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The Determinants Affecting Blood Glucose Levels among Prolanis Participants with Type 2 Diabetes Mellitus (T2DM)

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ABSTRACT

Background: The control of blood glucose levels in patients with Type 2 Diabetes Mellitus (T2DM) requires attention to various lifestyle factors. Determinants such as diet, physical activity, treatment adherence, overweight (obesity), high blood pressure, stress level, smoking, and alcohol consumption play important roles in maintaining stable blood glucose levels in patients with (T2DM). To identify the determinants affecting blood glucose levels among Prolanis participants with (T2DM).
Methods: This study employed a quantitative method with a cross-sectional design involving 79 respondents selected using the Slovin formula. The research was conducted at Baturraden II Public Health Center from February to March 2025. The research instrument consisted of a combined questionnaire, including the IPAQ to assess physical activity, DASS-21 to measure stress level, and MMAS-8 to evaluate medication adherence. All three instruments were used in their standardized and internationally validated versions. Questions related to diet, overweight (obesity), blood pressure, smoking habits, and alcohol consumption were developed by the researcher and tested for validity and reliability. Data were analyzed using Spearman rank correlation and multiple linear regression tests.
Results: The majority of respondents (81%) had fasting blood glucose levels ≥126 mg/dL. Three variables showed significant correlations in the bivariate analysis, namely diet (p=0.000; r=-0.695), medication adherence (p=0.000; r=-0.526), and physical activity (p=0.046; r=-0.225). Multiple linear regression analysis revealed that only diet had a significant partial effect on fasting blood glucose levels (B=18.940; p=0.000).
Conclusion: Diet is the most dominant factor influencing fasting blood glucose levels. Nutritional education should be intensified in the implementation of the Prolanis program.

Keywords: Determinants; Type 2 Diabetes Mellitus (T2DM); Prolanis

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INTRODUCTION

Diabetes mellitus is one of the major global health problems. According to the International Diabetes Federation, 463 million people aged 20 to 79 years are living with diabetes, and this number is projected to increase to 700 million by 2045 (1). In 2021, it was estimated that 10.6% of the world's adult population had prediabetes. The global prevalence of diabetes among adults was estimated at 9.3% in 2019 and is projected to rise to 10.9% by 2045. Half of the 463 million people living with diabetes are undiagnosed or unaware of their diabetic status (2).

The transformation of Indonesia's health system focuses on improving specialist care for four major diseases that contribute to the highest mortality rates and impose a heavy burden on national healthcare financing—heart disease, stroke, cancer, and kidney disorders (3). One chronic disease that can affect multiple organs, including the kidneys, is diabetes mellitus (4). According to the 2018 Basic Health Research (Riskesdas), the prevalence of diabetes mellitus among individuals aged ≥15 years based on blood glucose measurements was 8.5%. This figure increased to 11.7% in the 2023 Indonesian Health Survey (SKI). This upward trend indicates that diabetes mellitus remains a growing public health concern in Indonesia (3). Among individuals aged ≥15 years diagnosed by a doctor, the prevalence rose from 2.0% to 2.2%. This indicates the need for self-care support, such as improving self-care knowledge and skills through healthy eating habits, physical activity, and medical adherence to maintain their health and well-being (5).

One of the approaches that can be used to analyze blood glucose levels is Abraham Maslow's theory. In Maslow's hierarchy of needs, physiological needs are the most fundamental level of the pyramid (6). These basic needs include food and drink, sleep, exercise or physical activity, stress management, normal body temperature, sexual needs, and other physiological necessities (7). The theory emphasizes care tailored to the patient's stage to meet individual pathological and psychological needs as optimally as possible. It is essential to provide effective nursing programs to enhance treatment adherence (8).

The Chronic Disease Management Program (*Program Pengelolaan Penyakit Kronis or Prolanis*) is a national program by *BPJS Kesehatan* for National Health Insurance participants with Type 2 Diabetes Mellitus (T2DM) and hypertension, aiming to improve their quality of life. Participants are selected by primary healthcare facilities based on a chronic disease diagnosis and their willingness to participate continuously. *Prolanis* activities are conducted monthly on an ongoing basis, it is not a pilot project but a nationwide program implemented across Indonesia (9). The program is carried out through routine monitoring activities, health education, and structured, continuous interventions (10).

BPJS Kesehatan stipulates that at least 75% of *Prolanis* participants should achieve disease control, including blood glucose regulation among T2DM patients. Participants who engage in regular physical activity show lower fasting blood glucose levels compared to those who are inactive (11). Support from healthcare professionals and medication adherence significantly influence glycemic control and quality of life among diabetes patients in the *Prolanis* program (12). Based on data from the Non-Communicable Disease Program at Baturraden II Public Health Center, there were 168 active *Prolanis* participants with T2DM. Among them, about 50% had fluctuating and uncontrolled blood glucose levels. Interviews with *Prolanis* participants revealed several factors suspected to contribute to these fluctuations, including diet, overweight (obesity), high blood pressure, smoking, physical activity, stress level, alcohol consumption, and therapy adherence. Participants who reported engaging in regular exercise had lower average blood glucose levels than those who were minimally active or inactive.

Based on the background above, the purpose of this study is to analyze the relationship between physical activity, stress levels, medication adherence, and other factors with blood glucose levels among *Prolanis* participants with T2DM. This study is expected to provide an overview of the factors contributing to blood glucose control and serve as a basis for more effective self-care interventions in supporting chronic disease management, particularly T2DM.

METHODS

This study used a quantitative approach with a correlational observational design and a cross-sectional method, which was conducted to determine the factors that affect blood glucose levels among participants of the Chronic Disease Management Program (*Prolanis*). The research instrument used a combined questionnaire consisting of the IPAQ to assess physical activity (13), DASS-21 to measure stress levels (14), and MMAS-8 to assess medication adherence (15), all three instruments were used in standardized versions that have been internationally validated. Questions related to diet, overweight (obesity), blood pressure, smoking habits, and alcohol consumption had been tested for validity and reliability.

Validity and reliability tests were carried out in January 2025 with a total of 30 respondents at Baturraden I Public Health Center. The study was conducted in February–March 2025. The research location was in the working area of Baturraden II Public Health Center, Banyumas Regency, which includes six assisted villages.

The population in this study were all *Prolanis* participants with T2DM at Baturraden II Public Health Center, totaling 168 people. The sample was calculated using the Slovin formula with a significance level of 10%, resulting in 63 respondents (16). To anticipate dropout, the sample size was increased by 10% to 79 respondents. The sampling technique used was purposive sampling. This technique was chosen to ensure that only participants who met the inclusion criteria were included, with the inclusion criteria being: *Prolanis* participants with T2DM, having fasting blood glucose data, willing to become respondents, and attending regularly for at least the last 3 months. The exclusion criteria included random blood glucose data, unwillingness to participate, and irregular attendance in the *Prolanis* program.

The independent variables in this study included diet (grouped as adequate if meeting ≥80% of daily nutritional needs and inadequate if <80%), overweight or obesity (based on Body Mass Index/BMI: normal=18.5–22.9 kg/m^2, overweight=23–24.9 kg/m^2, obesity ≥25 kg/m^2), high blood pressure (normal <120/80 mmHg, prehypertension=120–139/80–89 mmHg, hypertension ≥140/90 mmHg), smoking (light=1–5 cigarettes/day, moderate=6–10 cigarettes/day, heavy >10 cigarettes/day), physical activity measured using the International Physical Activity Questionnaire (IPAQ) and classified as light <600 MET-min/week, moderate=600–3000 MET-min/week, and heavy >3000 MET-min/week, stress level measured using the Depression Anxiety Stress Scale-21 (DASS-21) with mild=0–14, moderate=15–25, and severe ≥26, alcohol consumption (low risk <7 drinks/week for women or <14 drinks/week for men; at risk ≥ those limits), and adherence to therapy assessed with the Morisky Medication Adherence Scale-8 (MMAS-8) and categorized as high=score 8, moderate=6–7, and low <6. Data were collected using questionnaires and observation sheets. The validity of the instrument was tested using Pearson Product Moment analysis and reliability using Cronbach's Alpha, which showed valid and reliable results (α>0.6).

Data were analyzed univariately to describe the characteristics of variables, bivariately using the Spearman Rank test because the data were not normally distributed, and multivariately using multiple linear regression after passing the classical assumption tests (residual normality, multicollinearity, and heteroscedasticity).

This study has obtained ethical approval from the Health Research Ethics Committee of the Faculty of Health Sciences, Universitas Muhammadiyah Purwokerto (No. KEPK/UMP/157/IV/2025), and was carried out following ethical principles such as informed consent, data confidentiality, honesty, and fairness toward the research subjects.

RESULTS

This study was conducted at Baturraden II Public Health Center, Banyumas Regency, from March 6–8, 2025. The total number of respondents was 79 *Prolanis* Diabetes Mellitus participants who attended and participated in fasting blood glucose examinations.

Of the 79 respondents studied, 1 respondent (1.3%) was aged 18–24 years (late adolescence), 52 respondents (65.8%) were aged 25–59 years (adulthood), and 26 respondents (32.9%) were aged over 60 years (elderly). The age range of respondents in this study was between 24 and 74 years. The median age of respondents was 56 years, with an average age of approximately 55.9 years. A total of 11 respondents (13.9%) were male, while 68 respondents (86.1%) were female. Based on the education level, most respondents only completed elementary school (34.2%), and 12.7% had never attended school. Only 3.8% of respondents had higher education (diploma or bachelor's degree). The occupations of respondents were dominated by housewives (25.3%), farmers/laborers (21.5%), unemployed individuals (16.5%), and traders (15.2%). The remaining respondents worked as private employees (8.9%), retirees (7.6%), and others (5.1%).

The fasting blood glucose profile referred to the criteria of the American Diabetes Association and the Indonesian Society of Endocrinology (*Perkeni*). Most respondents (81.0%) had fasting blood glucose levels ≥126 mg/dL (diabetes category), 16.5% were in the prediabetes range (100–125 mg/dL), and only 2.5% were in the normal range (<100 mg/dL). The average fasting blood glucose level was 172.7 mg/dL, with a median of 158 mg/dL and a range of 70–370 mg/dL.

Based on the results, all respondents (100%) showed adequate dietary patterns, with none categorized as inadequate. The nutritional status of respondents varied: 37 respondents (46.8%) were in the normal category, 31 respondents (39.2%) were overweight (obese), and 11 respondents (13.9%) were underweight. Blood pressure data showed that 37 respondents (46.8%) were prehypertensive, 30 respondents (38.0%) were normal, and 12 respondents (15.2%) were hypertensive.

Smoking exposure was mostly in the moderate category (54 respondents or 68.4%), followed by light or non-smokers (23 respondents or 29.1%), and heavy smokers (2 respondents or 2.5%). The majority of respondents had light physical activity (39 respondents or 49.4%), followed by moderate (31 respondents or 39.2%) and vigorous activity (2 respondents or 2.5%). The stress level of most respondents was in the severe category (72 respondents or 91.1%), while 7 respondents (8.9%) were in the moderate category, and none were in the mild category.

Alcohol consumption was not a significant issue, as 75 respondents (94.9%) were in the normal category, while 4 respondents (5.1%) were at risk, with no cases of alcoholism. Medication adherence was also high, with 76 respondents (96.2%) being adherent and only 3 respondents (3.8%) non-adherent.

The Spearman rank test was used because the data were not normally distributed. The results showed that three variables had a statistically significant relationship with fasting blood glucose levels, as shown in the **Table 1**.

Table 1: Spearman Rank Test (N=79)

Variable	Sig. Value (2-tailed)	Correlation Coefficient
Dietary and Drinking Patterns	*0.000	0.695
Overweight (Obesity)	0.365	0.103
High Blood Pressure	0.592	0.061
Smoking	0.375	-0.101
Physical Activity	*0.046	0.225
Stress Level	0.417	0.093
Alcohol Consumption	0.066	-0.208
Medication Adherence	*0.000	-0.526

*$p<0.05$

Based on the results of the bivariate analysis using the Spearman rank test, the results showed that the variables of overweight (obesity), blood pressure, smoking habits, stress level, and alcohol consumption habits were not statistically significant on blood glucose levels because $p>0.05$. The variables of eating and drinking patterns, physical activity, and medication adherence were found to be significantly related to blood glucose levels in *Prolanis* participants with T2DM. Eating and drinking patterns (r=0.695; $p<0.001$). Physical activity (r=-0.225; $p<0.046$). Medication adherence (r=-0.526; $p<0.001$).

The feasibility test with residual normality test, multicollinearity test, and heteroscedasticity test had been carried out beforehand, so that multiple linear regression test could be performed to see the simultaneous effect of independent variables on fasting blood glucose levels with the results as shown in the following **Table 2**.

Only dietary and drinking patterns had a statistically significant effect on fasting blood glucose (FBG) levels (B=18.940; $p<0.001$). Other variables did not demonstrate a significant statistical influence. The analysis yielded an R value of 0.741 and an R Square of 0.549, indicating that 54.9% of the variation in FBG levels could be explained by the variables included in the model.

Table 2: Multiple Liver Regression (N=79)

Variable	Coefficients	
	Unstandardized Coefficient B	Sig.
(Constant)	41.387	0.622
Dietary and Drinking Patterns	18.940	0.000*
Overweight (Obesity)	0.316	0.821
High Blood Pressure	0.084	0.881
Smoking	1.825	0.379
Physical Activity	1.153	0.374
Stress Level	-0.268	0.905
Alcohol Consumption	-0.320	0.743
Medication Adherence	-3.410	0.113

*p<0.05

DISCUSSION

This study found that eating and drinking patterns were the most dominant factors affecting fasting blood glucose levels among *Prolanis* participants with T2DM at Puskesmas Baturraden II. The regression results showed that dietary patterns had a significant effect, with a regression coefficient value of B=18.940 and p=0.000. This means that every one-unit increase in the eating and drinking pattern score will increase fasting blood glucose levels by 18.94 mg/dL, assuming other variables remain constant. This finding reinforces the evidence that nutritional interventions are the main pillar in managing T2DM. Similar studies have shown that dietary patterns with a high glycemic index, low fiber intake, and excessive sugar consumption have a significant impact on increased blood glucose levels (17). Another study found that dietary patterns such as ketogenic, low-carbohydrate, and low-glycemic-index diets were proven effective in significantly lowering fasting blood glucose and HbA1c levels (18). Respondents who consumed high-fat and processed foods had higher glucose levels compared to those who applied balanced eating patterns (19). Another finding revealed that sweetened beverages and foods high in simple carbohydrates were associated with increased blood glucose levels and difficulty in glucose management among diabetic patients (20). A study conducted at Puskesmas Kota Bengkulu also showed a relationship where the higher the participants' adherence to a healthy lifestyle, the lower the patient referral rate in Bengkulu City (p=0.024) (21).

Bivariate testing using the Spearman rank test showed a significant relationship between physical activity and fasting blood glucose levels, with a significance value of p=0.046 and a correlation coefficient of -0.225. This negative correlation indicates that the higher the level of physical activity, the lower the fasting blood glucose level tends to be. However, the results of the multiple linear regression analysis (multivariate) showed that physical activity did not have a statistically significant effect on fasting blood glucose levels. This is indicated by the regression coefficient (B) value of 1.153 and a significance value of p=0.374. The difference between the bivariate and multivariate results may be due to the influence of other variables that were controlled in the regression model. The bivariate test only shows the direct relationship between physical activity and fasting blood glucose levels, while the multivariate analysis considers other variables such as medication adherence, stress, eating patterns, obesity, and blood pressure. After these variables were included, the effect of physical activity was no longer statistically significant, indicating that the relationship was likely influenced by other factors or its effect was not independent. This finding is consistent with a study using the Mendelian randomization approach on more than 300,000 respondents, which concluded that physical activity (both moderate and vigorous) did not have a significant causal relationship with blood glucose levels, HbA1c, or the risk of T2DM (22). Experimental studies have also shown that increasing the number of steps or daily physical activity in pregnant women with diabetes did not have a significant impact on fasting blood glucose levels, although there was a slight average decrease, it was not statistically significant (p=0.54) (23). Another study showed that intensive lifestyle interventions involving moderate dietary regulation (low-carbohydrate Mediterranean diet) and structured physical activity were able to reduce blood glucose levels and even achieve partial remission of T2DM in up to 41% of participants within 12 months (24). Another study confirmed that moderate-to-high-intensity physical activity for ≥150 minutes per week resulted in greater improvement in glycemic control compared to shorter durations (25). Similar research reinforced that engaging in regular physical activity, including aerobic exercises, strength training, or a combination of both performed consistently every week, helps the body maintain controlled blood glucose levels. This habit not only provides protection against vascular complications such as heart disease and stroke but also increases the body's sensitivity to insulin. Thus, the body responds more effectively to medication therapy, improving the quality of life of diabetes patients (26).

Medication adherence in the bivariate test using the Spearman rank method also showed a significant relationship with fasting blood glucose levels, with a significance value of p=0.000 and a correlation coefficient of -0.526. This negative correlation indicates that the higher the level of adherence to medication, the lower the fasting blood glucose level tends to be, reflecting better glycemic control among respondents. However, the results of the multivariate analysis using multiple linear regression showed that the medication therapy variable did not have a statistically significant effect on fasting blood glucose levels. This is indicated by the regression coefficient (B) value of -3.410 and a significance value of p=0.113. After accounting for other variables such as eating patterns, stress level, physical activity, and smoking habits, medication adherence did not appear as a main predictive factor in the regression model. This finding is supported by studies showing that patients with T2DM who adhere to oral medication regimens have much better-controlled fasting blood glucose levels compared to those who are non-adherent (p=0.000) (27). Another study also stated that the use of insulin or oral medication alone is not effective in controlling blood glucose levels if patients are not consistent in taking medication and attending regular check-ups. It was even found that patients who adhered to simple therapy tended to have better fasting blood glucose outcomes than those with complex therapy but poor adherence (28). A similar study in Western Ethiopia concluded that low medication adherence was significantly associated with poor glycemic control among patients with T2DM (29). A study in the United States using AI-based analysis also confirmed a significant relationship between medication adherence and blood glucose levels in patients with T2DM (30).

CONCLUSION

The results of the study showed that although most *Prolanis* participants had relatively good eating and drinking patterns, high adherence to therapy, and low stress levels, the majority still exhibited fasting blood glucose levels ≥126 mg/dL. Bivariate analysis indicated that eating and drinking patterns had the strongest and most significant relationship with fasting blood glucose levels (p=0.000; r=-0.695), followed by medication adherence (p=0.000; r=-0.526) and physical activity (p=0.046; r=-0.225). Meanwhile, the multivariate analysis results showed that only eating and drinking patterns had a partially significant effect on blood glucose levels (B=18.940; p=0.000), although all variables simultaneously contributed significantly to the model (p=0.000).

These findings indicate that glycemic control among *Prolanis* participants is not only influenced by therapy adherence but also heavily depends on healthy and consistent eating habits. Therefore, these results emphasize the importance of strengthening nutritional education, monitoring eating behavior, and promoting healthy lifestyle habits within the implementation of the *Prolanis* program. In the context of primary healthcare services, integrated interventions involving medical personnel, nurses, and nutritionists are needed to enhance program effectiveness and help patients achieve optimal and sustainable blood glucose control.

LIMITATIONS AND RECOMMENDATIONS

This study is limited by the exclusion of external factors such as education, herbal medicine use, and family support. Data were obtained from self-administered questionnaires, which are prone to bias, and the study location and number of respondents were limited. Future research is recommended to employ more detailed quantitative methods, such as comprehensive dietary intake analysis and disease duration assessment, to achieve more accurate results.

CONFLICT OF INTEREST

The authors declare no conflict of interest in this study.

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AUTHOR CONTRIBUTIONS

FMN: Drafted the manuscript and contributed to the conceptual development and design of the article through data collection, analysis, and interpretation for this study.
S: Critically revised the manuscript by providing intellectual input and approved the final version of the manuscript.
ADA: Supervision, guidance during the research process, data interpretation support and critical review of the manuscript.

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