



ANALYSIS OF RISK FACTORS ASSOCIATED WITH TYPE 2 DIABETES MELLITUS AMONG REGIONAL GOVERNMENT ORGANIZATIONS EMPLOYEES

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ABSTRACT

Type 2 diabetes mellitus was a major non communicable disease with an increasing prevalence among the productive-age population. Multiple risk factors, including sociodemographic characteristics, lifestyle behaviors, clinical conditions, and family history, were known to contribute to its development. Employees of Regional Government Organizations (RGO) represented a productive age group with a potentially high risk of type 2 diabetes mellitus. This study aimed to analyze risk factors associated with type 2 diabetes mellitus. A quantitative cross sectional study was conducted from January to February 2023 involving 3,313 RGO employees. A total of 1,955 respondents were selected using accidental sampling based on the Lemeshow formula. Data were collected through questionnaire, physical examinations, and random blood glucose measurements. The questionnaire was not subjected to validity and reliability testing, as the data were derived from direct measurements and interview findings. Statistical analyses were performed using chi-square tests and multiple logistic regression. The results showed that body mass index, sex, family history of diabetes mellitus, blood pressure, and history of heart disease were significantly associated with type 2 diabetes mellitus ($p < 0.05$). In contrast, smoking behavior, physical activity, fruit and vegetable consumption, and history of stroke were not significantly associated. Multivariate analysis indicated that family history of diabetes mellitus was the most dominant risk factor ($OR = 4.882$). It was concluded that family history of diabetes mellitus was the strongest determinant of type 2 diabetes mellitus among RGO employees, emphasizing the importance of early screening and risk factor management in the productive age population.

Keywords: regional government organizations; risk factors; type 2 diabetes mellitus

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INTRODUCTION

Diabetes mellitus (DM) was a group of metabolic disorders characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. DM consisted of two types type 1 DM, which occurred when the pancreas was unable to produce insulin and commonly affected children as a congenital condition caused by autoimmune destruction of pancreatic beta cells, and type 2 DM, which had a higher prevalence (Alkandari et al., 2020; Milita et al., 2021). The prevalence of type 2 DM frequently occurred at a young or productive age, and type 2 DM progressed more rapidly, leading to a greater number of complications compared to type 1 DM. Children with type 2 diabetes were more likely to experience complications during adolescence or young adulthood (72% - 32%) compared with those with type 1 DM (Rao & Jensen, 2020).

Various risk factors for diabetes mellitus had been identified, including sex, age, overweight and obesity, waist circumference, hypertension, dyslipidemia, and a family history of type 2 DM, all of which influenced the occurrence of type 2 DM in individuals (Alkandari et al., 2020). Physical activity, performed through exercise for at least 150 minutes per week, was reported to reduce HbA1c levels to a degree that could prevent complications (Arania et al., 2021). A meta-analysis study by Yuan et al., (2022), reported associations between obesity, type 2 DM, lifestyle factors, and gallstone disease risk, indicating relationships among body mass index (BMI), smoking behavior, and type 2 DM. Sociodemographic characteristics such as age, sex, educational level, and

occupation, together with behavioral factors including alcohol consumption and physical activity, were strongly suspected to influence the occurrence of diabetes mellitus. In addition, clinical conditions such as body mass index, waist circumference, and stress levels were also estimated to play a role in the development of this disease. Specifically, among civil servants in Aceh Province, regular physical activity was found to influence physical fitness, while BMI affected the risk of diabetes (Nasrulsyah et al., 2022).

Type 2 DM screening programs had also been implemented in Bontang City as an effort to detect cases among the productive age population, particularly employees of RGO. In 2020, screenings were conducted among 1,597 employees, and in 2023 among 2,459 employees. The screening activities included measurements of height, weight, waist circumference, body mass index (BMI), blood pressure, blood glucose, cholesterol, and uric acid levels. The screening results showed that 6.09% of RGO employees in Bontang City in 2023 had blood glucose levels above 200 mg/dL. This proportion indicated a substantial number of employees at potential risk of developing type 2 DM and was considerably higher than the national prevalence of 2%.

In addition to physical examinations, the screening also collected data on various risk factors for type 2 DM, including family history of diabetes, history of degenerative diseases, smoking behavior, alcohol consumption, fruit and vegetable intake, and physical activity. To date, these data had not been optimally analyzed. Analysis of risk factors was essential, as it served as the basis for managing non-communicable disease control programs. Clear identification of risk factors could become a benchmark for promotive and preventive efforts aimed at controlling the prevalence of type 2 DM through minimizing modifiable risk factors. Based on these conditions, a comprehensive analysis was required to determine whether smoking behavior, fruit and vegetable consumption, physical activity, body mass index, sex, family history of diabetes, and history of degenerative diseases (hypertension, heart disease, and stroke) constituted risk factors for the occurrence of type 2 diabetes mellitus. Therefore, this study aimed to provide empirical evidence regarding the association between risk factors and type 2 diabetes mellitus among employees of RGO in Bontang City.

METHOD

This study employed a quantitative research design with a cross-sectional approach to analyze independent variables, including smoking behavior, fruit and vegetable consumption, physical activity, body mass index (BMI), sex, family history of disease, and history of degenerative diseases (hypertension, heart disease, and stroke), as well as the dependent variable, type 2 diabetes mellitus, within the same period. The study was conducted in Bontang City from January to February 2023. The study population consisted of all employees of the Regional Government Organizations in Bontang City, totaling 3,313 employees, including civil servants, regional contract workers, and daily workers. The sample was selected using an accidental sampling technique. Based on the Lemeshow formula, a final sample size of 1,955 respondents was obtained. Data were collected using a questionnaire. The questionnaire was not subjected to validity and reliability testing, as the data were derived from direct measurements and interview findings. The data included demographic information, measurements of body mass index, blood pressure, and random blood glucose levels, as well as interviews regarding smoking behavior, fruit and vegetable consumption, physical activity, history of degenerative diseases, and family history of disease.

Data analysis was performed using bivariate analysis with the chi square test to examine the association between the independent and dependent variables. Furthermore, multiple logistic regression analysis was applied to identify the most dominant influencing factors. This study received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Mulawarman University (Ethical Clearance No. 111/KEPK-FK/V/2024). The researchers ensured compliance with all biomedical research ethical principles, including obtaining informed consent,

maintaining participant confidentiality, and respecting participants' rights to withdraw from the study at any time without consequences, in accordance with established ethical standards.

RESULT

Univariate Analysis of Respondent Characteristics

The table below presented the results of the univariate analysis of respondents' characteristics. The characteristics examined in this study included age, marital status, occupation, and education level. The distribution of type 2 diabetes mellitus occurrence was analyzed based on smoking behavior, physical activity, fruit and vegetable consumption, body mass index, sex, family history of diabetes mellitus, and history of hypertension, heart disease, and stroke.

Table 1.

Univariate Analysis of Respondent Characteristics and Distribution of type 2 Diabetes Mellitus

Characteristics of Respondents (N=1995)	f	%
Age		
< 45 Years	1363	69,7
45-59 Years	548	28,0
>=60 Years	44	2,3
Marital Status		
Married	1413	72,3
Unmarried	415	21,2
Widow/Widower	127	6,5
Occupation		
Civil Servant	779	39,8
Regional Contract Worker	876	44,8
Daily Contract Worker	300	15,3
Education Level		
No formal education	12	0,6
Primary school	130	6,6
Junior high school	77	3,9
Senior high school	775	39,6
Diploma/Bachelor's degree	671	44,6
Master's degree	90	4,6
Smoking Behavior		
Smoker	513	26,2
Non-smoker	1442	73,8
Physical Activity		
More than 30 minutes/day	613	31,4
Less than 30 minutes/day	1342	68,6
Fruit and Vegetable Consumption		
Adequate	1594	81,5
Inadequate	361	18,5
Body Mass Index (BMI)		
Normal	486	24,9
Overweight	1459	75,1
Sex		
Male	1044	53,4
Female	911	46,6
Family History of Diabetes Mellitus		
Yes	244	12,5
No	1711	87,5
History of Hypertension		
Normal blood pressure	1150	58,8
High blood pressure	805	41,2
History of Heart Disease		
Yes	41	2,1
No	1914	97,9
History of Stroke		
Yes	12	0,6
No	1943	99,4

Table 1, the majority of respondents were aged <45 years (69.7%) and were married (72.3%). In

terms of occupation, respondents were predominantly regional contract workers (44.8%), followed by civil servants (39.8%). Most respondents had an educational level of Diploma/Bachelor's degree (44.6%) and senior high school (39.6%). Regarding the occurrence of type 2 diabetes mellitus based on risk factors, most respondents were non-smokers (73.8%), engaged in physical activity for less than 30 minutes per day (68.6%), and had adequate fruit and vegetable consumption (81.5%). However, the majority of respondents were overweight based on body mass index (BMI) classification (75.1%). Respondents were predominantly male (53.4%), and most had no family history of diabetes mellitus (87.5%) or history of heart disease and stroke. These findings indicated that the respondents were mainly from the productive age group with moderate to high educational levels, while the dominant risk factors for type 2 diabetes mellitus were overweight and low physical activity.

Bivariate Analysis

The table below presents a bivariate analysis between independent and dependent variables based on the research results.

Table 2
Bivariate Analysis

Variable	Diabetes Mellitus Status		Totally n=1955	p value
	Diabetes Mellitus n=119	Non Diabetes Mellitus n=1836		
Smoking Behavior				
Smoker	31 (6%)	482 (94%)	513 (100)	1,000
Non-Smoker	88 (6,1%)	1354 (93,9%)	1442 (100)	
Physical Activity				
More than 30 minutes/day	35 (5,7%)	578 (94,3%)	613 (100)	0,712
Less than 30 minutes/day	84 (6,3%)	1258 (93,7%)	1342 (100)	
Fruit and Vegetable Consumption				
Inadequate	15 (4,2%)	346 (95,8%)	361 (100)	0,115
Adequate	104 (6,5%)	1490 (93,5%)	1594 (100)	
Body Mass Index (BMI)				
Overweight	103 (7%)	1366 (93%)	1469 (100)	0,004
Normal	16 (3,3%)	470 (96,7%)	486 (100)	
Sex				
Male	79 (7,6%)	965 (92,4%)	1044 (100)	0,005
Female	40 (4,4%)	871 (95,6%)	911 (100)	
Family History of Diabetes Mellitus				
Yes	42 (17,2%)	202 (82,8%)	244 (100)	< 0,01
No	77 (4,5%)	1634 (95,5%)	1711 (100)	
History of Hypertension				
Normal blood pressure	78 (9,7%)	727 (90,3%)	805 (100)	< 0,01
High blood pressure	41 (3,6%)	1109 (96,4%)	1150 (100)	
History of Heart Disease				
Yes	7 (17,1%)	34 (82,9%)	41 (100)	0,008
No	112 (5,9%)	1502 (94,1%)	1614 (100)	
History of Stroke				
Yes	1 (8,3%)	11 (91,7%)	12 (100)	1,000
No	118 (6,1%)	1825 (93,9%)	1943 (100)	

The bivariate analysis showed that body mass index (BMI), sex, family history of diabetes mellitus, history of hypertension, and history of heart disease were significantly associated with type 2 diabetes mellitus ($p < 0.05$). Overweight respondents had a higher proportion of diabetes mellitus compared to those with normal BMI (7.0%-3.3%; $p = 0.004$). Male respondents showed a higher prevalence of diabetes mellitus than females (7.6% vs. 4.4%; $p = 0.005$). A significantly higher proportion of diabetes mellitus was observed among respondents with a family history of diabetes mellitus (17.2%) compared to those without such history (4.5%; $p < 0.01$). Additionally, respondents with a history of hypertension and heart disease had significantly higher proportions of diabetes mellitus ($p < 0.01$ and $p = 0.008$, respectively). In contrast, smoking behavior, physical

activity, fruit and vegetable consumption, and history of stroke were not significantly associated with diabetes mellitus ($p > 0.05$).

Multivariate Analysis

The parameter coefficients or odds ratios represented the tendency of association between one category and another within qualitative explanatory variables. Based on the results of the multivariate logistic regression analysis, all variables analyzed showed statistically significant associations with the occurrence of diabetes mellitus ($p < 0,05$). Family history of diabetes mellitus was identified as the most dominant factor associated with the occurrence of DM, with an Odds Ratio (OR) of 4,882 (95% CI: 2,941–6,832; $p < 0,001$). This indicated that individuals with a family history of DM had nearly a fivefold higher risk of developing DM compared to those without a family history, after controlling for other variables in the model. Other variables that were also significantly associated with the occurrence of DM included history of heart disease (OR = 2,627; $p = 0,031$), history of hypertension (OR = 2,340; $p < 0,001$), sex (OR = 1,901; $p = 0,002$), and body mass index (BMI) (OR = 1,773; $p = 0,043$). Although all these variables contributed to the occurrence of diabetes mellitus, their OR values indicated weaker effects compared to family history of diabetes mellitus.

DISCUSSION

The Relationship Between Smoking Behavior and The Occurrence of Type 2 Diabetes Mellitus

The results of this study showed no significant association between smoking behavior and the occurrence of type 2 diabetes mellitus, with a p-value of 1.000. Regarding smoking status, the number of respondents who smoked was relatively lower compared to non smokers. Therefore, future studies on smoking behavior and the occurrence of type 2 diabetes mellitus should include more detailed questions regarding smoking habits and patterns. Previous studies suggested that smoking might worsen insulin resistance through indirect mechanisms rather than acting as a direct causal factor (Kaplan & Sezgin, 2023).

This finding was consistent with Fajriati (2021), who reported no significant association between smoking habits including intensity, duration, and passive smoking and the occurrence of type 2 diabetes mellitus. However, smoking has been widely reported to increase all cause mortality and exacerbate complications and poor glycemic control among individuals with diabetes mellitus (Durlach et al., 2022). Moreover, early and frequent exposure to tobacco smoke was associated with a higher risk of developing type 2 diabetes mellitus later in life, underscoring the importance of public health education to reduce smoking behavior (Ye et al., 2023). In a study conducted by Li et al. (2020), male smokers who were heavy smokers (≥ 15 cigarettes per day) had the lowest disease free life expectancy compared to their total life expectancy at the age of 50 years. Therefore, the study concluded that adherence to healthy lifestyle behaviors, including smoking behavior during middle age, was associated with longer life expectancy and a lower risk of chronic non communicable diseases.

The Relationship Between Physical Activity and The Occurrence of Type 2 Diabetes Mellitus

The results of this study showed no significant association between physical activity and the occurrence of type 2 diabetes mellitus. The non significant finding might have been influenced by the presence of bias. One possible source of bias was recall bias, in which respondents may have had difficulty accurately recalling the frequency and duration of their routine physical activity. In addition, misclassification bias might have occurred when categorizing respondents' physical activities into different intensity levels (Rosita et al., 2022).

The absence of an association between physical activity and diabetes provided additional evidence that specific types of physical activity might play different roles in the development of diabetes mellitus. Further studies were required to confirm these findings across diverse ethnic populations.

Previous research reported that leisure-time physical activity was inversely associated with the prevalence of diabetes among both men and women in Korea, whereas transport related physical activity was associated with diabetes only among men (Lee et al., 2021).

The benefits of physical activity for individuals with diabetes were reflected in improved glycemic control, reduced glycemic variability, and decreased insulin resistance. However, physical activity posed a challenge for patients with diabetes due to the risk of inducing hypoglycemia. During physical activity, individuals with diabetes needed to adjust carbohydrate intake and insulin administration accordingly. The use of alternative monitoring tools, such as Continuous Glucose Monitoring (CGM), was recommended to detect blood glucose levels. CGM had been shown to effectively detect glycemic fluctuations during exercise more rapidly, prevent hypoglycemia risk, and enable timely management of glycemic episodes (Schubert Olesen et al., 2022).

The Relationship Between Fruit and Vegetable Consumption and The Occurrence of Type 2 Diabetes Mellitus

The statistical test results showed that the association between fruit and vegetable consumption and the occurrence of diabetes mellitus was not statistically significant ($p = 0.115$). Therefore, it was concluded that, in this study, fruit and vegetable consumption was not significantly associated with the occurrence of Diabetes Mellitus. This finding might have been influenced by other factors, such as body mass index (BMI), family history of diabetes mellitus, age, and physical activity, which may have had stronger effects on the occurrence of diabetes mellitus than fruit and vegetable consumption, thereby rendering its effect statistically non significant.

Previous studies, however, reported a significant association between fruit and vegetable consumption and diabetes outcomes. Sunarti et al., (2022), reported that the consumption of 32 g of high fiber snacks (a mixture of *Dioscorea esculenta*, arrowroot, cassava, and pumpkin) for four weeks significantly reduced fasting blood glucose levels. Similarly, Ayasa Anita et al. (2022) found that consuming vegetables before carbohydrates was effective in achieving better glycemic control. Dietary fiber intake, particularly soluble fiber derived from vegetables, fruits, whole grains, or supplementation, was reported to improve glycemic control when consumed regularly and consistently for more than four weeks, providing long term protective effects. However, within a duration of four weeks or less, adequate fiber intake did not show a significant effect on glycemic control. Although glycemic control in individuals with type 2 diabetes mellitus was influenced by multiple factors, adequate daily fiber intake, especially soluble fiber, remained an important consideration.

The Relationship Between Body Mass Index (BMI) and The Occurrence of Type 2 Diabetes Mellitus

The results of this study showed that BMI was significantly associated with the occurrence of diabetes mellitus ($p = 0.004$). Similar findings were reported by Agustina et al., (2023) and Kurniawaty (2020), who also demonstrated a significant relationship between BMI and diabetes mellitus. Body mass index was identified as one of the risk factors for type 2 diabetes mellitus among individuals of productive age. An elevated BMI among individuals with type 2 diabetes mellitus, as well as type 1 diabetes mellitus, was associated with increased morbidity and mortality. Substantial evidence has demonstrated a strong relationship between type 2 diabetes mellitus and excess body weight, unhealthy dietary patterns, and poor lifestyle behaviors. These factors contributed to increased BMI, which played a significant role as a risk factor in the development of the disease (Soelistijo, 2021).

The prevalence of diabetes mellitus was higher among individuals with excess body weight as a risk factor. Overweight conditions, whether assessed through central obesity measured by waist circumference or general overweight assessed by BMI, were recognized as major risk factors for the

occurrence of diabetes mellitus and hypertension (Ministry of Health of the Republic of Indonesia, 2023). These findings indicated a clear association between BMI and the risk of diabetes mellitus, where elevated BMI increased the risk of abnormal blood glucose levels among individuals with diabetes. The higher the BMI value, the greater the risk of developing type 2 diabetes mellitus (Harahap et al., 2020).

The Relationship Between Sex and The Occurrence of Type 2 Diabetes Mellitus

The results of this study showed that sex was significantly associated with the incidence of Diabetes Mellitus (p -value = 0.005). According to a study by Tramunt et al., (2020), insulin sensitivity was higher in women, as indicated by a greater insulin secretion capacity compared to men; however, this advantage diminished when glucose tolerance deteriorated due to diabetes.

Differences between men and women were also observed in terms of daily caloric requirements, which influenced the increasing prevalence of obesity as a major risk factor for diabetes and the rising incidence of overweight. Women were found to have a higher risk of developing diabetes mellitus, as they were physiologically more prone to increases in body mass index, which is a known risk factor for diabetes. This condition was influenced by hormonal changes related to the menstrual cycle (premenstrual syndrome), pregnancy, and menopause, which facilitated fat accumulation and altered body fat distribution (Ministry of Health of the Republic of Indonesia, 2021).

The Relationship Between Family History of Diabetes Mellitus, Blood Pressure, Heart Disease, stroke and The Occurrence of Type 2 Diabetes Mellitus

The results of this study showed that there were significant associations between family history of diabetes mellitus, blood pressure, and heart disease with the occurrence of Diabetes Mellitus ($p < 0.05$). In contrast, no significant association was found between a history of stroke and the occurrence of Diabetes Mellitus ($p = 1.000$).

A family history of type 2 Diabetes Mellitus was identified as a non-modifiable risk factor, along with age and sex, and was considered an essential component of comprehensive evaluation in diabetes management. A history of diabetes and other endocrine diseases within the family was routinely assessed during patient examinations (Soelistijo, 2021). Family history of Diabetes Mellitus had consistently been proven to be a major determinant of Diabetes Mellitus; therefore, its implications for public health programs were substantial. These findings suggested a paradigm shift in the prevention and management of the disease, emphasizing genetic risk assessment, primary and secondary prevention, pharmacological interventions, and health policy adjustments.

Regarding blood pressure, Zhang et al., (2020), reported that individuals with systolic blood pressure ranging from 120 to less than 130 mmHg had a lower risk of developing Diabetes Mellitus compared to those with systolic blood pressure between 130 and less than 140 mmHg. Hypertension had been associated with an 11% increased risk of developing Diabetes Mellitus among adults in China (Wu et al., 2021).

Concerning the relationship between heart disease and Diabetes Mellitus, a study by Ismail, Materwala, and Al Kaabi (2021), reported that increased heart rate and cardiovascular disease elevated blood pressure, which subsequently reduced glucose uptake in the body, leading to insulin resistance. Consequently, individuals with heart disease were at a higher risk of developing type 2 Diabetes Mellitus. Heart disease had consistently been identified as a major contributor to Diabetes Mellitus, suggesting a significant paradigm shift in approaches to prevention and treatment of both conditions. Strengthening heart disease prevention through intensive cardiovascular screening programs, particularly among high risk populations such as individuals with Diabetes Mellitus, hypertension, and dyslipidemia, was therefore essential. Management of heart disease was

considered a priority in efforts to prevent Diabetes Mellitus.

Although no association between stroke and the occurrence of Diabetes Mellitus was found in this study, several related studies reported that the risks of stroke and other cardiovascular diseases were significantly higher among individuals with Diabetes Mellitus, with increased risks of 4.123 times and 3.223 times, respectively (Kim & Lee, 2023). These findings indicated that the incidence of stroke and heart disease was significantly higher in individuals with Diabetes Mellitus. The underlying mechanisms suggested that stroke could contribute to the development of Diabetes Mellitus through vascular obstruction or rupture in the brain, which might extend to systemic vascular damage, including blood vessels supplying the pancreas. As the pancreas played a crucial role in insulin production and glucose regulation, vascular damage to the pancreas could impair insulin function and lead to Diabetes Mellitus. Furthermore, cerebral microvascular dysfunction was a widespread phenomenon in individuals with Diabetes Mellitus and had systemic implications. Stroke also triggered systemic inflammatory responses that increased insulin resistance, thereby reducing the body's ability to utilize insulin effectively to regulate blood glucose levels.

CONCLUSION

The results of the study identified that metabolic factors and a history of chronic diseases, particularly excess body mass index, sex, family history of Diabetes Mellitus, hypertension, and heart disease, were significantly associated with the occurrence of Diabetes Mellitus. In contrast, lifestyle related factors such as smoking behavior, physical activity, fruit and vegetable consumption, and history of stroke were not significantly associated with Diabetes Mellitus. These findings suggested that Diabetes Mellitus prevention strategies needed to be prioritized toward weight control and early

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