

Body Mass Index, Plasma Glucose Level, and Subjective Psychological Well-Being of Diabetes Mellitus Type 2 Patients as the Risk of Tuberculosis Coincidence

Muhammad Atoillah Isfandiari¹, Chatarina Umbul Wahyuni²,
Agung Pranoto³

¹Faculty of Public Health, Universitas Airlangga, Indonesia, 60115

²Airlangga Health Science Institute, Universitas Airlangga, Indonesia, 60115

³Surabaya Diabetes and Nutrition Center Faculty of Medicine Universitas
Airlangga-dr. Soetomo Hospital, Internal Medicine, Surabaya, Indonesia,
60285

Abstract

Background. Body Mass Index (BMI) and Plasma Glucose Level are independent risk factor for both Tuberculosis and Diabetes Mellitus, respectively, while psychological well-being might affect immune system of diabetic patients. The objective of this study was to analyze the risk of BMI, Plasma Glucose level, and subjective psychological well-being to affect tuberculosis coincidence in diabetes mellitus patients.

Materials and methods. This case-control study involved 492 respondents consisting of 246 diabetes mellitus patients with TB coincidence as case group and 246 diabetes mellitus patients without TB as control. The variables analyzed were BMI, mean fasting and 2-hour plasma glucose level and subjective psychological well-being using logistic regression test.

Results. The results showed that there were significant associations between BMI ($p=0.001$; OR 3.25 with 95% CI 1.88-5.62), mean fasting glucose levels ($p=0.001$; OR 3.3 with 95% CI 1.93-5.74), 2-hour plasma glucose ($p=0.001$; OR 1.6 with 95% CI 1.09-2.34), subjective psychological well-being ($p=0.001$; OR 2.02 with 95% CI 1.40-2.93) and diabetes mellitus with tuberculosis coincidence.

Conclusion. BMI, Plasma Glucose level, and subjective psychological well-being are risk factors of diabetes mellitus coincidence with tuberculosis.

Keywords: *Body Mass Index, Mean Plasma Glucose Level, Subjective Psychological Well-being, Diabetes Mellitus Coincidence Tuberculosis.*

I. INTRODUCTION

The double burden of disease is currently be major health problem that many developing countries deal with. Therefore, Indonesia as a developing country is also currently undergoing an epidemiological transition as the aftermath of fundamental economic and demographic transition, and the consequence is that prevalence of non-communicable diseases increases with diabetes mellitus is among the most rapid increasing one, but in the other hand the communicable diseases such as tuberculosis remain to be important health problem (Ministry of Health of Republic of Indonesia, 2011).

The prevalence of diabetes mellitus increases rapidly in many developing countries including Indonesia, as the result of the changes in diet patterns and lifestyles. The increasing prevalence in Indonesia can be estimated by the rise of the number of diabetes mellitus patients in Indonesia from approximately 171 million people in 2000 to 440 million by 2030 (WHO, 2013). In terms of epidemiological transition, WHO identifies diabetes mellitus as an important, re-emerging, but neglected risk factor for tuberculosis (WHO, 2013). Several factors associated with of tuberculosis coincidence in type 2 diabetes mellitus are, among others, history of contact with previous TB patients, poor glycemic control, impaired immunity, quality of the house's environment, and mental stress (García & Rey-Pineda, 2014).

Increased cases of tuberculosis in patients with diabetes mellitus also occurs in Indonesia so that it increases morbidity and mortality of both tuberculosis and diabetes mellitus patients. In an epidemiologic study it was reported that the prevalence of tuberculosis was between 10-15% and 2-5 times higher in diabetic patients compared to non-diabetic patients as control (Yamashiro, Kawakami, Kinjo, Miyagi, & Nakamura, 2005). In another study conducted by Alisjahbana et al in 2001-2005, diabetes mellitus was more common in new pulmonary tuberculosis patients than non-tuberculosis patients (Alisjahbana, et al., 2006). In another studies Alisjahbana et al also noted that the previous weight of tuberculosis patients with diabetes mellitus usually heavier compared to those who did not have diabetes mellitus, and even heavier after tuberculosis treatment. In that study it was revealed that in Indonesia, the median of 53% diabetic patients with tuberculosis coincidence weight was above 50 kg before treatment, compared with non-diabetic patients who had a 16.5% lower body weight in average (Alisjahbana, et al., 2007).

Psychological stress is also among factors that can also reduce the immune system of diabetic patients is. It may occurs because of inadequate fulfilling of basic human needs in particular, and will be manifested by the changes in physiological, cognitive, emotional and behavioral functions (Soewadi, 1997), which of course begins with a change of perception on the quality of life.

According to many studies, psychological stress level can be measured by several methods. During 2014, The Australian Psychological Society undertook a national survey, and the result was that stress was related to the mental status represented by psychological well-being. It is a multi-dimensional concept, subjectively indicated by feelings of cheerfulness, optimism, self-control, freedom from feelings of frustration, anxiety and loneliness (Singh & Shyam, 2007). In some studies psychological well-being is frequently used to explain the concept of mental health in general (Borden & Berlin, 1990).

Thus, estimating the risk of a diabetic patient to develop TB as a coincidence is important so the earlier and more adequate prevention efforts may be well undertaken. In this study plasma glucose level represented by mean fasting and 2-

hours plasma glucose level and psychological well-being are variables analyzed to measure the risk of TB coincidence in patients with diabetes mellitus.

Furthermore, assessing Body Mass Index, Plasma glucose level, and subjective psychological well being is expected to be implemented in order to improve case finding protocol of diabetes mellitus with tuberculosis coincidence particularly in remote Primary Health Centers and hospitals with limited screening tools, and to intensify early prevention of diabetes mellitus with TB coincidence.

II. MATERIALS AND METHODS

In this case control study we analyze the risk of Body Mass Index, mean plasma glucose level and psychological well-being of diabetes mellitus patients to tuberculosis coincidence. Case control design was used, considering that tuberculosis is a chronic infectious disease which has relatively long latent period and – in spite of increasing rapidly, tuberculosis coincidence is not frequently found among diabetic patients.

The study was conducted at 29 Primary Health Centers with a high prevalence of tuberculosis coincident with diabetes mellitus, and also in pulmonary hospital in Surabaya. The study was conducted from May 2016 to April 2017, involving 492 out of 509 respondents drawn, consisting of 246 diabetes mellitus patient with TB coincidence as case group and 246 patients with diabetes mellitus without TB as control group, both case and control groups has the history of contact with previous tuberculosis patients, recruited using simple random sampling technique, so that every type 2 diabetes mellitus patient who is also diagnosed as tuberculosis has equal opportunity to be drawn as respondent. Data was analyzed using simple logistic regression test.

a. Body Mass Index

Body Mass Index was used to represent nutritional state of respondent, and was defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m^2 (WHO, 2017). In this study, data of Body Mass Index was collected from medical record in the Primary Health Centers recorded three month earlier to obtain the data of body mass of the patients at the time when they were first diagnosed as tuberculosis patients for case group compared to body mass index for control group at similar period. The result was divided into 2 categories, below 18.5 kg/m^2 , based on WHO classification that normal Body Mass Index is ranged between 18.5 to 24.99 kg/m^2 (WHO, 2017).

b. Plasma Glucose Level

In this study Plasma Glucose Level was defined by the mean of 3 times measurement of Fasting Plasma Glucose (FPG) and 2-hours plasma glucose level of respondents respectively during last 6 months. The data were taken randomly during those period from medical records of Primary Health Centers and Hospitals. Plasma Glucose Level was categorized as ‘well controlled’ if the mean Fasting Plasma Glucose was $<126 \text{ mg/dL}$ and 2-hours plasma glucose level was $<200 \text{ mg/dL}$ (WHO, 2017). In contrast, Plasma Glucose Level was categorized as ‘poor controlled’ in one or both these two conditions: the mean FGL was $\geq 126 \text{ mg/dL}$ or 2-hours plasma glucose level was $\geq 200 \text{ mg/dL}$. HbA1C measurement was not used in this study, aside from the use of this measurement is not routinely implemented in primary health centers in Indonesia for its highly cost, the result of this study is expected to be able to be implemented in the remote primary health centers with very limited resources.

c. Psychological Well-being

Psychological well-being is subjective important dimension of overall perceived quality of life, demonstrated by feelings of joy, optimism, self-control, freedom from frustration, and loneliness to represent of the physical stress experienced by a person affecting the immune status. In this study, data of psychological wellbeing was obtained through interviews using WHO-5 well-being index because this index is a short, self-administered questionnaire covering 5 positively worded items, related to positive mood, vitality, and general interests. It is also shown to be a reliable measure of emotional functioning and a good screener for depression (Wu, 2014). Administering the WHO-5 Well-being Index takes only 2-3 minutes and can be integrated in clinical routine, both in primary and secondary care.

Each respondent was given five statements include: I feel cheerful and excited; I feel calm and relaxed; I feel active and vigorous; I woke up feeling refreshed and rested; My everyday life is filled with things that interest me. In each of the proposed statements, the respondent selects one of the options of answers as rating on a 6-point Likert scale from at no the time (0), some of the time (1), less than half of time (2), more than half of the time (3), most of the time (4), all the time (5). Scores are summated, with raw score ranging from 0 to 25, then the scores are transformed to 0-100 by multiplying by 4, with higher scores meaning better well-being. A score of 50 or below is indicative for low mod, and score above t 50 shows the opposite (Diabetes Attitudes Wishes and Needs, 2011).

III. RESULTS

a. Body Mass Index

This study showed that Diabetes Mellitus patients with tuberculosis coincidence mostly had normal Body Mass Index at the first time they were diagnosed as tuberculosis patients, whereas the control group mostly showed mild obesity. As shown in the table 1, diabetic patient with lower BMI when they were diagnosed as tuberculosis, which was defined as BMI lower than 18.5 kg/m², were more common in case group rather than in the control group. Contrarily, diabetic patients with normal or higher BMI were more common in the control group than in case group.

Table 1. Distribution of Body Mass Index of respondents

BMI	Case group	Control group	p-value
	N (%)	N (%)	
<18.5 kg/m ²	55 (22.4)	20 (8.1)	0.001
≥18.5 kg/m ²	191 (77.7)	226 (91.9)	
TOTAL	246 (100.0)	246 (100.0)	

Logistic regression analysis showed that there was a significant association between BMI and tuberculosis diabetes mellitus patients, and according to Odds Ratio value the risk of tuberculosis in diabetic patients with lower BMI (<18.5 kg / m²) is 3.25 fold greater (95% CI 1.88-5.62) compared to diabetic patients with BMI ≥ 18.5 kg/m².

b. Plasma Glucose level

The 2015 Indonesian Society of Endocrinology consensus defined that normal Fasting Plasma Glucose (FPG) level is 126 mg/dL (Perkumpulan Endokrinologi Indonesia, 2015). According to this criterion the result showed that the mean fasting plasma glucose of respondents in both groups in general is higher than the normal value. It was also shown in the table 2 that the mean FPG in the case group is higher than normal values and even the mean of FPG of control group.

Table 2. Distribution of Fasting Plasma Glucose (FPG) in both Case and Control Group

FPG	Case group	Control group	p-value
	N (%)	N (%)	
>126 mg/dL	226 (91.9)	190 (77.2)	0.001
≤126 mg/dL	20 (8.1)	56 (22.8)	
TOTAL	246 (100.0)	246 (100.0)	

Statistical analysis also showed that there was a significant association between mean FPG level and tuberculosis coincidence in diabetes mellitus patients, and the risk of mean FPG above the normal value to lead tuberculosis coincidence among these diabetic patients based on odds ratio value was 3.3 fold greater (CI 95 % 1.93-5.74) compared to mean FPG less than normal value.

The 2015 Indonesian Society of Endocrinology consensus also defined that normal 2-hour plasma glucose level is 200 mg/dL, so according to this criterion it was shown in table 3 that the mean 2-hour plasma glucose level of both case and control groups were higher than normal value, in general. The table also show that the mean 2-hour Plasma Glucose level in case group is higher than both normal value and the mean of 2-hour Plasma Glucose level in control group.

Table 3. Distribution of 2-hour Plasma Glucose Level in both Case and Control Group

2-hour Plasma glucose level	Case group	Control group	p-value
	N (%)	N (%)	
> 200 mg/dL	180 (73.2)	155 (63.0)	0.016
≤ 200 mg/dL	66 (26.8)	91 (37.0)	
TOTAL	246 (100.0)	246 (100.0)	

Statistical analysis showed that there was a significant association between mean 2-hour Plasma Glucose level and tuberculosis coincidence among type 2 diabetes mellitus patients and when the mean 2-hour plasma glucose level is above the normal value, it will increase the risk of tuberculosis coincidence 1.6 fold greater (95 CI % 1.09-2.34) than those who had mean 2-hour plasma glucose level less than normal value.

c. Subjective Psychological well-being

Most of respondents in both case and control group actually had good subjective psychological well-being, however the proportion of respondents with good and low psychological well-being is different between case and control group. The patients with good psychological well-being was more common in control group than in case group. Moreover, statistical analysis also confirmed the risk of low psychological well-being of type-2 diabetes mellitus patients with tuberculosis coincidence as shown in table 4.

Table 4. Distribution of Subjective Psychological Well-Being in both Case and Control Group

Psychological well being	Case group	Control group	p-value
	N (%)	N (%)	
Low psychological well-being (Low mood)	117 (47.6)	76 (30.9)	0.001
Good psychological wellbeing (Good mood)	129 (52.4)	170 (69.1)	
TOTAL	246 (100.0)	246 (100.0)	

Logistic regression analysis showed that there was a significant association between psychological well-being and tuberculosis coincidence in patients with diabetes mellitus ($p = 0.001$) with the risk for tuberculosis coincidence 2.02 fold greater in patients with low psychological well-being compared to those with good psychological well-being (95% CI 1.40-2.93).

Table 5. Distribution of Subjective Psychological Well-Being Based on Five Statements in both Case and Control Group

Answer	Q1	Q2	Q3	Q4	Q5
	N (%)				
0	10 (2.0)	8 (1.6)	14 (2.8)	23 (4.7)	23 (4.7)
1	106 (21.5)	100 (20.3)	83 (16.9)	76 (15.4)	82 (16.7)
2	34 (6.9)	33 (6.7)	31 (6.3)	23 (4.7)	33 (6.7)
3	38 (7.7)	54 (11.0)	55 (11.2)	48 (9.8)	52 (10.6)
4	145 (29.5)	143 (29.1)	122 (24.8)	152 (30.9)	139 (28.3)
5	159 (32.3)	154 (31.3)	187 (38.0)	170 (34.6)	163 (33.1)
Total	492 (100.0)	492 (100.0)	492 (100.0)	492 (100.0)	492 (100.0)

Note :

Answer 0: at no the time

Answer 1: some of the time

Answer 2: less than half of the time

Answer 3: more than half of the time

Answer 4: most of the time

Answer 5: All of the time

Q1: I feel cheerful and excited

Q2: I feel calm and relaxed

Q3: I feel active and vigorous

Q4: I woke up feeling refreshed and rested

Q5: My everyday life is filled with things that interest me

IV. DISCUSSION

Tuberculosis is among the cause of malnutrition, and malnutrition is one among factors affecting tuberculosis infection, vice versa. The risk to tuberculosis is due to malnutrition that tends to occur along with poverty, stress and smoking, and many other environmental and biological factors. In addition, Body Mass Index has been shown to be an independent risk factor for TB both in developed and developing countries. In the same study it was also said that in particular, tuberculosis in Indonesia might be linked to malnutrition and diabetes mellitus (Wulandari & Sugiri, 2013). This study showed that the average Body Mass Index (BMI) of respondents at the time they were diagnosed as tuberculosis was generally in the normal category. In the case group the average BMI of respondents were also generally in the normal category, whereas in the control group the average BMI of respondents showed mild obesity.

Statistical analysis result showed that in this study there was a significant association between BMI (based on the criteria of the Ministry of Health of Republic of Indonesia) and tuberculosis coincidence whereas the risk of

tuberculosis among these diabetic patients with lower BMI based on odds ratio value was 3.25 fold greater than those with diabetic patients with normal BMI or more.

Similar result was shown by Ullah et al who found that all respondents who suffered from pulmonary tuberculosis came from a lower economic income (Ullah, Iqbal, Ullah, Mahboob, & Rehman, 2013). In many studies, household income is frequently associated with the risk factor for pulmonary TB, although it was difficult to explain whether the association is the actual linkage between the incomes or it was caused by other confounding variables which are identical with poverty such as overcrowded housing, malnutrition, and exposure to indoor air pollution from gas Households (Narasimhan, Wood, Raina, & Mathai, 2013). In this study, 84% of respondents with lower BMI were respondents with incomes below the Average Regional Income (ARI) determined by local authority, in which the ARI was considered to represent their economic status. One of the main goals of diabetes mellitus management is to achieve good or targeted glycemic control so as to prevent long-term complications. In the context of TB coincidence, one of the most important determinants of TB incidence in people with diabetes mellitus is the level of glycemic control or control of blood sugar levels.

Increased risk of smear-positive pulmonary TB has been demonstrated in HbA1c levels of 7% or more (Wen, 2010). These results are supported by Leung et al. that diabetes mellitus patients with HbA1c <7% did not increase the risk of TB (Leung, et al., 2008). Nathella Pavan Kumar et al also found that there was a significant association between high HbA1c levels which indicated poor glycemic control with the incidence of coincidental diabetes mellitus with tuberculosis (Kumar, Shridar, Banurekha, Jawahar, & Nutman, 2013).

In this study, although mean fasting and 2-hour post prandial plasma glucose level was used to represent glycemic control indicator rather than HbA1c level considering that this examination is more feasible to be performed in the remote area health centers, the results of this study show the conformable conclusion, because in this study it was found that poor glycemic control showed by poor average of Fasting Plasma glucose and 2-hour plasma glucose, significantly affect the incidence of tuberculosis. The result of subjective psychological well-being analysis showed that most of the respondents had good psychological well-being, whether they're case or control group. This measurement is indicated by cheerfulness, optimism, self-control, freedom from feelings of frustration, anxiety and loneliness assessed using WHO-5 well-being index instrument.

As shown in the table 5, feeling active and vigorous is among 5 feeling asked in this study that mostly answered as experienced all the time by respondent both in case and control group, while only 2 % of respondents, both in case and control group testify that they have felt any good psychological well-being at no time. However, the proportion of respondents with good psychological wellbeing in control group were larger compared to those with tuberculosis coincidence, so by using logistic regression analysis it was found that there was a significant association between psychological well-being and the coincidence of TB in diabetic patients, with the risk of low psychological well-being for suffering from tuberculosis coincidence is 2.02 fold higher (95% CI 1.40-2.93) compared to those with good psychological wellbeing.

V. CONCLUSION

Body Mass Index, Plasma glucose level consisting of average fasting blood glucose and 2-hour plasma glucose level, and subjective psychological wellbeing

are significant risk factors of tuberculosis coincidence in patients with type-2 Diabetes Mellitus.

According to these results, it is expected that diabetic patients with history of contact with previous tuberculosis patients will be able to perform self-assessment to measure the risk of tuberculosis coincidence so the prevention will be performed as early as possible.

Further studies to develop more comprehensive predictive measurement by investigating other risk factors are suggested in order to effectively prevent tuberculosis coincident with diabetes mellitus better in the community.

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