ABSTRACT

Underweight increases the risk of pulmonary tuberculosis in adult

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BACKGROUND
Tuberculosis (TB) is a leading cause of morbidity and mortality, especially in middle- and low-income countries. The risk of developing TB may be related to nutritional status. Socioeconomic and behavioral factors are also shown to increase the susceptibility to TB infection. The objective of this study was to determine nutritional factors as risk factors of pulmonary TB in adult.

METHODS
This was an observational study of case control design. The study subjects were community members consisting of 19 adult cases of pulmonary tuberculosis and 38 controls. Data on nutritional intakes were obtained by semiquantitative food frequency questionnaire (FFQ), while smoking behavior, history of DM, body mass index, education, and income were obtained by structured interviews. The data were analyzed by independent t-test and logistic regression for calculation of the odds ratio (OR).

RESULTS
The bivariate test showed that the adequacy levels for energy (OR=6.8; 95% CI: 1.51-30.54), protein (OR=5.1; 95% CI: 1.52-17.14), vitamin A (OR=4.2; 5% CI: 1.31-13.54), vitamin C (OR=3.8; 95% CI: 1.21-12.36), selenium (OR=4.2; 95% CI: 1.34-13.58), body mass index (OR=4.4; 95% CI: 1.32-14.35) and smoking behavior (OR=3.7; 95% CI: 1.15-11.9), were significant risk factors for pulmonary tuberculosis. Multiple logistic regression test showed that low body mass index (<18.5 kg/m2) (OR=6.0; 95% CI: 1.32-27.18) was the most influential risk factor of pulmonary tuberculosis.

CONCLUSION
Low body mass index is the most influential risk factor for pulmonary tuberculosis incidence in adult. Nutrition profile in adult is an important determinant of TB incidence.

Keywords: Pulmonary tuberculosis, body mass index, energy, smoking behavior, adult
INTRODUCTION

Pulmonary tuberculosis is a directly transmissible disease caused by *Mycobacterium tuberculosis*. *Mycobacterium tuberculosis* mostly attacks the lungs, but may also affect other organs.\(^\text{1}\) Pulmonary tuberculosis is a communicable disease that is still attracting global attention, since to date there is no single country that is free of pulmonary tuberculosis.\(^\text{1}\) The number of patients with pulmonary tuberculosis in the world is increasing annually. The results of a WHO survey in 2013 showed that there were approximately 9 million patients with pulmonary tuberculosis, with more than half (56%) living in Southeast Asia and the Western Pacific region.\(^\text{1}\) Indonesia currently ranks third as one of the countries with the largest numbers of pulmonary tuberculosis cases in the world after China and India, with the number of patients reaching 325,582 in 2013.\(^\text{2}\) The prevalence of tuberculosis in Central Java ranks fifth at 0.4%.\(^\text{2}\) Banjarnegara district in 2013 had a prevalence of 0.3% per 100,000 inhabitants.\(^\text{3}\) The number of pulmonary tuberculosis patients in 2014-2016 in Karangkobar subdistrict showed a fluctuating trend, with 14 cases in 2014, 123 suspected and 30 confirmed cases in 2015 and 19 cases in May 2016.\(^\text{3}\) Apart from home environmental health factors, nutritional status is also associated with the incidence of pulmonary tuberculosis.\(^\text{4}\) Inadequate intakes of protein and energy result in excessive utilization of the energy reserves of the body, thus causing weight loss and biochemical abnormalities.\(^\text{5}\)

One study states that energy adequacy level affects nutritional status.\(^\text{6}\) Undernutrition may increase the risk of pulmonary tuberculosis, since poor nutritional status may undermine the immune system and facilitate aggravation of the tuberculosis.\(^\text{7}\) Pulmonary tuberculosis may cause nutritional deficiency from decreased appetite, thus influencing nutrient intakes, with consequent changes in metabolic processes. The association between poor nutrition and pulmonary tuberculosis has been demonstrated by the BCG vaccine trial conducted in the US in 1960 and it has been estimated that undernourished children have a two-fold risk of pulmonary tuberculosis as compared with well-nourished children.\(^\text{8}\)

Nutrients such as vitamin A and zinc are micronutrients that play an important role in immunity. In addition, other antioxidant compounds such as selenium, vitamin C, vitamin D, vitamin E and iron may assist in maintaining the host defences in a healthy condition, by preventing oxidative processes and inflammatory responses.\(^\text{8}\) Smoking behavior is also a factor that is associated with pulmonary tuberculosis incidence, in addition to nutrient intakes.\(^\text{9}\) One study showed that there is an association between smoking and pulmonary tuberculosis incidence and that smokers have a 3.1-fold higher risk for pulmonary tuberculosis than non-smokers.\(^\text{9}\) Up to the present, pulmonary tuberculosis has been associated solely with poor nutrition caused by environmental factors and the epidemiological spread of the disease, so that there is a need for a more specific study on nutrient intakes, in order to know the nutrient adequacy levels at risk for pulmonary tuberculosis.\(^\text{10}\) Previous studies on nutritional status as risk factor have not shown consistent results. A study conducted in rural India stated that there was no association between body mass index and pulmonary tuberculosis incidence.\(^\text{11}\) Therefore a study is needed that aims to determine nutritional status as risk factor for pulmonary tuberculosis incidence in adults.

METHODS

Research design

The study was of case-control observational design and conducted at Puskesmas Karangkobar in Banjarnegara District, Central Java, between July and August 2016.

Research subjects

The subjects of this study were adult males and females aged 19-63 years, consisting of 19 cases of pulmonary tuberculosis and 38 controls.
(non-tuberculosis cases), yielding a total of 57 subjects. The total number of study subjects was arrived at on the basis of a total sampling of cases that were registered during the previous 6 months at Puskesmas Karangkobar as patients with pulmonary tuberculosis. The inclusion criteria in this study were subjects diagnosed with pulmonary tuberculosis who were positive for acid-fast bacilli and had positive radiographs, community members with suspect pulmonary tuberculosis, and healthy community members living with pulmonary tuberculosis patients, who resided in the catchment area of Puskesmas Karangkobar, Banjarnegara District, and were willing to participate in the study. The exclusion criteria were pulmonary tuberculosis patients with complications.

**Assessment of nutrient intakes**

Nutrient intakes were obtained from the results of interviews performed by the investigators using semi-quantitative food frequency questionnaires. The assessed nutrient intakes comprised energy, protein, vitamin A, vitamin C, and selenium. Nutrient adequacy levels were calculated using the Nutrisurvey 2007 program and were based on the Indonesian Recommended Daily Allowances (IRDA) for 2013. Energy and protein adequacy levels were categorized as poor if <90% of IRDA and optimal if $\geq 90\%$ of IRDA. Vitamin A, vitamin C and selenium adequacy levels were categorized as poor if <77% of IRDA and optimal if $\geq 77\%$ of IRDA.

**Anthropometric measurements**

Assessment of body mass index (BMI) of the study subjects was performed by the investigators. The BMI values of the study subjects were obtained from measurements of body weight before receiving treatment for 6 months and divided by height. BMI was categorized as underweight if $<18.5$, normal if $18.5 \leq 24.9$, and overweight if $>25 \leq 29.9$.

**Smoking habits**

Smoking behavior was obtained through structured interviews. The instruments used were the list of interview questions and the informed consent form. The associated data were presence of active smoking behavior at a frequency of more than once on the day previous to the establishment of the diagnosis of pulmonary tuberculosis.

**Statistical analysis**

Data analysis was performed by means of the independent t-test and logistic regression. Multiple logistic regression was performed to control for possible confounding factors and to identify factors that are independently associated with undernutrition. A p value of less than 0.05 was used to declare the presence of a statistically significant association between variables.

**Ethical clearance**

This study was conducted after obtaining approval from the ethical commission under no.774/EC/FK-RSDK/2016.

**RESULTS**

Table 1 shows that for the characteristics of age and gender there were no differences ($p>0.05$) between the group of cases and the group of controls.

<table>
<thead>
<tr>
<th></th>
<th>Cases (n=19)</th>
<th>Controls (n=38)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>31.0 ± 17.3</td>
<td>32.0 ± 13.5</td>
<td>0.406</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>9 (47.4)</td>
<td>14 (36.8)</td>
<td>0.633</td>
</tr>
<tr>
<td>Female</td>
<td>10 (52.6)</td>
<td>24 (63.2)</td>
<td></td>
</tr>
</tbody>
</table>
Table 2 lists the risk factors for pulmonary tuberculosis. Poor adequacy levels for energy and protein were risk factors for pulmonary tuberculosis incidence, with respective OR values of 6.8 (95% CI=1.51 – 30.54) and 5.1 (95% CI=1.52 – 17.14). Poor adequacy levels for vitamin A, vitamin C and selenium were also risk factors for pulmonary tuberculosis incidence, with respective OR values of 4.2 (95% IC=1.31 – 13.54), 3.8 (95% IC=1.21 – 12.36), and 4.2 (95% IC=1.34 – 13.58). In addition, body mass index of <18.5 kg/m² (OR=4.4; 95% CI=1.32 – 14.35) and smoking behavior (OR=3.7; 95% IC= 1.15 – 11.91) were risk factors for pulmonary tuberculosis incidence. Body mass index of <18.5 kg/m² was the major risk factor for pulmonary tuberculosis incidence (OR=6.0; 95% CI=1.32 – 27.4) (Table 3).

### DISCUSSION

Poor adequacy levels for energy were more frequently found in the group of cases than in the group of controls, whereas optimal adequacy levels for energy were more frequently found in the group of controls than in the group of cases. A similar study in the province of Nusa Tenggara Timur found that respondents with poor energy intakes were closely associated with pulmonary tuberculosis incidence. The body uses 60-70% of the total energy requirement for maintaining its basic functions, called the basal metabolism. The energy is required for the basal metabolism and such body functions as digestion, processing, and absorption of food in the digestive tract, moving, walking, working, and other activities. Inadequate energy consumption leads to

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Pulmonary tuberculosis category</th>
<th>p</th>
<th>OR 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adequacy level for energy (Cal)</strong></td>
<td>Poor</td>
<td>0.011</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>Optimal</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adequacy level for protein (g)</strong></td>
<td>Poor</td>
<td>0.016</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Optimal</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adequacy level for vitamin A (mcg)</strong></td>
<td>Poor</td>
<td>0.023</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Optimal</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adequacy level for vitamin C (mcg)</strong></td>
<td>Poor</td>
<td>0.042</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Optimal</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adequacy level for selenium (mcg)</strong></td>
<td>Poor</td>
<td>0.026</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Optimal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>Low</td>
<td>0.031</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Normal/high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking behavior</td>
<td>Yes</td>
<td>0.046</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Multiple logistic regression of significant variables of pulmonary tuberculosis

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>p</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index</td>
<td>6.0</td>
<td>0.020</td>
<td>1.32</td>
</tr>
<tr>
<td>Adequacy level for selenium</td>
<td>3.7</td>
<td>0.096</td>
<td>0.79</td>
</tr>
<tr>
<td>Adequacy level for vitamin A</td>
<td>3.7</td>
<td>0.084</td>
<td>0.84</td>
</tr>
<tr>
<td>Adequacy level for protein</td>
<td>3.5</td>
<td>0.085</td>
<td>0.82</td>
</tr>
<tr>
<td>Adequacy level for vitamin C</td>
<td>3.0</td>
<td>0.094</td>
<td>0.82</td>
</tr>
<tr>
<td>Smoking behavior</td>
<td>2.8</td>
<td>0.152</td>
<td>0.67</td>
</tr>
<tr>
<td>Adequacy level for energy</td>
<td>1.8</td>
<td>0.485</td>
<td>0.34</td>
</tr>
</tbody>
</table>
excessive utilization of the energy reserves of
the body, thus resulting in weight loss and
biochemical abnormalities.(5)

In the group of cases only 8 subjects had an
optimal adequacy level for protein, whereas 11
of the 19 subjects had poor adequacy levels for
protein. Low protein intake is a risk factor for
pulmonary tuberculosis incidence, e.g. energy-
protein deficiency is associated with abnormal
cell-mediated immunity, phagocytic function,
complement system, immunoglobulin A secretion,
and cytokine production.(7) This is in agreement
with a study conducted in Africa, showing that
the majority of pulmonary tuberculosis patients
have chronic energy-protein deficiency.(7)

Vitamin A deficiency as seen from its
adequacy levels was also found in the group of
cases in comparison with the group of controls.
This was because there were more subjects
(79.4%) with optimal adequacy levels for vitamin
A in the group of controls than in the group of
cases. Inadequate vitamin A is a risk factor for
pulmonary tuberculosis incidence. The present
study is in line with another study conducted in
the community of Nusa Tenggara Timur province,
stating that low vitamin A intake carries a 3.2-
fold risk of pulmonary tuberculosis.(16) On the
other hand, a study conducted in Delft, Western
Cape, South Africa, found no relationship between
vitamin A intake and pulmonary tuberculosis
incidence.(18)

In the group of cases, 57.9% of the
community members had poor adequacy levels
for vitamin C, whereas in the group of controls,
26.3% had poor adequacy levels for vitamin C.
This shows that in the group of controls the
adequacy level for vitamin C was higher than
that in the group of cases. The study by
Johnkennedy et al.(19) reported that the vitamin
C level in patients with tuberculosis tends to be
low, which results in decreased total serum
antioxidant levels in patients with tuberculosis.
The low antioxidant level is caused by inadequate
intake and increased free radicals in the
phagocytosis of Mycobacterium. These results
agree with the study by Madhavi et al.,(20) who
found that tuberculosis patients receiving high
doses of vitamin C for 2 weeks showed increased
total antioxidants. These results are supported
by a study in Bandung, reporting that
administration of vitamin C is of benefit for
increasing the antioxidant level in patients with
pulmonary tuberculosis.(21)

Poor adequacy level for selenium is a risk
factor for pulmonary tuberculosis incidence.
This may be seen from the number of subjects
with pulmonary tuberculosis who had poor
adequacy levels for selenium, namely 52.2%,
when compared with the number of healthy
subjects who had poor adequacy levels for
selenium, i.e. only 28.9%. Our study results are
supported by a study in India, stating that
selenium levels in the blood of patients with
pulmonary tuberculosis are lower than in healthy
persons.(21) Selenium supplementation may
improve the antioxidant status in patients with
pulmonary tuberculosis on standard treatment,
thus assisting the healing process.(22)

Low body mass index was more frequently
found in the group of cases, while in the group of
controls only a few had low body mass index.
The majority of the controls had normal body
mass index, while some had a higher than normal
body mass index. Body mass index may be said
to be a risk factor for pulmonary tuberculosis.
The results of a study in Aceh showed a significant
association between nutritional status (body mass
index) and pulmonary tuberculosis incidence.(4)
A similar study conducted in Indian communities
also found an association between body mass
index and pulmonary tuberculosis.(24) However, a
study in connection with body mass index among
adult females in rural India showed no differences
in body mass index before and after 6 months of
treatment.(11) The study also showed no differences
in body mass index among male patients who
dropped out of the study.(11) This was caused by a
low motivation for taking food among patients
with pulmonary tuberculosis.

Smoking behavior was frequently found both
in the group of cases and in the group of controls,
since mountain communities are avid smokers,
for warming the body, in spite of its impact on their health. Smoking increases the risk of infection with *Mycobacterium tuberculosis* and the risk of the disease developing and leading to death among patients with pulmonary tuberculosis.\(^{(25)}\) This signifies that smoking behavior is a risk factor for pulmonary tuberculosis incidence. Our study results showed an association between smoking and pulmonary tuberculosis incidence, with smokers being 3.1 times at higher risk of pulmonary tuberculosis in comparison with non-smokers.\(^{(8)}\)

A cohort study in rural China found no significant association between smoking behavior and pulmonary tuberculosis incidence.\(^{(15)}\) Another study also reported no significant association between smoking behavior and pulmonary tuberculosis incidence, because smoking was counterbalanced by high nutritional intakes, thus decreasing the risk of infection with pulmonary tuberculosis.\(^{(26)}\)

A limitation of the present study lies in the use of the semiquantitative FFQ to determine the intakes of the nutrients under study, thus requiring a strong recall capacity. Another limitation is the lack of assessment of serum albumin, vitamin A, vitamin C and selenium. The study was of case-control design, therefore the occurrence of recall bias may have influenced the collected data.

This study proves that low nutrient intake is a risk factor for contracting tuberculosis. Nutritional supplementation should be aimed at those individuals with poor nutritional status, in order to improve it, which will reduce the risk of contracting tuberculosis.

**CONCLUSIONS**

Low body mass index is a risk factor for pulmonary tuberculosis, after controlling for energy adequacy level. Further studies are required to evaluate the effect of nutritional supplementation on tuberculosis incidence in adults.

**CONFLICT OF INTEREST**

There was no conflict of interest between the authors and the study subjects.

**ACKNOWLEDGMENTS**

We thank the Head and staff of Puskesmas Karangkobar, Banjarnege district, Central Java and the pulmonary tuberculosis patients and their families who allowed the principal investigator to conduct the study and obtain the data at the aforementioned Puskesmas.

**CONTRIBUTORS**

GCI contributed to drafting the manuscript and the study design. GCI, AM, and AR contributed to data collection, analysis and interpretation. GCI and AM contributed revising manuscript critically for important intellectual content. All authors read and approved the final manuscript.

**REFERENCES**


