationship between information facilities and infrastructure with blood glucose levels. Additionally, the results revealed an odds ratio (OR) value of 2.6, indicating that respondents who reported inadequate facilities and infrastructure were 2.6 times more likely to have uncontrolled blood glucose levels than those who reported adequate facilities and infrastructure.

Next, the analysis of the relationship between access to health facilities and blood glucose levels demonstrated that 34 respondents (47.9%) who reported difficulty accessing health facilities had uncontrolled blood glucose, while 85 respondents (63.9%) who found access to health facilities easy also had uncontrolled blood glucose. The results of the statistical test showed a *p*-value of 0.039 (<0.05), which indicated a significant relationship between access to health facilities and blood glucose levels. The findings also revealed an odds ratio (OR) value of 0.5, indicating that respondents who said it was hard to get to medical facilities were 0.5 times more likely to have blood glucose levels that were not under control than those who said it was easy.

Multivariate analysis, as presented in Table **4**, identified that among factors, such as education level, knowledge level, attitude, diet, psychological condition, family support, health worker support, and information facilities and infrastructure, the dominant factors influencing blood glucose levels were the health worker support variable and the information facilities and infrastructure variable with a *p*-value of 0.000, followed by the knowledge level variable and the diet variable with a *p*-value of 0.002.

4. DISCUSSION

Diabetes is a well-known chronic condition; nevertheless, the information disseminated about it is frequently erroneous. Misconceptions can influence an individual's approach to the prevention or management of diabetes [8]. Misunderstandings lead to improper diabetes management, including discontinuation of medication or avoidance of medical treatment in favor of unproven alternative therapies, potentially exacerbating the condition. This may result in delayed diagnosis and treatment, as individuals may perceive their symptoms as non-diabetic or not sufficiently severe, thereby heightening the risk of severe complications, such as renal, cardiac, ocular, and neurological damage [16]. It exerts both physical and psychological effects; for instance, misunderstandings can foster stigma, leading to the idea that individuals with diabetes are incapable of leading a regular life and may induce fear. This may diminish self-confidence and impact the mental health of individuals, with some ultimately losing hope [17, 18].

Ludiana *et al*. [19] found a significant relationship between psychological factors of stress and depression and blood sugar levels in patients with type 2 diabetes mellitus. The correlation between stress and blood sugar was found to be strong, while the association with depression was categorized as moderate. This association indicated a positive relationship, signifying that increased levels of stress and sadness correspond with elevated blood sugar levels in diabetes mellitus patients.

According to a study, individuals diagnosed with type 2 diabetes before the age of 40 are twice as likely to require treatment for mental illness, whereas the likelihood is lower for those who develop diabetes after the age of 40. Researchers noted that around 37% of hospitalizations in the under-40 age group were caused by mental illness. Mood disorders, such as depression, bipolar depression, and self-harm, are the most common conditions. Not only that, according to the US Department of Health and Human Services, psychotic disorders, including delusions, hallucinations, and schizophrenia, are also experienced by people with diabetes under 40 years of age [20]. Dr. Juliana Chan reported that the psychological burden associated with managing diabetes can activate stress hormones, which, in turn, may worsen blood sugar control, increase obesity, and contribute to inflammation [21].

In addition to managing psychological conditions, other interventions are also very supportive in controlling blood glucose in this technological era, including health interventions driven by Artificial Intelligence (AI), which fall into four categories that are relevant to global health researchers: (1) diagnosis, (2) assessment of patient

Table 4. Results of analysis of the most dominant variables in influencing blood glucose levels in diabetes mellitus patients with logistic regression test.

No.	Variables	Exp(B)	95% CI for EXp(B)		Sig
			Lower	Upper	
1	Education level	1.419	1.010	1.992	0,044
2	Knowledge level	3.171	1.501	6.698	0,002
3	Attitude	2.430	1.210	4.878	0,013
4	Eating pattern	3.159	1.541	6.476	0,002
5	Psychological condition	2.605	1.313	5.169	0,006
6	Family support	2.139	1.094	4.182	0,026
7	Health caregiver support	3.995	1.936	8.242	0,000
8	Information facilities and infrastructure	3.579	1.773	7.226	0,000

morbidity or mortality risk, (3) prediction and surveillance of disease outbreaks, and (4) health policy and planning. However, most studies of AI-driven interventions in global health do not explain the ethical, regulatory, or practical considerations needed for its widespread use or implementation on a large scale [22]. In assessing patient morbidity or mortality, the role of health workers is very important in terms of both emotional and information support. The results of previous research using the Fisher's Exact test showed that family support and health worker support had *p*-values of 0.007 and 0.000 (both $p < 0.05$), respectively. This indicates that, statistically, there is a significant relationship between family support and health worker support in influencing dietary compliance among diabetes mellitus patients to maintain controlled blood glucose levels [23-25].

Another research [26] indicated that Artificial Intelligence (AI), telenursing, or nurse follow-up *via* telephone significantly enhanced the self-care efficacy score of diabetes patients, improved treatment adherence, reduced glycosylated hemoglobin and plasma glucose levels, and elevated the quality of life of patients compared to standard routine care. Telenursing can proficiently prepare healthcare professionals to address non-communicable diseases, including diabetes. It is highly effective in enhancing patient understanding of drugs and insulin administration, preventing diabetes complications, and promoting self-care behaviors.

Individuals may be motivated to pursue health-related initiatives through the support and encouragement of their families and healthcare professionals. Family members and healthcare professionals may advocate for consistent blood glucose monitoring for individuals with diabetes. The formation of a new habit begins with cognitive understanding, necessitating that an individual comprehends the subject matter prior to its influence on their attitudes and behaviors. The actions taken to prevent diabetes mellitus will be determined by an individual's knowledge and understanding of the condition [27].

Understanding the patient's condition is crucial since it allows one to take preventative measures and avoid complications from diabetes mellitus. One of the reasons for the high prevalence of certain diseases, such as type 2 diabetes mellitus, is a lack of education and information. Preventing diabetes mellitus requires adequate knowledge, including an understanding of the disease, its signs and symptoms, risk factors, and effective prevention strategies. Health promotion is a key strategy for acquiring essential health-related information [28]. Knowledge plays a foundational role in guiding individual actions; people typically need to understand an issue before they can take meaningful steps to address it. According to Oyarce Calderón *et al.* [24], knowledge is crucial for facilitating positive societal change. Moreover, behaviors that are rooted in a solid understanding tend to be more sustainable over time [24].

Human behavior, including attitudes and actions related to health, is strongly influenced by an individual's level of knowledge. Previous studies have shown that individuals with higher health literacy are more likely to adopt preventive behaviors and manage chronic conditions effectively. In our study, respondents with higher knowledge levels were more likely to maintain healthy eating habits and engage in regular physical activity, supporting this association. Generally, the more knowledgeable a person is, the more likely they are to engage in appropriate or effective behavior, and vice versa. According to a study [29], 21 respondents (51.2%) with a high level of knowledge were successful in managing dengue vectors, compared to only 16 respondents (27.6%) with low knowledge who achieved the same outcome. With a *p*-value of 0.029 (≤ 0.05), the statistical test findings demonstrated a substantial link between knowledge and dengue vector control. Furthermore, the study revealed a likelihood ratio (OR) of 2.7, indicating that respondents with high knowledge were 2.7 times more likely to successfully implement dengue vector control measures than respondents with poor knowledge.

People are also influenced to take preventative action by trust. People's perceptions of the risks they face in the case of contracting the disease undoubtedly affect their decision to take preventative action. Supporting aspects come in second. This factor is dependent on whether or not there are facilities, such as sports facilities and infrastructure, that can help people take preventative steps against diabetes mellitus [30].

The availability of jogging routes, sports facilities,

including sports arenas, and other public spaces for physical activity plays a crucial role in supporting an active lifestyle and promoting overall public health. Furthermore, access to medical facilities, including clinics, physician offices, community health centers, and hospitals, is another contributing factor. People who already have diabetes will find it easier to maintain their blood glucose levels or prevent diabetes mellitus if these supporting elements are present. Studies have shown that individuals with access to safe and accessible physical activity environments are more likely to engage in regular exercise, which contributes to better glycemic control and overall well-being. In our study context, the limited availability of such facilities may be a contributing factor to the low levels of physical activity among respondents. Driving variables are impacted by the attitudes and actions of those in the patient's immediate vicinity. People who reside in places where most people regularly exercise tend to act similarly. This situation results from the person being impacted by other people's actions. [30].

This is comparable to a study [31], which examined the relationship between family support, knowledge, and blood sugar control practices in individuals with type 2 diabetes mellitus. The statistical analysis revealed a significant association, with a *p*-value of 0.002 for the influence of knowledge on blood sugar control and a *p*-value of 0.001 for the role of family support in blood sugar control. The findings indicated that among patients with type 2 diabetes mellitus in the Mangasa Health Center Work Area, Makassar City, routines for blood sugar control are significantly correlated with family support and knowledge.

According to the findings of another research [32], titled “The Relationship Between Family Support and Patients' Attitudes with Efforts to Control Blood Sugar Levels in Type 2 Diabetes Mellitus at the Banyuanyar Surakarta Health Center”, family support has a significant impact on the attitudes of individuals with diabetes as well as on their ability to control their blood glucose. The results showed a *p*-value of 0.015 for the association between family support and blood sugar control efforts and an overall *p*-value of 0.003. The findings indicated that attempts to control blood sugar levels in patients with type 2 diabetes mellitus are correlated with family support and patient attitude. This indicates that greater family support and a more positive attitude from the patient are associated with increased efforts to control blood sugar levels.

In addition to providing educational, evaluative, instrumental, and emotional support, family involvement also helps protect individuals from the harmful effects of stress and fosters a sense of acceptance from family members.

To provide family members with the impression that someone cares about them, family support is a type of interpersonal interaction that encompasses attitudes, behaviors, and acceptance of family members [33, 34].

CONCLUSION

This study reports a significant relationship between education level, knowledge, attitude, diet, psychological condition, family support, health worker support, and information facilities and infrastructure and blood glucose control behavior in patients with diabetes mellitus. Based on multivariate analysis, it was found that support from health workers and infrastructure are the most dominant factors influencing this behavior. To avoid diabetes complications and improve the quality of life of sufferers, maximum support from health workers and improvement of information sources are needed through integrated education. One of the limitations of this study is that it did not involve direct observation of the behaviors of individuals with diabetes during the research process. Instead, data were collected solely through questionnaires, with responses provided by participants based on their self-reported conditions. For this reason, it is recommended that subsequent researchers use direct observation methods or continuous monitoring techniques, such as recording diet and physical activity or continuous glucose monitoring (CGM), in order to provide more objective results regarding the behavior of people with diabetes in controlling blood glucose levels, so that the research results are more accurate and comprehensive. In addition, another limitation of this study is the limited samples. Therefore, future research is recommended to use a wider sample so that the results are more generalizable.

AUTHORS’ CONTRIBUTIONS

The authors confirm their contribution to the paper as follows: study conception and design: F, M, EY, and RS; data collection: DY; data analysis or interpretation: NN; validation: MM; draft manuscript: ASI. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

DM	=	Diabetes Mellitus
BMI	=	Body Mass Index
ADA	=	American Diabetes Association
OR	=	Odds Ratio
CGM	=	Continuous glucose Monitoring

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This research was conducted after obtaining an ethical certificate from the Research Ethics Committee of the Faculty of Medicine, Andalas University, with approval number 34/UN.16.2/KEP-FK/2023, dated January 27th, 2023, and a research permit from the Doctoral Study Program in Public Health with a number. 16/UN16/S3-KES/TU/2023. In addition, a research permit was also obtained from the Integrated Licensing Agency and One-Stop Integrated Service of Padang City, Indonesia with permit number 070.4294/DPMPTSP-PP/I/2023 dated January 30th, 2023.

HUMAN AND ANIMAL RIGHTS

All research procedures were performed on human participants and were conducted by the ethical standards of the institutional and research committee and the principles of the 1975 Helsinki Declaration, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of this article are available in the Zenodo repository at https://zenodo.org/records/15586139.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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