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Risk factors associated with type 2 diabetes mellitus in early adulthood within urban populations

Eliza Fitria, Ermi Girsang*, Ali Napih Nasution

Fakultas Kedokteran, Universitas Prima Indonesia

Corresponding author: *E-mail: ermigirsang@unprimdn.ac.id

Abstract

Background: Type 2 diabetes mellitus (DM) is a chronic metabolic disease whose prevalence is increasing globally, including in Indonesia. Risk factors such as unhealthy diet, low physical activity, smoking, low fiber consumption, and pesticide exposure contribute significantly to the incidence of type 2 DM.

Purpose: To analyze the association between pesticide exposure, smoking habit, physical activity, consumption of sweet foods, and fiber consumption with the incidence of type 2 DM in the early adult population.

Method: A cross-sectional design was conducted to 110 early adult respondents aged 24-40 years. Data were collected through a structured questionnaire and analyzed using the chi-square test with a significance level of 5%. Odds Ratio (OR) was used to assess the odds of risk.

Results: Pesticide exposure ($p=0.009$; $OR=3.4$), low physical activity ($p=0.004$; $OR=3.5$), excessive consumption of high-sugar foods ($p=0.009$; $OR=3.1$), and low fiber consumption ($p=0.004$; $OR=3.7$) were significantly associated with the incidence of type 2 DM. However, smoking habit showed no significant association ($p=0.453$).

Conclusion: Factors such as pesticide exposure, low physical activity, excessive consumption of sugary foods, and low fiber consumption are significant predictors of type 2 DM. Healthy lifestyle education and control of environmental risk factors are recommended to reduce the prevalence of type 2 DM.

Keywords: Fiber Consumption; Pesticide Exposure; Physical Activity; Type 2 Diabetes Mellitus.

INTRODUCTION

Type 2 diabetes mellitus (DM) is a chronic metabolic disease characterized by high blood glucose levels due to relative or absolute impairment of insulin function. The prevalence of type 2 DM continues to increase globally. Data from the International Diabetes Federation (IDF) in 2021 reported that approximately 10.5% of the world's population (536.6 million people) aged 20-79 years have diabetes, with a projected increase to 12.2% by 2045. About 90% of these cases are type 2 DM, most of which occur in low- and middle-income countries. In Indonesia, the prevalence of type 2 DM shows an increasing trend. The prevalence of DM in the population aged ≥ 15 years increased from 1.5% in

2013 to 2% in 2018, with the number of sufferers reaching 19.5 million people in 2021 (Fujii, Iwase, Ohkuma, Ogata-Kaizu, Ide, Kikuchi, & Kitazono, 2013). This makes Indonesia the fifth most diabetic country in the world after China, India, the United States, and Brazil (Wang, Yu, Fang, & Hu, 2015).

Type 2 DM has a significant impact on individual health and the public health system. The disease can lead to serious complications such as heart disease, stroke, kidney failure, neuropathy, and retinopathy, which reduce the quality of life and increase the risk of premature death (Adderley, Subramanian, Toulis, Gokhale, Taverner, Hanif, & Nirantharakumar, 2020; Rawshani, Rawshani, Franzén, Sattar, Eliasson,

Svensson, & Gudbjörnsdóttir, 2018). In addition, type 2 DM imposes a large economic burden, both directly through the cost of medical care and indirectly through reduced work productivity (Andersson, Persson, Hallén, Ericsson, Thielke, Lindgren, & Jendle, 2020). Efforts have been made to tackle type 2 DM through the Integrated Health Post program which aims to detect risk factors early, including unhealthy diet, physical inactivity, and obesity (Alzaid, Ladrón de Guevara, Beillat, Lehner Martin, & Atanasov, 2021). Healthy living campaigns also continue, including the promotion of a balanced diet, regular exercise, and weight control, aiming to reduce the prevalence of DM nationwide (Phrommintikul, Dilokthornsakul, & Permsuwan, 2022).

Several risk factors have been associated with the incidence of type 2 diabetes mellitus, including unhealthy diet, low physical activity, smoking, and pesticide exposure. Recent studies have found that a healthy lifestyle, including a healthy diet, sufficient physical activity, and not smoking, can reduce the risk of type 2 DM by 75% (Zhang, Pan, Chen, Xia, Cao, Zhang, & Pan, 2020). Lack of physical activity is a strong predictor for the development of type 2 DM in individuals with prediabetes. In addition, another study found that a healthy lifestyle can reduce the risk of type 2 DM-related heart disease by up to 56% through physical activity and a good diet (Yang, Xu, Pedersen, Li, Yu, Bao, & Xu, 2021). Increasing dietary fiber intake to 35 grams per day significantly reduces the risk of type 2 DM, accompanied by improvements in glycemic control and cardiovascular risk factors (Reynolds, Akerman, & Mann, 2020). In addition, another study found that fiber consumption increases the population of beneficial gut bacteria, which supports the control of blood glucose levels and inflammation in patients with type 2 diabetes (Ojo, Feng, Ojo, & Wang, 2020). Consumption of fiber from whole grains significantly improves insulin sensitivity and reduces the risk of type 2 DM through mechanisms involving reduced metabolism of certain amino acids and increased gut hormones that regulate glucose levels (Ojo et al., 2020).

RESEARCH METHOD

A quantitative approach with a cross-sectional research design was conducted to examine the relationship between several risk factors, namely a history of pesticide exposure, smoking habits, physical activity, consumption of sweet foods, and fiber consumption with the incidence of type 2 DM in the early adult age group in urban Riau Province. The study was conducted in a health center and urban area that has community characteristics that fit the inclusion criteria. The population of this study was all early adult individuals aged 24-40 years who live in urban areas. The sample size in this study was 110 respondents and was taken using a purposive sampling technique that met the inclusion criteria: (1) individuals who regularly reside and use health services in the area for at least the last six months, and (2) able to provide verbal or written information. Exclusion criteria included individuals who were suffering from severe illness or were unwilling to provide the requested information. Data collection was conducted using a structured questionnaire designed to obtain data related to respondent characteristics, including age, gender, education level, and occupation. The questionnaire also included the main variables of the study, such as history of pesticide exposure (yes/no), smoking habit (yes/no), physical activity level (sufficient/insufficient), high-sugar food consumption (yes/no), and fiber consumption (adequate/inadequate). The incidence of type 2 DM in respondents was determined based on the history of diagnosis or confirmation of medical data at health facilities.

The collected data were analyzed using statistical methods. Descriptive analysis was conducted to describe the frequency distribution of respondent characteristics and risk variables. Furthermore, bivariate analysis using the chi-square test with a significance level of 5% was used to determine the association between risk factors and the incidence of type 2 DM. In addition, the odds ratio (OR) calculation was performed to measure the magnitude of the risk of each factor.

Eliza Fitria, Ermi Girsang*, Ali Napih Nasution

Fakultas Kedokteran, Universitas Prima Indonesia

Corresponding author: *E-mail: ermigirsang@unprimdn.ac.id

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RESEARCH RESULTS

Table Characteristics of the Respondents (N=110)

Variable	Results	P-value	OR 95% CI
Age(n/%) (Mean $\pm$ SD)(Range)(Year)	(31.5 $\pm$ 5.404)(24-40)		
Gender (n/%)			
Male	38/34.5		
Female	72/65.5		
Education (n/%)			
Elementary	19/17.3		
Junior High	20/18.1		
Senior High	47/42.8		
College	24/21.8		
Employment Status (n/%)			
Employed	48/43.6		
Unemployed	62/56.4		
Incidence of Type 2 DM (n/%)			
Yes	40/36.4		
No	70/63.6		
History of Pesticide Exposure (n/%)		0.009	3.444 1.432-8.285
Yes	66/60.0		
No	44/40.0		
Smoking (n/%)		0.453	1.476 0.661-3.295
Yes	65/59.1		
No	45/40.9		
Physical Activity (n/%)		0.004	3.560 1.574-8.049
Insufficient	50/45.5		
Sufficient	60/54.5		
High-Sugar Food Consumption (n/%)		0.009	3.143 1.397-7.070
Yes	52/47.3		
No	58/52.7		
Fiber Consumption (n/%)		0.004	3.774 1.602-8.893
Inadequate	61/55.5		
Adequate	49/44.5		

Eliza Fitria, Ermi Girsang*, Ali Napiah Nasution

Fakultas Kedokteran, Universitas Prima Indonesia

Corresponding author: *E-mail: ermigirsang@unprimdn.ac.id

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Table 1 shows that the respondents have an average age of 31.5 years, with a standard deviation of 5.404. The youngest participant is 24 years old, while the oldest is 40. The majority of respondents are female, totaling 72 individuals (65.5%). Most of them are high school graduates, accounting for 47 respondents (42.8%). A total of 62 respondents (56.4%) are unemployed. Furthermore, 70 respondents (63.6%) do not have type 2 diabetes. A significant portion, 66 individuals (60.0%), reported a history of pesticide exposure. Additionally, 65 respondents (59.1%) are smokers. In terms of physical activity, 60 respondents (54.5%) engage in sufficient exercise. Regarding dietary habits, 58 respondents (52.7%) do not consume high-sugar foods, and 61 respondents (55.5%) have inadequate fiber intake. The chi-square test yielded a p-value of 0.009, indicating a significant association between pesticide exposure and type 2 diabetes (OR = 3.4). This suggests those exposed are 3.4 times more likely to develop the disease. Among smokers, the p-value of 0.453 shows no significant relationship between smoking and type 2 diabetes. Respondents with insufficient physical activity show a significant relationship with type 2 diabetes ($p = 0.004$, OR = 3.5). For high-sugar food consumption, the relationship is significant ($p = 0.009$, OR = 3.1), indicating a 3.1-fold higher risk. A significant association was found ($p = 0.004$, OR = 3.7), meaning those with low fiber intake are 3.7 times more likely to have the condition.

DISCUSSION

The results showed a significant association between pesticide exposure and the incidence of type 2 DM among the respondents. Individuals exposed to pesticides had a greater chance of developing type 2 DM than those who were not exposed. Statistical analysis revealed that pesticide exposure increased the risk by more than three times. This reflects the impact of environmental chemical exposure on metabolic health, which is an important concern, especially in areas with high pesticide exposure. Exposure to organochlorine-type pesticides increased the risk of type 2 DM by 1.6-fold (Akter, Okazaki, Kuwahara, Miyamoto, Murakami, & Shimizu, 2015). Workers exposed to organophosphates have a higher risk of type 2 DM with a specific dose-response pattern (Isopencu, Mocanu, & Deleanu, 2022). A study in Saudi Arabia found that

Hexachlorocyclohexane (HCH) pesticides are strongly linked to metabolic disorders and type 2 diabetes (Al-Othman, Yakout, Abd-Alrahman, & Al-Daghri, 2014). Theoretically, pesticide exposure may lead to impaired pancreatic beta cell function, insulin resistance, and oxidative stress, all of which contribute to the development type 2 DM. Epidemiologic studies show that exposure to organochlorine pesticides such as Dichloro Diphenyl Trichloroethane (DDT) and Dichloro Diphenyl Ethylene (DDE) is significantly correlated with an increased risk of insulin resistance and type 2 diabetes (Han, Zhang, Meng, Xu, Li, Li, & Jiang, 2020). Another study in the Korean population also revealed that pesticide exposure significantly increases the risk of diabetes, especially in individuals with a higher body mass index (Park, Kim, Kim, Lee, Choi, Chang, & Koh, 2019). Another study found that organochlorine pesticides have diabetogenic effects by increasing insulin resistance through accumulation in visceral adipose tissue (Kim, Lee, Kim, Lee, Lee, Kim, & Lee, 2014). In the local context, observations in Riau Province show that pesticide exposure occurs mostly through residues in the environment due to intensive agricultural activities. These residues can accumulate in water, air, and food, potentially increasing the risk of metabolic disorders in communities around urban areas.

Although the results of this study showed that there was no significant association between smoking and the incidence of type 2 DM ($p = 0.453$), smoking is still considered one of the risk factors for diabetes in many populations. Statistically, 40% of respondents who smoked suffered from type 2 DM, but this result is not enough to declare a significant direct relationship. This may be due to other more dominant factors, such as diet, physical activity, or genetic predisposition that have not been analyzed in more depth. Genetic influences and other lifestyle factors, such as physical activity and food consumption, may interact with smoking increasing the risk of diabetes (Carlsson, Kuja-Halkola, Magnusson, Lagerros, & Andersson, 2019). The risk of type 2 DM in smokers may be influenced by body mass index and overall lifestyle (Akter et al., 2015). Globally, various studies have shown the link between smoking and the risk of type 2 DM. A meta-analysis found that active smokers have a 37% higher risk of developing type 2 DM compared to non-smokers (Pan, Wang, Talaei, Hu, &

Eliza Fitria, Ermi Girsang*, Ali Napiah Nasution

Fakultas Kedokteran, Universitas Prima Indonesia

Corresponding author: *E-mail: ermigirsang@unprimdn.ac.id

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Wu, 2015). Nicotine in cigarettes may affect pancreatic beta cell function and insulin sensitivity, contributing to an increased risk of type 2 DM (Maddatu, Anderson-Baucum, & Evans-Molina, 2017). In addition, a Japanese study showed a dose-response relationship, where the higher the smoking intensity, the greater the risk of developing type 2 DM (Akter et al., 2015). The field findings suggest that smoking may interact with other lifestyle factors such as consumption of high-sugar foods, which may obscure the direct association with type 2 DM.

The results showed a significant association between excessive consumption of sugary foods and the incidence of type 2 DM. People who consumed excess sweets were 3.1 times more likely to develop type 2 DM than those who did not. These findings underscore the impact of high sugar consumption on metabolic health, particularly through elevated blood glucose levels and insulin resistance. This unhealthy consumption pattern is of particular concern in preventing the incidence of type 2 DM, especially among people who have high access to sugary foods or drinks. Previous studies have shown that consumption of sugary drinks significantly increases the risk of type 2 DM, with an increased risk of up to 30% in heavy consumers (Wang et al., 2015). Added sugar consumption is associated with an increase in inflammatory proteins that contribute to the risk of type 2 DM (Ramne, Drake, Ericson, Nilsson, Orho-Melander, Engström, & Sonestedt, 2020). A prospective meta-analysis study showed that each additional serving of sugary drinks per day increased the risk of type 2 DM by 27%, independent of obesity, with significant effects on metabolic factors that influence insulin resistance (Meng, Li, Khan, Dai, Li, Hu, & Xue, 2021). On the ground, urban communities tend to have easy access to foods and beverages high in sugar, which exacerbates health risks.

The results showed that there was a significant association between lack of fiber consumption and the incidence of type 2 DM, with a 3.7 times greater chance in those with low fiber intake. Low fiber consumption results in disruption of blood glucose regulation, insulin resistance, and fat metabolism, which are major risk factors for type 2 DM. These findings highlight the importance of adequate fiber intake in preventing type 2 DM, especially in people who have a low-fiber diet. An increase in total fiber consumption, particularly cereal fiber, correlates with

a 19% reduction in the risk of type 2 DM for every 10 gram increase in fiber per day (Yao, Fang, Xu, Yan, Xu, Liu, & Zhao, 2014; Weickert, & Pfeiffer, 2018). Increasing fiber consumption can improve glycemic control, lower the risk of obesity, and reduce the prevalence of metabolic syndrome in patients with type 2 diabetes in Japan (Fujii et al., 2013). A meta-analysis study found that dietary fiber may improve glycemic control through its effects on the gut microbiota, including increased production of short-chain fatty acids that have a role in regulating blood glucose levels (Ojo et al., 2020). In field findings, people in urban areas tend to consume processed foods that are low in fiber, which can exacerbate metabolic risks.

CONCLUSION

A significant correlation was found between pesticide exposure, physical activity, sweet food consumption, and fiber intake with the incidence of type 2 diabetes mellitus (DM) among early adults in urban areas of Riau Province. Although smoking is widely acknowledged as a risk factor in previous studies, this study did not find a statistically significant link between smoking and type 2 DM.

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