

Relationship Between Obesity and Diabetes Mellitus in People Above 40 Years Old in Indonesia: A Retrospective Cohort Study, Analysis of 2007 and 2014 Indonesian Family Life Survey Data

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Abstract— Diabetes mellitus is one of the most common diseases in the world with an incidence increase from 151 million in 2000 to 425 million in 2017. It is estimated that in 2045, its occurrence has the tendency of increasing to 629 million cases. Also, Indonesia is among the top 10 countries with the highest prevalence of this disease in the world. Therefore, the aim of this research is to determine the relationship between obesity and diabetes mellitus. The multistage random sampling method was used to obtain data from 2034 respondents using the quantitative and retrospective cohort study design which met the inclusion and exclusion criteria. In addition, the data analysis technique used was complex with three stages comprising of univariate, bivariate and multivariate. The results showed a relationship between obesity and diabetes mellitus in accordance with waist circumference, hypertension and physical activity (RR = 1.988; 95% CI = 1.679 – 2.354). The multivariate analysis showed a relationship between obesity and diabetes mellitus with a 4.1% incidence. Therefore, obsessed people need to indulge in weight loss programs, stick to a diet plan with less daily carbohydrate consumption and conduct regular physical activity to prevent diabetes mellitus.

Keywords: *diabetes mellitus, obesity, IFLS*

I. INTRODUCTION

Non communicable diseases (NCD) have become a public health problem across the world. In 2012, a total number of 56 million

deaths were recorded with 38 million (68%) due to Non-Infectious diseases such as diabetes.[1] This disease is globally recognized as one of the causes of premature death and disability, with world leaders listing it as one of the four main priorities of non-infectious ailments.[2] Diabetes is a complex disease and classified as severe, capable of causing complications and causing death.[3]

The International Diabetes Federation (IDF) report shows the number of infected people reached 425 million in 2017, and it is estimated to increase to 629 million in 2045. Furthermore, Indonesia is ranked 7th with a current total number of 10.3 million and an estimated 16.7 million in 2045.[4]

Diabetes is influenced by modifiable risk factors such as overweight, abdominal obesity, lack of physical activity, hypertension, dyslipidemia, unbalanced diet, history of impaired glucose tolerance (IGT) or blood sugar Impaired fasting, and smoking.[5] It is also influenced by unmodified factors namely race and ethnicity, age, sex, family history of diabetes mellitus and history of giving birth to a baby with a birth weight of more than 4000 grams. Obesity along with its increasing cases in the community, is one of the main risk factors.[6][7][8]

Diabetes Mellitus type 2 occurs due to obesity and improper dieting, thereby, causing body tissue and muscle cells to become insensitive or resistant to insulin with glucose buried in the blood circulation. Typically, its sufferers are diagnosed from the age of 40 with body fat and symptoms slowly or chronically occurring.[9][10][11]

Manifestations of obesity in its case, are related to the presence of the hormones leptin and insulin which functions to regulate and burn body fat levels into energy, thereby, creating a feeling of fullness. Generally, obsessed people experience leptin resistance, and tend to consume more food. The high levels of glucose in the body, makes the pancreas prone to insulin resistance thereby, circulating it in the blood leading to diabetes mellitus. [12]

It tends to affect various ages and economic levels, with its complications causing fatal health problems. It has the ability to cause a decrease in the quality of a person's life and predispose to a high mortality rate. This research aims to determine the relationship between obesity and diabetes mellitus in Indonesians above 40 years.

II. METHOD

This is a quantitative research with a retrospective cohort study design. It was conducted by analyzing secondary data on Indonesian Family Life Survey from 2007-2014 using a multistage random sampling technique. The data sample were people above 40 years, which led to a total of 2,034 respondents. Furthermore, the dependent and independent variables used are diabetes mellitus and obesity in accordance with waist circumference, age, sex, hypertension, total cholesterol, HDL, physical activity, smoking status and consumption of vegetables and fruits. Analysis of the data used is complex with three stages, namely univariate, bivariate and multivariate. The bivariate analysis uses the chi-square method while multivariate uses multiple logistic regressions with risk factor models.

III. RESULT

Univariate analysis was performed to determine the frequency distribution of respondents based on variables from the independent, dependent and confounding.

The results of this research indicate that those suffering from this disease for the past 7 years are 84 respondents (4.1%). The results of the univariate analysis in the table shows the distribution of respondents based on the obesity

variable were 345 (16.9%). The results also showed the majority of respondents were female (52.1%), aged ≥ 45 years (72.5%), did not suffer from hypertension (61.4%), non-smokers (66%), vegetable consumption and fruit (60.2%), no risky waist circumference (62.9%), possess normal cholesterol levels (62.9%), low HDL levels (69.2%), and belong to the category of adequate physical activity (51.7%).

TABLE 1
Variable frequency distribution which affects diabetes cases of people above 40 years old in Indonesia

Variable	Total of respondent	
	n	%
Dependent Variable		
Diabetes mellitus		
Yes	84	4.1
No	1950	95.9
Main Independent Variable		
Obesity		
Yes	345	16.9
No	1689	83.1
Confounding Variable		
Gender		
Female	1101	54.1
Male	933	45.9
Age		
≥ 45 years old	1474	72.5
< 45 years old	560	27.5
Hypertension		
Hypertension	785	38.6
Tidak Hipertensi	1249	61.4
Smoking Status		
Smoker	631	31
Ex-smoker	60	3
Not smoker	1343	66
Consumption of vegetables and fruits		
Less	1224	60.2
Enough	810	39.8
Waist size		
Risky	755	37.1
Unrisky	1279	62.9
Total cholesterol		
High	754	37.1
Normal	1280	62.9
HDL		

Low	1407	69.2
Normal	627	30.8
Physical Activity		
Less	983	48.3
Enough	1051	51.7

The results of the bivariate analysis showed that all variables were less than alpha (0.05), therefore, there was a relationship between the variables of obesity, sex, age, hypertension, smoking status, vegetable and fruit consumption, waist circumference, total cholesterol, HDL and physical activity with case of diabetes mellitus. The results of the statistical analysis above show the RR value of the main independent variable is 3.394. Furthermore, it shows that obesity is a risk factor for cases of diabetes with 95% CI ranging from 2.929 to 3.934.

TABLE 2

Relationship between main independent and confounding variable in diabetes mellitus

Variable	Diabetes Mellitus				<i>p-value</i>	RR 95% CI
	Yes		No			
	n	%	n	%		
Obesity						
Yes	35	9.9	310	90.1	<0.001	3.394 (2.929 – 3.934)
No	49	2.9	1640	97.1		
Gender						
Female	54	4.8	1047	95.2	<0.001	1.501 (1.333 – 1.691)
Male	30	3.2	903	96.8		
Age						
≥ 45 years old	70	4.8	1404	95.2	<0.001	1.978 (1.457 – 2.686)
< 45 years old	14	2.4	546	97.6		
Hypertension						
Yes	46	5.8	740	94.2	<0.001	1.887 (1.634 – 2.179)
No	38	3.1	1210	96.9		
Smoking Status						
Smoker	15	2.3	616	97.7	<0.001	0.470 (0.428 – 0.515) 1.777 (1.264 – 2.498) Reff.
Ex-smoker	5	8.2	55	91.8	<0.001	
Not smoker	64	4.8	1279	95.2		
Consumption of vegetables and fruits						
Less	44	3.6	1180	96.4	<0.001	0.757 (0.663 – 0.864)
Enough	40	4.8	770	95.2		
Waist size						
Risky	56	7.4	699	92.6	<0.001	3.455 (2.978 – 4.007)
Unrisky	28	2.1	1251	97.9		
Total cholesterol						
High	57	7.6	697	92.4	<0.001	3.658 (3.163 – 4.230)
Normal	27	2.1	1253	97.9		
HDL						
Low	44	3.1	1363	96.9	<0.001	0.498 (0.428 – 0.578)
Normal	40	6.3	587	93.7		
Physical						

Activity						
Less	53	5.4	930	94.5	<0.001	1.844 (1.628 – 2.089)
Enough	31	2.9	1020	97.1		

*Significant : *p*-value < 0.05

Similarly other variables, such as gender, age, hypertension, waist circumference, total cholesterol and physical activity also indicate a risk for developing diabetes mellitus, where women, above 45 years, suffer from hypertension with each RR 1.501; 1.978; 1.887; 3.455; 3.658; 1.844. While the smoking status variable, shows that ex-smokers are more at risk of developing diabetes mellitus with RR = 1.777 and RR = 0.470 showing protective results. Variable consumption of fruit and HDL also showed protective results with RR = 0.757 and 0.498.

TABLE 3

Final multivariate analysis model relationship between obesity and diabetes mellitus

Variable	p-value	RR _{Adjusted}	95% CI
Obesity			
Yes	<0.001	1.988	1.679 – 2.354
No			
Hypertension			
Yes	<0.001	1.431	1.235 – 1.657
No			
Waist Size			
Risky	<0.001	2.295	1.955 – 2.695
Unrisky			
Physical Activity			
Less	<0.001	1.386	1.221 – 1.574
Enough			

*Significant : *p*-value < 0.05

Based on the results of multivariate analysis, there is a relationship between obesity and diabetes with control from hypertension, waist circumference and physical activity RR = 1.988; 95% CI = 1.679 - 2.354.

IV. DISCUSSION

The purpose of this research was to determine the relationship between obesity and diabetes mellitus after being controlled by confounding variables. The results of this research indicate the incidence in the population aged above 40 years old in a period of 7 years 4.1%. These results are in line with some data which show an

increase in cases of diabetes mellitus every year.[4][13][14]

Diabetes is recognized as one of the causes of premature death and disability. It is included in the four main priorities of Non-Infectious diseases followed up by world leaders. Data from WHO shows that 1.5 million deaths in the world in 2012 were caused by diabetes mellitus.[2] Meanwhile, in 2017, deaths due to diabetes increased to 4 million people aged 20 to 79 years old which is equivalent to one death every eight seconds. Diabetes accounts for 10.7% of all causes of global death among people aged people between 20-79 years old.[4]

The results of this research indicate. a relationship between obesity and diabetes mellitus after being controlled with the variables of hypertension. waist circumference and physical activity. These results are in line with Nainggolan et.al research which shows obesity based on Body Mass Index (BMI) affects diabetes mellitus, overweight respondents have a risk of 1.98 times, compared to normal weight respondents (95% CI = 1.17 – 3.35).[15] According to Soriguer, obesity is significantly related to diabetes mellitus with OR 1.7 and 95% CI = 1.37 - 2.05.[16] Similarly, Idris et.al stated that there is a relationship between obesity and diabetes mellitus (OR = 1.46 95% CI = 1.35 – 1.58).[17]

Obesity is always accompanied by insulin resistance, which causes diabetes, and impairs metabolic energy control by creating and triggering the body. Leptin functions in influencing the work of the hypothalamus to regulate the amount of body fat, the ability to burn it into energy and satiety. Overweight increases the leptin levels in the body, however, it function is inhibited. Leptin is also related to the stress hormone cortisol which is increased by obsessed people. This is because fat tissue stimulates the production of the hormone cortisol. which has a function to stimulate the liver to release glucose.[18] [19]High levels of glucose in the body require the pancreas to continue producing the hormone insulin. Conditions of the body that produce too much insulin make it difficult for it to respond and ultimately cause insulin resistance. As a result of this. the amount of glucose in the body cannot be

stored and only circulates in the blood causing blood sugar levels to always be high and end up with diabetes mellitus.

The results of this research indicate the relationship between obesity and diabetes mellitus is influenced by other variables, namely waist circumference, hypertension and physical activity. The manifestations of waist circumference are similar to those of obesity because these two variables are equally related to fat levels in the body, with differences in fat deposits. The high amount of fat around the abdominal cavity tends to cause various health problems due to its ability to excrete free fatty acids and dozens of hormones which inhibits the body's function. The presence of body fat tissue. especially those found in the abdominal cavity interferes with the working process of insulin. [20]Tandra also stated that fat deposits around the stomach area tends to block the action of insulin which stores sugars in cells and only accumulates circulation in the blood.[18] This theory is in line with Wijayaningrum's research which showed a positive correlation between abdominal circumference and the incidence of insulin resistance.[21] Pusparini also stated that the accumulation of adipose tissue in the abdominal cavity increases the risk of insulin resistance to the development of metabolic syndrome compared to fat accumulation in other stomach area.[22]

Eyre in Supriyadi stated that hypertension causes diabetes mellitus through the distribution of blood sugar in the body which becomes difficult to circulate into cells resulting in accumulation.[23] Meanwhile, Brunner and Suddarth stated that hypertension causes diabetes mellitus due to hypertension which increases the incidence of atherosclerosis which has an impact on decreasing beta pancreatic cells.[24] Obsessed people tend to be at greater risk of developing hypertension with their heart pumping blood harder than usual because it is stuck in fat.[25]

Physical activity is believed to stimulate insulin in order to use glucose synergistically. People with diabetes mellitus generally experience insulin resistance but the stimulation of body movements in physical activity has an effect on use of glucose optimally. Physical

activity is known to be able to increase the concentration of GLUT-4 in cell membranes which has an impact on increasing glucose absorption using low insulin levels. This provides a very good effect because with physical activity blood sugar levels can be more controlled. which leads to diabetes mellitus when not controlled.[26]

One of the advantages of cohort research design is calculate the probability of disease based on its variables. Here are some probability calculations based on the results of this research:

$$z = -4,112 + 0,687X_1 + 0,358X_2 + 0,831X_3 + 0,326X_4$$

Probability of obese people to get diabetes mellitus

$$f(Z) = \frac{1}{1 + e^{-\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}$$

$$f(Z) = \frac{1}{1 + e^{-(-4.112 + 0.687(1) + 0.358(0) + 0.831(0) + 0.326(0))}}$$

$$f(Z) = 0.0315 \approx 3\%$$

Probability of hypertension to get diabetes mellitus

$$f(Z) = \frac{1}{1 + e^{-\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}$$

$$f(Z) = \frac{1}{1 + e^{-(-4.112 + 0.687(0) + 0.358(1) + 0.831(0) + 0.326(0))}}$$

$$f(Z) = 0.0228 \approx 2\%$$

Probability of people with a risky waist circumference to get diabetes mellitus

$$f(Z) = \frac{1}{1 + e^{-\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}$$

$$f(Z) = \frac{1}{1 + e^{-(-4.112 + 0.687(0) + 0.358(0) + 0.831(1) + 0.326(0))}}$$

$$f(Z) = 0.0362 \approx 4\%$$

Probability of people with less physical activity to get diabetes mellitus

$$f(Z) = \frac{1}{1 + e^{-\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}$$

$$f(Z) = \frac{1}{1 + e^{-(-4.112 + 0.687(0) + 0.358(0) + 0.831(0) + 0.326(1))}}$$

$$f(Z) = 0.0221 \approx 2\%$$

Probability of people with 4 risk factors (obesity, hypertension, risky waist circumference and less physical activity) to get diabetes mellitus

$$f(Z) = \frac{1}{1 + e^{-\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}$$

$$f(Z) = \frac{1}{1 + e^{-(-4.112 + 0.687(1) + 0.358(1) + 0.831(1) + 0.326(1))}}$$

$$f(Z) = 0.1289 \approx 13\%$$

Probability of people without 4 risk factors (obesity, hypertension, risky waist circumference and less physical activity) to get diabetes mellitus

$$f(Z) = \frac{1}{1 + e^{-\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}$$

$$f(Z) = \frac{1}{1 + e^{-(-4.112 + 0.687(0) + 0.358(0) + 0.831(0) + 0.326(0))}}$$

$$f(Z) = 0.0161 \approx 2\%$$

The results of the probability calculation show that people above 40 years and without risk factors have a chance of suffering from diabetes mellitus by 2% during the 7-year follow-up period, while those only with one risk factor namely hypertension or lack of physical activity also have a chance of suffering from diabetes mellitus by 2%. In addition, people with a risk factor of obesity, has a 3% chance of having diabetes mellitus and a risk factor for waist circumference of 4%. Furthermore, those with four risk factors namely obesity, hypertension, risky waist circumference and lack of physical activity have a 13% chance to acquire diabetes mellitus.

V. CONCLUSION

The incidence of diabetes mellitus in this research was 4.1%. while the results of the bivariate analysis showed a relationship between the variables of obesity, age, sex, hypertension, total cholesterol, HDL, waist circumference, smoking status, vegetable and fruit consumption and physical activity. Also, the results of multivariate analysis showed a relationship between obesity and diabetes mellitus after being controlled with confounding variables such as hypertension, waist circumference and physical activity.

People are expected to make physical activity regularly, diligently carry out sugar screening. The elementary school is expected to provide

education on healthy lifestyles. and this helps prevent obesity with early optimization.

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