Exploring Factors Influencing Diabetes Mellitus Incidence Among Participants of Chronic Disease Management Program in Rural Areas

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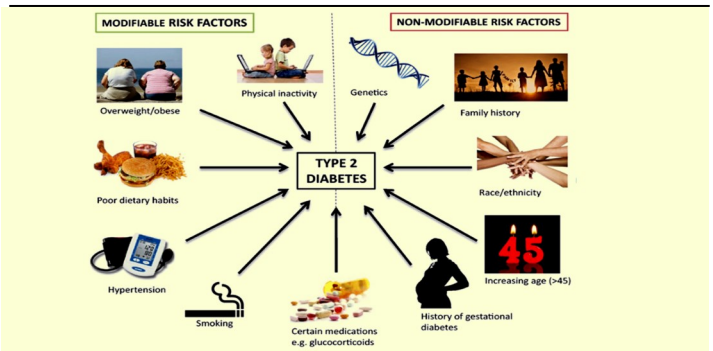
ABSTRACT

Diabetes mellitus (DM) is a chronic disease with an increasing global prevalence, including in Gorontalo Province, specifically type 2 DM (T2DM). Various risk factors, such as lifestyle, obesity, and lack of physical activity have been reported to contribute to DM incidence. This shows the importance of developing more effective prevention and management strategies. Therefore, this study aimed to explore factors related to DM incidence among participants of Chronic Disease Management Program (Prolanis) in rural areas of Boalemo District, Gorontalo Province. A quantitative method was used with a cross-sectional approach on 300 participants who were selected through the purposive sampling method. Data were collected using questionnaires to measure physical activity, dietary patterns, and smoking habits. Meanwhile, body mass index (BMI) and blood glucose levels were measured anthropometrically and through blood sugar tests. The results showed that dietary patterns (carbohydrates (p=0.003), fats (p=0.00), and fiber (p=0.000)), smoking habits (p=0.016), BMI (p=0.039), age (p=0.00), genetic factors (p=0.00), and gender (p=0.00) were significantly associated with DM incidence, while physical activity (p=0.095) and protein intake (p=0.128) were not associated. In this context, dietary fiber intake was the strongest predictor with Odds Ratio (OR) value of 7.37. Based on the results, dietary fiber intake, smoking habits, BMI, and age had a significant influence as predictors of DM incidence. The implications for public health included the need to increase awareness of the importance of healthy dietary patterns, reduce smoking habits, and monitor BMI to control the prevalence and improve the overall welfare of rural community.

ABSTRAK

Diabetes melitus (DM) adalah penyakit kronis dengan prevalensi global yang meningkat, termasuk di Provinsi Gorontalo terutama DM tipe 2. Berbagai faktor risiko seperti gaya hidup, obesitas, dan kurangnya aktivitas fisik berkontribusi pada kejadian DM, yang mendorong pentingnya penelitian lebih lanjut untuk strategi pencegahan dan pengelolaan yang lebih efektif. Penelitian ini bertujuan untuk mengeksplorasi faktor-faktor yang berhubungan dengan kejadian diabetes melitus (DM) pada peserta program Pengelolaan Penyakit Kronis (Prolanis) di wilyah pedesaan Kabupaten Boalemo, Provinsi Gorontalo. Metode penelitian yang digunakan adalah studi kuantitatif dengan pendekatan cross-sectional. Sampel sebanyak 300 peserta dipilih melalui metode purposive sampling. Data dikumpulkan menggunakan kuesioner untuk mengukur aktivitas fisik, pola makan, kebiasaan merokok, sedangkan indeks massa tubuh (IMT) dan kadar glukosa darah dilakukan pengukuran atropometri dan tes gula darah. Hasil penelitian menunjukkan bahwa pola makan (karbohidrat (p=0,003), lemak (p=0,00), dan serat (p=0,000), kebiasaan merokok (p=0,016), IMT (p=0,039), usia (p=0,00), faktor genetic (p=0,00), dan jenis kelamin (p=0,00) memiliki hubungan yang signifikan dengan kejadian DM, sementara aktivitas fisik (p=0,095) dan asupan protein (p=0,128) tidak berhubungan. Asupan serat makanan merupakan prediktor terkuat kejadian DM dengan nilai OR = 7,37. Hasil penlitian disimpulkan bahwa asupan serat makanan, kebiasaan merokok, IMT dan umur sebagai memiliki pengaruh signifikan sebagai predictor pada kejadian diabetes. Implikasinya pada kesehatan masyarakat adalah perlunya peningkatan kesadaran akan pentingnya pola makan yang sehat, pengurangan kebiasaan merokok, dan monitoring IMT untuk mengendalikan prevalensi diabetes dan meningkatkan kesejahteraan masyarakat desa secara keseluruhan.

GRAPHICAL ABSTRACT



Keyword
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INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disease and a public health problem with an increasing global prevalence. The disease is characterized by hyperglycemia caused by impaired insulin secretion, insulin action, or both (American Diabetes Association, 2021). In addition, the prevalence of DM in Indonesia has also significantly increased, specifically with the increase in the number of type 2 DM (T2DM) patients, which is often related to lifestyle and other risk factors (Ministry of Health of Indonesia, 2019).

According to the International Diabetes Federation (IDF), approximately 537 million individuals aged 20 to 79 are expected to have DM worldwide by 2021, a 3-fold increase since 2000. The IDF also estimated that 240 million individuals are undiagnosed, hence, 1 in 2 adults may have the disease without a diagnosis. The number of DM patients was predicted to reach 643 million by 2030 and 783 million by 2045. In the United States, a new individual is diagnosed with DM every 21 seconds, as reported by the American Diabetes Association (2021), with increasing prevalence being recorded in Indonesia. Data from the Ministry of Health of Indonesia (2019) showed that approximately 10.7 million individuals in Indonesia had DM. This number is expected to continue increasing along with changes in lifestyles and diets. The Ministry of Health also reports that many cases of DM in the country are undiagnosed, making the prevention and management of the disease a major challenge for the national health system.

In line with the results, various factors are associated with DM incidence. For example, a previous study reported significant risk factors, such as age above 45 years, gender, family history of DM, obesity, hypertension, and lack of physical activity (Saputra & Budiyasa, 2023; Irma, 2019; Jiang et al., 2019; Zhou et al., 2016). In addition, environmental factors, such as lifestyle choices, diet, physical activity, and epigenetic changes play an important role in the development of DM (Rahman et.al., 2021). Obesity and unhealthy diets have also been reported to be significant contributors to the increasing prevalence, with approximately 422 million patients worldwide, particularly in low- and middle-income countries, and 1.5 million deaths each year (World Health Organization, 2020). Stress and psychosocial factors have been found to be associated with an increased risk of DM. In this context, chronic stress can affect the balance of hormones in the body, including those that regulate blood sugar levels (Hackett & Steptoe, 2016). Therefore, a multidisciplinary method to the prevention and management of DM is needed to reduce the prevalence and negative impact.

The high incidence of the disease has prompted the government to pay more attention, thereby ensuring that affected patients can lead a healthy lifestyle and improve the quality of life. The prevalence of DM in Indonesia varies between regions, including Gorontalo Province and Boalemo District. Based on data from the local Health Office, there has been a significant increase in recent years. In Gorontalo Province, the prevalence reached 3.8% in 2021, up from 3.5% in the previous year, due to lifestyle changes and unhealthy eating patterns (Health Office of Gorontalo Province, 2022). Meanwhile, in Boalemo District, the value increased to 4.1% in 2021 from 3.9% in 2020, with major risk factors including obesity and lack of physical activity. The high DM incidence in this area has prompted the local government to improve efforts to prevent and manage the disease through Chronic Disease Management Program (Prolanis) program. Prolanis aims to educate and support patients in controlling blood sugar levels and living a healthy lifestyle.

Although studies on factors associated with DM incidence have been conducted, the majority only solely focused on Prolanis participants, specifically in rural Boalemo District, Gorontalo. Building on this idea, there are still several gaps that need to be further explored regarding specific variables, such as physical

activity, diet, smoking habits, and body mass index (BMI) as important factors in the prevention and management. Therefore, this study aims to explore factors associated with DM incidence in Prolanis participants and identify predictors in rural areas of Boalemo District, Gorontalo.

METHODS

This was a quantitative study with a cross-sectional approach that explored the relationship between dependent and independent variables. The procedures were carried out in Boalemo Regency, Gorontalo Province from April 17, 2023, to May 17, 2023. The sample population comprised 1,140 patients suffering from DM and receiving standard treatment in Boalemo District (Health Office of Bolaang Mongondow District, 2022). The participants were obtained using the Slovin formula, leading to a sample size of 300 individuals selected using the purposive sampling method.

Data collection was conducted using several detailed steps to obtain comprehensive information on physical activity, diet, smoking habits, BMI, and blood glucose of Prolanis program participants in Bolamangondow, Gorontalo. The study team used a pre-validated questionnaire to evaluate habitual physical activity levels. These included the type and intensity of physical activity performed and the estimated time spent on each type of physical activity in the past week. The questionnaire used was adopted from the GPAQ (Global Physical Activity Questionnaire) as a physical activity measurement tool developed by WHO to determine the intensity, which was categorized as light, medium, or high (World Health Organization, 2022).

A structured interview using the FFQ, which comprised questions on the frequency, amount, and type of food consumed, as well as additional information, such as meal timing and food preferences was carried out to obtain information on participants' diet. In addition, the identification of smoking habits was carried out after informed consent by asking specific questions that explored smoking history, frequency, and amount of cigarette consumption per day. These questionnaires provided an overview of smoking habits and exposure to health risks. BMI measurement was conducted by measuring the weight and height using standardized tools, such as digital scales and multifunctional height measuring instruments. Subsequently, BMI value was calculated to evaluate nutritional status and obesity risk. Blood glucose measurement was conducted by the manager of Prolanis of community health care program using a rapid test tool in the form of an autocheck brand glucometer.

Data were analyzed descriptively to understand the characteristics of the observed variables. Subsequently, a correlation was performed to analyze the relationship between gender, genetics, physical activity, diet, smoking habit, and BMI with DM incidence using a chi-square test. Logistic regression was then used to identify the variables that had the most influence on DM, presented in the form of tables. This study obtained ethical eligibility on April 10, 2023, with No. B.408/KEPK/F: B.408/KEPK/FKIK/IV/2023 from the Health Studies Ethics Committee, Faculty of Medicine and Health Sciences, UIN Alauddin Makassar.

RESULTS

Table 1 provided an overview of the characteristics of Prolanis program participants. The data indicated the distribution based on gender, age, family history of DM, physical activity, diet, smoking habits, BMI, and blood glucose test results. The majority were female (66.3%), aged 41-60 years (36.0%) who had a family history of DM (35.7%), heavy physical activity (41.6%), a risky diet associated with DM, and a normal BMI (56.0%). The results of GDS examination showed that the majority had the disease (71.67%).

Table 2 revealed the factors associated with DM in Prolanis program participants. The results of the bivariate analysis showed that

Table 1
The characteristics of Prolanis program participants

Characteristics of Variables	Frequency	Percentage
Gender		
Male	101	33.7
Female	199	66.3
Age		
25-30 years	10	3.3
31-40 years	28	9.3
41-50 years	108	36
51-60 years	147	49
61-75 years	7	2.4
Genetic (Family History of DM)		
Yes	107	35.7
No	193	64.3
Physical Activity		
Light	101	33.7
Medium	74	24.7
Heavy	125	41.6
Diet (risk of DM)		
Carbohydrate Source		
Risk	179	59.7
Not at risk	121	40.3
Protein Source		
Risk	207	69
Not at risk	93	31
Fat Source		
Risk	213	71
Not at risk	87	29
Fiber Source		
Risk	186	62
Not at risk	114	38
Smoking habit		
Not at risk	180	60
Low risk	46	15.3
High risk	74	24.7
Body Mass Index (BMI)		
Underweight	15	5
Normal weight	168	56
Overweight	42	14
Obesity level 1	75	25
Real-Time Blood Glucose		
Normal (< 140 mg/dl)	52	17.3
Pra DM (140-199 mg/dl)	33	11
DM (> 199 mg/dl)	215	71.67

carbohydrate sources, fat sources, smoking habits, BMI, age, genetics, and gender exhibited significant p values associated with the incidence of the disease. The variables of carbohydrate sources, fat sources, smoking habits, BMI, age, genetics, and gender showed an important association with DM based on the results of the Chi-Square test ($p<0.05$). This indicated that the factors could be predictors for risk of DM in Prolanis program participants.

The results of a multivariate analysis of risk factors for DM incidence in Prolanis program participants were presented in Table 3. The results of the analysis using regression tests showed that carbohydrate sources, fat sources, genetics, and gender were not significantly related to the incidence of the disease. This indicated that the 4 variables were not predictors of risk in participants. Meanwhile, the variables of fiber source, smoking habit, BMI, and age were known to be significantly influential.

Table 2
Bivariate analysis factors associated with DM Prolanis participants

Variable	Diabetes Mellitus				Total	P-value
	Yes		No			
	n	%	n	%		
Physical activity						
Heavy	99	79.2	26	20.8	125	0.095
Medium	59	79.7	15	20.3	74	
Light	90	89.1	11	10.9	101	
Carbohydrate Source						
Risk	158	88.3	21	11.7	179	0.003*
Not at risk	90	74.4	31	25.6	121	
Protein Source						
Risk	166	80.2	41	19.8	207	0.128
Not at risk	82	88.2	11	11.8	93	
Fat Source						
Risk	190	89.2	23	10.8	213	0.000*
Not at risk	58	66.7	29	33.3	87	
Fiber Source						
Risk	173	93	13	7	186	0.000*
Not at risk	75	65.8	39	34.2	114	
Smoking Habit						
High risk	59	79.7	15	20.3	74	0.016*
Low risk	44	95.7	2	4.3	196	
Not at risk	145	80.6	35	19.4	180	
IMT						
Obese I	57	76	18	24	75	0.039*
Overweight	34	81	8	19	42	
Normal weight	142	84.5	26	15.5	168	
Underweight	15	100	0	0	15	
Age						
>40 years	240	91.6	22	8.4	262	0.000*
<40 years	8	21.1	30	78.9	38	
Gen						
Yes	172	89.1	21	10.9	193	0.000*
No	76	71	31	29	107	
Gender						
Female	176	88.4	23	11.6	199	0.000*
Male	72	71.3	29	28.7	101	

Note: *p < 0.05 significant value; using Chi Square test

DISCUSSION

Based on studies that have been conducted, factors such as diet (sources of carbohydrates, fat, and fiber), smoking habits, BMI, age, genetics, and gender had been shown to exhibit a significant relationship with DM incidence. Meanwhile, physical activity in this study had no association in Prolanis participants.

Relationship between Physical Activity and Diabetes Mellitus Incidence

The results showed that although many participants engaged in strenuous physical activity in Boalemo District, the majority were at risk of developing DM. Most participants had occupations as farmers, which promoted the engagement in strenuous physical activity despite suffering from DM. However, there was no significant association between physical activity and DM incidence, with a p-value of

Table 3
Multivariate analysis of risk factors for DM incidence

Sub Variables	Coefficient	S.E	P-value	OR	CI 95%
Carbohydrate Source	0.041	0.45	0.928	0.96	0.397-2.320
Fat source	0.322	0.472	0.492	1.384	0.548-3.494
Fiber source	1.994	0.453	0.000*	7.371	3.024-17.853
Smoking habit	0.882	0.433	0.042*	2.416	1.034-5.647
IMT	0.339	0.151	0.024*	1.404	1.045-1.886
Age	-3.623	0.599	0.000*	0.027	0.008-0.86
Genetic	0.074	0.461	0.872	0.929	0.377-2.290
Gender	0,383	0,555	0,489	0,682	0,230-2,021

Note: *p < 0.05 significant value; OR: Odds Ratio; CI: Confidence Interval; using logistic regression test

0.095. This study contradicted Veridiana,& Nurjana (2019), which stated that higher physical activity could reduce risk of DM, while low activity increased the risk. However, the results were consistent with Nuraini & Supriatna (2019), which found no significant relationship between physical activity and DM incidence at Bunda Margonda Depok General Hospital.

Physical activity played an important role in the prevention and management of DM. Studies indicated a negative association between physical inactivity and T2DM, which could lead to decreased insulin sensitivity and glucose tolerance (Chen, 2023). de Oliveira et al. (2021) highlighted the benefits of physical exercise, including improved glycemic control and reduced HbA1c levels in individuals with T2DM. Although many participants engaged in strenuous physical activity in Boalemo District, there was no significant association between physical activity and DM incidence, physical activity was important in the prevention and management of the condition.

Relationship between Diet and Diabetes Mellitus Incidence

The relationship between diet such as carbohydrate, fat, and fiber intake, as well as DM was found in the study. The majority of participants (88.3%) who consumed carbohydrates were at risk of DM, with carbohydrates as the staple food. Meanwhile, most participants (89.2%) who consumed vegetable fat were also at risk of DM as fatty foods were part of the local habit. There was a significant relationship between carbohydrate, and vegetable fat consum'ption, and DM incidence. In addition, the majority of participants (93.0%) who consumed a lot of fruits were at risk of DM, primarily due to the consumption of high-sugar fruits such as bananas. However, some did not have DM despite consuming large amounts of fruit, indicating a significant association between fruit consumption and DM.

The result was consistent with previous studies, stating that consumption of simple carbohydrates including added sugars and high-carbohydrate processed foods was associated with an increased risk of T2DM. In contrast, consumption of complex carbohydrates such as fiber from vegetables, fruits, and whole grains had a protective effect against DM (Schwingshackl et al., 2017). Another study published in the American Journal of Clinical Nutrition indicated that high saturated fat intake also increases risk of DM, while unsaturated fats such as fats from olive oil and canola oil exhibited a protective effect (Guasch-Ferré et al., 2015). Fiber sources had an association with DM incidence. Each increase in fiber intake by 8 grams per day was related to an 18% reduction in the risk of T2DM (Reynolds et al., 2019).

A large study involving over 36,000 participants found that higher fiber intake, specifically from plant-based sources comprising

vegetables, fruits, and whole cereals, was associated with a 25% reduced risk of T2DM (The InterAct Consortium, 2015).

Diet played an important role in DM incidence, with specific nutrient composition impacting risk of DM. Studies revealed that a high intake of chocolate, confectionery, butter, low-fiber bread, and added sugar foods, coupled with low consumption of fresh fruits and vegetables, was associated with a higher risk of developing T2DM, specifically among younger individuals and those who were obese (Sudrajat et al., 2023). Furthermore, diets rich in fruits or vegetables, fiber, vitamins, minerals, and antioxidants, while low in animal products, processed foods, sugar, and saturated fats, were associated with a reduced risk of metabolically unhealthy obesity, metabolic syndrome, and ultimately, T2DM (Zhang et al., 2023). Understanding these dietary patterns and the impact on DM was crucial to developing effective prevention measures and public health interventions to combat this growing health problem.

Relationship between Smoking Habit and Diabetes Mellitus Incidence

The study observed that the majority of participants who smoked (79.7%) were at risk of DM, specifically men who had long been accustomed to smoking large quantities of cigarettes. Although some men were not diagnosed with DM, and still smoke cigarettes in large quantities, increasing risk of DM recurrence. Some participants did not exhibit DM despite smoking. The association between smoking and DM was significant according to the results of the study (p=0.016).

The result was supported by previous studies that confirmed that smoking increases the risk of T2DM, with a higher risk in heavy smokers and long-term smokers (Pan et al., 2015). This was in line with a large study in the Chinese population which found that smoking increased the risk of T2DM (Yan et al., 2022). Recent meta-analyses had also confirmed the association between active and passive smoking and increased risk of T2DM (Akter et al., 2017; Pan et al., 2015). Although some of participants, who were no longer diagnosed with DM still smoke large amounts of cigarettes, which increased risk of DM recurrence. This was consistent with the results of a meta-analysis involving 56 studies, which found a significant association between smoking and increased risk of T2DM (Liu et al., 2019). The mechanisms behind the association between smoking and DM include increased insulin resistance, impaired pancreatic beta-cell function, systemic inflammation, and oxidative stress (Halim & Halim, 2019).

Relationship between Body Mass Index and Diabetes Mellitus Incidence

The results showed a significant relationship between BMI and DM in Boalemo Regency, with a p-value of 0.039. The majority of participants with Obesity I (76%) also exhibited DM. This result was in line with a recent meta-analysis involving 89 cohort studies which observed a strong association between obesity and increased risk of T2DM (**Afshin et al., 2017**). Increased body weight and obesity could lead to insulin resistance and impaired glucose metabolism, which contributed to the development of DM (Galicia-Garcia et al., 2020).

In this study, some participants stopped physical activity, which led to an increase in body weight and risk of DM. This was supported by studies showing that a lack of physical activity and a sedentary lifestyle were independent risk factors for obesity and T2DM (Altobelli et al., 2020). However, some participants experienced Obesity I but did not suffer from DM, as a result of irregular eating habits, which could still affect weight gain, though it had not led to DM. Other factors such as genetics and body composition could also play a role (Cole & Florez, 2020).

Relationship between Age, Genetics, and Gender with Diabetes Mellitus Incidence

Based on the results, there was a significant relationship between age and DM with a p-value of 0.000. The majority of participants over 40 years old (76%) had DM. This result was consistent with previous studies indicating that risk of DM increased with age, specifically after 40 years of age (Chatterjee et al., 2017). Increased age was associated with decreased insulin sensitivity and impaired function of insulin-producing pancreatic beta cells (Guevara et al., 2021). Many participants over the age of 40 were not physically active and were targeted by Prolanis program in this study. This was consistent with the result that lack of physical activity and a sedentary lifestyle were important risk factors for DM in older age. Although, there were still some participants who were over 40 years old who did not suffer from this disease. This could be because the regular check-ups were continued despite not experiencing the disease. Genetic factors and a healthy diet could also play a role in preventing DM at an older age (Ligthart et al., 2016). However, there were also participants under the age of 40 who had DM. Furthermore, this study confirmed a significant association between age and DM. Although the risk tended to increase with age, other factors such as physical activity, diet, and genetics also played a significant role in determining risk of DM, both at older and younger ages.

This study found a relationship between genetic factors and DM, with most participants who had a family history (89.1%) also suffering from this disease. Other studies had shown similar results, about the relationship between heredity and DM. The study by Kral et al. (2019) showed that family history increased the risk of T2DM in the population. Manson et al. (2020) indicated that genetic factors contributed about 40% to the risk in a multi-ethnic US population. Li et al. (2021) in China found that individuals with a family history and unhealthy lifestyles had a higher risk. Lohmueller et al. (2022) identified genetic variants that heightened the risk of heritable T2DM and the risk in individuals with a family history could be influenced by age, gender, and ethnicity.

The majority of female participants (88.4%) also had DM, utilizing Prolanis program more. In contrast, most male participants (71.3%) had DM, primarily due to old age and participation in Prolanis program. There were still some male participants who did not have DM despite participating in the program. Various studies had revealed differences in the risk of T2DM between men and women. Kautzky-Willer et al. (2016) indicated that Austrian women were at higher risk after menopause. Men were at higher risk at a young age, but women were more at risk at a later age in China (Wang et al., 2021). Ohkuma et al. (2018) revealed that obese Dutch women were at higher risk compared to men.

Predictors of Diabetes Mellitus Incidence

The results of a multivariate analysis of risk factors for DM incidence in Prolanis program participants indicated that several variables studied, such as carbohydrate sources, fat sources, genetics, and gender, were not significantly related to DM incidence. However, the variables of fiber source, smoking habit, BMI, and age proved to have a significant influence. These variables could be considered risk predictors of DM in Prolanis program participants. The results of the analysis showed that fiber intake was the most influential variable, such as fruit consumption with Odds Ratio (OR) value of 7.348. This indicated means that participants who had low or inadequate fruit consumption were at 7.3 times the risk of experiencing DM.

Dietary fiber intake played an important role in predicting DM incidence. Studies showed that higher dietary fiber consumption was associated with a decreased risk of developing T2DM (Cao et al., 2023; Gao, 2022; Jin et al., 2021). Studies also showed that individuals with a higher intake of total fiber and fruit fiber exhibited a reduced risk of gestational diabetes mellitus (GDM) (Xu et al, 2021). The associa-

tion between dietary fiber and impaired glucose metabolism, which included pre-DM and T2DM, highlighted the importance of including sufficient fiber in the diet to reduce the risk of developing this disease. These results emphasized the potential of dietary fiber as a predictive factor for DM incidence. Other predictors found in this study to be associated with DM were smoking, BMI, and age.

Smoking significantly influenced the development of DM by contributing to insulin resistance, dyslipidemia, altered pancreatic function, and increased risk of cardiovascular disease (Artese et al., 2019). Nicotine, known as a key component of cigarettes, played an important role in activating pathways that led to insulin resistance, which ultimately increased risk of DM (Rehman et al., 2021). Studies have shown that smokers exhibit higher insulin levels, impaired pancreatic enzyme activity, and dysregulated lipid profiles compared to non-smokers, which were risk factors for the development of this disease. Furthermore, smoking cessation or reduction was highlighted as a beneficial strategy in preventing DM, as it could help improve insulin sensitivity, reduce the risk of vascular complications, and aid glycemic management in individuals with this disease. Therefore, addressing smoking was essential in the prevention and management of DM.

BMI also played a significant role as a predictor for DM. Studies had shown a primary relationship between BMI and DM incidence, where higher BMI values were associated with an increased risk of developing DM (Irawan et al., 2021). In addition, studies had highlighted the correlation between BMI and HbA1c levels in T2DM patients, emphasizing the importance of monitoring BMI as a potential indicator for DM conditions (Irma et al, 2022). Furthermore, investigations revealed that BMI was not only important for assessing body proportionality but also served as a tool for monitoring body condition and the relationship with weight abnormalities, making it a valuable asset in managing weight-related health issues such as DM (Tursinawati et al., 2022).

The results supported the importance of addressing diet, smoking, and BMI in the prevention and management of DM. The results of this study had direct implications for public health. The importance of dietary fiber intake needed to be emphasized in DM prevention. Greater efforts were necessary to reduce smoking due to its strong association with DM. Monitoring BMI must be a focus in public health programs to control the prevalence of DM. These measures could help reduce the disease burden of DM and improve the overall welfare of the community. This study had several limitations that needed to be noted. First, the cross-sectional design used only allowed data collection at one point in time, so it could not directly evaluate cause-and-effect relationships. The results could not be fully applicable because it was conducted in a location with a specific cultural and environmental context.

CONCLUSIONS

In conclusion, this study identified factors associated with DM incidence, including diet, smoking habits, BMI, age, genetics, and gender. The results showed that dietary fiber intake, smoking habits, BMI, and age had a significant influence as predictors of DM incidence. The implication for public health was the need to heighten awareness about the importance of a healthy diet, reduce smoking, and monitor BMI to control the prevalence of DM and improve the overall welfare of the community. In addition, for rural communities, it was important to create awareness about a healthy diet with more fiber and fewer foods high in sugar and fat. Smoking habits could be reduced through smoking cessation programs, regular monitoring of BMI, and regular physical activity. In addition, awareness about age risk and genetic factors needed to be improved through regular health checks. Therefore, it was important to conduct longitudinal studies, develop specific interventions, understand genetic and

socioeconomic influences, and evaluate existing health programs to improve DM prevention and management in rural areas.

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AUTHORS' CONTRIBUTIONS

Syamsul Alam and Dian R. Wijaya designed the study, formulated the concept, wrote the manuscript and revised the manuscript, and analysed the data. Agil Kurniawan and Maesarah Maesarah enrolled participants, collected and analyzed the data, and performed the field work. All authors approved the final version to be published.

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COMPETING INTERESTS

The authors confirm that all of the text, figures, and tables in the submitted manuscript work are original work created by the authors and that there are no competing professional, financial, or personal interests from other parties.

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