

The Effect of Wetland Geography on the Prevalence of Diabetes Mellitus in South Kalimantan

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Abstract:

Diabetes mellitus (DM) is a high-burden disease in Indonesia especially in South Kalimantan Province. South Kalimantan province lies in mostly wetlands areas. Identification of risk factors related to DM is necessary to prevent the disease. We conducted this study to assess the prevalence of DM in the South Kalimantan people, the impact of a wetlands area on DM prevalence, and other significant risk factors. A cross-sectional study approach was used to identify significant risk factors. We used adjusted multiple logistic regression to assess the association between risk factors and DM prevalence. There were 4612 subjects more than 18 years old in this study with 6.5% of them diagnosed as DM. Most of the subjects live in wetlands area (79.1%) and most of them >40 years old. Several important risk factors associated with DM were identified. Subjects in wetlands have a lower risk of DM compared to non-wetlands area (OR 0.73, CI 95%; 0.43-0.71, $p<0.001$). Age >40 years old increase the risk of DM (OR 2.24, CI 95 % 1.61-3.10, $p<0.001$), hypertension (OR 1.65, CI 95% 1.23-2.21, $p<0.001$), waist circumference >90 cm (OR 2.12, CI 95%. $p<0.001$), cholesterol level (>200 mg/dl) with DM prevalence (OR 1.38, CI 95% 1.02-1.87, $p<0.04$) and family history of DM (OR 10.28, CI 95% 7.67-13.76, $p<0.001$). This study found that wetlands areas may reduce the DM prevalence and other risk factors may increase the prevalence of DM. Further research is necessary to establish the relationship between wetlands area and DM.

Keywords: diabetes mellitus; wetlands area; risk factors

Introduction

Diabetes mellitus (DM) is a modifiable risk factor chronic disease that requires strategies and treatments to reduce the various complications associated with increasing glycemic levels. Diabetes mellitus is often undiagnosed for years because the glycemic level gradually increases and the patient's symptoms are still mild.^{1,2} Several risk factors are associated with diabetes including geo locality (domicile), age, sex, smoking, physical activity, hypertension, dyslipidemia, body mass index, waist circumference, history of DM, hypertension, dyslipidemia in the family, and others. Some prevention strategies for risk factors related to DM are needed to reduce the prevalence.^{3,4} According to the Indonesian basic health research 2018, the prevalence of DM in Indonesia reaches 1.5% of almost 270 million population and South Kalimantan has the prevalence of DM about 1.3% from about 3 million population.⁵

South Kalimantan has a unique feature because most of the area is covered in the wetlands area. Wetlands are one of the most populous places to live in the world.⁶ Characteristic of the wetland has some impact on health, social, economic, technological, and policy problem. Wetlands play an irreplaceable role in regulating the global climate, protecting the ecosystem and biodiversity, maintaining the global hydrological cycle, and safeguarding human welfare⁷. Ramsar convention declares that wetland areas are rivers, lakes, rice fields, and coastal areas. Those areas provide a good ecosystem for human well-being and economic values. Wetlands area contribute to several significant roles of in wetland for human health and well-being; a place for living, source of water and nutrition, and medicinal products. However, some health problems may occur in wetland areas related to safe water, nutrition, pollution, and infection. Access to nutrition is considered a

risk factor for diabetes in the wetlands area.^{4,8} A study suggested that biodiversity in wetlands areas may influence the risk of inflammatory-related diseases such as allergy, asthma, diabetes, inflammatory bowel disease, and others. Some studies reported that exposure of human gut and skin microbiota are related to those diseases.⁹

It is important to find suitable risk factors for DM to prevent the disease in the community. This study was conducted to assess the prevalence of DM in the South Kalimantan people, the impact of a wetlands area on DM prevalence, and other significant risk factors.

Research Method

Study Design and Participants

We conducted a cross-sectional study from the data of the Public Health Office of South Kalimantan Province for health surveillance from 2018 to 2019. The data were collected in the public health center from 13 regencies in South Kalimantan. The population was people in South Kalimantan Province, Indonesia, older than 18 years and willing to check their health status in the public health center. This study was approved by the ethics committee of the Faculty of Medicine, Universitas Lambung Mangkurat, Banjarmasin, Indonesia (ethical approval No. 097/KEPK-FKULM/EC/V/2023)

The enumerators collected the data of subjects based on the geographic profile (wetlands area and not wetlands area), sex, age, smoking status, physical activity, history of hypertension and dyslipidemia, family history of DM, dyslipidemia, hypertension, and stroke with questionnaire items. They also measured random blood sugar, blood pressure, body mass index (BMI), waist circumference, and cholesterol level. Random blood sugar (RBS) levels and cholesterol levels were examined with point-of-care glucose test by trained enumerators and recorded in

the form. RBS more than 200 mg/dl with diabetes classic symptoms were considered as diabetes mellitus according to the Indonesian Endocrinology Association.¹⁰ The cholesterol levels were considered as dyslipidemia if the subject had >200 mg/dl. BMI was calculated based on the weight and height of the subjects. If the subject had BMI >25.0 kg/m², they're categorized as overweight. We used >90 cm cut-off for waist circumference. The independent variables were domicile, age, less physical activity, hypertension, dyslipidemia, BMI, waist circumference, cholesterol level, family history of diabetes, dyslipidemia, hypertension, and stroke. DM prevalence was the dependent variable.

Data Analysis

We collected and tabulated the study variables to serve the baseline characteristics.

Table 1. Baseline characteristics

Risk factors	DM (n=301)	Non DM (n=4311)
Domicile in wetlands area <i>n</i> (%)	206 (68.44%)	3438 (79.75%)
Age (mean $\pm$ SD)	49.4 $\pm$ 12.23	45.34 $\pm$ 14.65
Age >40 years old	245 (81.40%)	2825 (65.53%)
Male sex <i>n</i> (%)	53 (17.61%)	807 (18.72%)
Smoking <i>n</i> (%)	29 (9.63%)	385 (8.93%)
Less physical activity <i>n</i> (%)	86 (28.57%)	988 (22.92%)
Systolic blood pressure (mean $\pm$ SD)	140.63 $\pm$ 25.59	129.58 $\pm$ 28.23
Diastolic blood pressure (mean $\pm$ SD)	87.26 $\pm$ 13.37	82.94 $\pm$ 18.3
Hypertension <i>n</i> (%)	188 (62.46%)	1880 (43.61%)
Body mass index (mean $\pm$ SD)	25.32 $\pm$ 18.2	25.62 $\pm$ 40.4
Body mass index >25.0	138 (45.85%)	1596 (37.02%)
Waist circumference (mean $\pm$ SD)	115.51 $\pm$ 46.2	84.54 $\pm$ 12.49
Waist circumference >90 cm <i>n</i> (%)	119 (39.53%)	925 (21.46%)
Cholesterol level (mean $\pm$ SD)	184.37 $\pm$ 55.66	165.95 $\pm$ 59.91
Cholesterol level >200 mg/dl <i>n</i> (%)	97 (32.23%)	996 (23.10%)
Family history of DM <i>n</i> (%)	113 (37.54%)	257 (5.96%)
Family history of dyslipidemia <i>n</i> (%)	26 (8.64%)	183 (4.24%)
Family history of hypertension <i>n</i> (%)	82 (27.24%)	1003 (23.27%)
Family history of stroke <i>n</i> (%)	16 (5.32%)	156 (3.62%)

We conducted the analysis of risk factors for DM prevalence in South Kalimantan in table 2.

Continuous data were presented as mean $\pm$ SD and categorical data were presented as proportion *n* (%). We used logistic regression with a 95% confidence interval to examine the relationship between domicile (wetlands area), independent variables with DM prevalence. The significant variables (*p*<0.05) were adjusted with multiple logistic regression to find the independent effect of each variable.

Results

There were 4612 subjects age 18 years and older who participated in this study and 301 subjects (6.5%) were diagnosed as DM. Baseline characteristics of the subjects were presented in table 1.

The table showed that domicile in wetlands area, age >40 years old, less physical activity,

hypertension, dyslipidemia, BMI >25.0, waist circumference >90 cm, cholesterol level >200 mg/dl, family history of diabetes, dyslipidemia, hypertension, and stroke were the significant contributors in bivariate logistic regression analysis. We performed further adjusted analysis with multiple logistic regression and found that domicile in the wetlands area, age >40 years old,

hypertension, waist circumference, cholesterol level >200 mg/dl, and family history of diabetes as the independent factors of DM prevalence. Domicile in wetlands area may reduce the risk until 27% (odds ratio (OR) 0.73, confidence interval (CI) 95%; 0.43-0.71, $p<0.001$) and family history of DM as the most significant predictor of DM (OR 10.28, CI 95%; 7.67-13.76, $p<0.001$).

Table 2. Important risk factors for DM prevalence in South Kalimantan

Risk factors	Unadjusted			Adjusted		
	Odds Ratio (OR)	95%CI	p	Odds Ratio (OR)	95%CI	p
Domicile in wetlands area	0.55	0.43-0.71	<0.001	0.73	0.54-0.97	0.03
Age >40 years old	2.30	1.71-3.10	<0.001	2.24	1.61-3.10	<0.001
Less physical activity	1.35	1.04-1.75	0.025	1.13	0.85-1.50	0.40
Hypertension	2.19	1.72-2.79	<0.001	1.65	1.23-2.21	<0.001
Dyslipidemia	1.62	1.19-2.21	0.002	0.85	0.58-1.26	0.42
Body mass index >25.0	1.44	1.14-1.82	0.002	0.86	0.64-1.16	0.33
Waist circumference >90 cm	2.39	1.88-3.05	<0.001	2.12	1.55-2.89	<0.001
Cholesterol level >200 mg/dl	1.58	1.23-2.04	<0.001	1.38	1.02-1.87	0.04
Family history of diabetes	9.48	7.27-12.36	<0.001	10.28	7.67-13.76	<0.001
Family history of dyslipidemia	2.13	1.39-3.27	0.001	0.98	0.58-1.64	0.94
Family history of hypertension	1.84	1.44-2.35	<0.001	0.96	0.69-1.30	0.77
Family history of stroke	3.15	1.46-6.83	0.004	1.43	0.59-3.47	0.43

Discussion

World Health Organization (WHO) predicts the number of people with DM may be rapidly increasing in the next decade. DM is considered a high burden disease in Indonesia because more than 10 million people suffer from this condition. This condition will impact the health condition and socioeconomic of people. The current trend shows the incidence of DM starts at a younger age. DM is a preventable disease thus identification of risk factors is necessary to avoid the higher prevalence.¹¹

South Kalimantan Province has two main tribes, Banjar and Dayak people. For hundreds of years, they live mostly in wetlands areas include swamps, delta river, and peatlands for agriculture, fishing, and poultry. This condition gives some benefits for growing rice, the most important food in the region.¹² According to the 2018 data, the prevalence of DM is 1.3% from all age.¹⁰

In this study, we found that 6.5% of 4612 subjects more than 18 years olds were diagnosed with DM. Most of the subjects lived

in wetlands area (79.01%) and more than 40 years old. Female subjects were 81.35% compared to male subjects 18.65% in this study. Smoking behavior was found in <10% of subjects. Of those who had DM, 68.44% lived in the wetlands area, with more than 80% had an age >40 years old. This study found 9.63% of subjects had a smoking history and almost 30% of them had less physical activity. Systolic blood pressure, diastolic blood pressure, and hypertension were higher in the DM category (62.46%) compared to non DM (43.61%). BMI >25.0, waist circumference >90 cm, and high cholesterol levels were found higher in the DM group. We also found DM group had a higher family history of diabetes, dyslipidemia, hypertension, and stroke prevalence compared to non DM.

Geography is an important factor for DM prevalence and the control of the disease.¹³ A study in Peru suggested that the incidence of DM was higher in high altitude places (relative risk (RR) 1.58; 95% CI 1.01–2.48).¹⁴ Our study demonstrated that people in the wetlands area had a significantly lower risk of DM compared to non-wetlands area (OR 0.73, CI 95%; 0.43-0.71, $p<0.001$). This finding is brand new information and may need further research to establish the relationship between wetlands area and DM. Some studies suggested that biodiversity and water characteristics in wetlands areas may have some roles to decrease some diseases and improve psychological health.^{9,15,16} Sociocultural, patterns of eating behavior, and economy may also have important roles in this condition.⁶

We also found some risk factors contributed significantly to DM prevalence in South Kalimantan. Age >40 years old may increase the risk of DM more than twice (OR 2.24, CI 95 % 1.61-3.10, $p<0.001$). This finding was similar to a study by Mansour *et al.*, who reported that subjects older than 40 years old had a higher prevalence of DM compared to

the younger.¹⁷ Older adults have some features related to DM. The genetic alteration, insulin resistance, and impaired insulin secretion increase the probability. Older adults also have lifestyle, sarcopenia, and physical inactivity problem.^{18,19} Recent data showed that the prevalence of type 2 DM increases significantly in younger adults and have poorer outcomes. This condition should be prevented to avoid any complications.^{20–22}

Hypertension and DM are closely related. WHO clarifies that arterial hypertension, DM, and obesity are the most prevalent risk factors in the world.²³ Some studies showed that vascular involvements were contributed to the association of hypertension and DM. Atherosclerosis, vascular inflammation, vascular fibrosis, endothelial dysfunction, and arterial remodeling were the main mechanisms of the condition.²⁴ The presence of DM is a causal factor in the risk of hypertension, but the reverse relationship needs more relevant data.²³ In this study hypertension may affect the prevalence of DM (OR 1.65, CI 95% 1.23-2.21, $p<0.001$). This study was similar to the Korean study that reported that hypertension increased the risk of DM (hazard ratio (HR) 1.48, 95% CI 1.20-1.83).²⁵

Waist circumference and BMI were reported from several studies as the important risk of type 2 DM.²⁶ Waist circumference is a good indicator to predict the risk of DM and cardiovascular disease.²⁷ This study reported that waist circumference >90 cm had a twice higher prevalence of DM (OR 2.12, CI 95%. $p<0.001$). BMI was one of the predictors of DM, however, after adjustment analysis, BMI was not significant. This study was similar to a previous study from Septyaningrum *et al.* (2014), they reported that waist circumference was the most significant factor related to blood glucose level but different but BMI also had a significant relationship.²⁸

There was an association of high total cholesterol level (>200 mg/dl) with DM prevalence (OR 1.38, CI 95% 1.02-1.87, $p<0.04$) in this study. Subjects with DM also had comorbid such as dyslipidemia. High cholesterol levels are associated with the risk of DM and atherosclerotic cardiovascular disease.^{29,30} A study in Korea with more than 2.8 million subjects revealed that high total cholesterol levels may increase the risk for DM development (HR 1.139; 95% CI 1.116-1.163).³¹ However, HDL cholesterol levels did not associate with increased risk of DM.³²

The most significant risk factor for DM prevalence in this study was a family history of DM (OR 10.28, CI 95% 7.67-13.76, $p<0.001$). Family history of DM was reported to play a significant role in DM especially associated with the risk of obesity.^{33,34} Study in Korea showed that affected family members were siblings.³⁵ Study in African American found that 55% of the subjects had a family history of DM and they consider health behavior was affected by family.³⁶

We realized there were some limitations to this study. We used a cross-sectional approach to find the relationship between risk factors to DM prevalence. The data was based on self-reporting, and certain behaviors would make overreported or underreported bias. Point of care blood glucose testing was used in the survey and make potentially bias since it was not the gold standard for diagnosis of DM. Although there were a lot of limitations, we believe this study would give some insights and information related to the risk factors of DM in our setting.

Conclusions

We concluded that wetlands areas may reduce the prevalence of DM significantly. Age >40 years old, hypertension, waist circumference >90 cm, cholesterol level (>200 mg/dl), and family history of DM may increase the risk of DM prevalence significantly.

Further research with better study design, examination, and a larger sample size is necessary to establish the relationship. A study of wetlands area is necessary to give a better explanation related to a lower prevalence of DM in the area.

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Conflict of Interest

The authors had no conflicts of interest related to this study.

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