Prediction of pulmonary tuberculosis incidence based on epidemiological triad as a preventive measure

Agung Sutriyawan¹, Anri Anri², Andri W. J. Imbar³, Ramdhani M. Natsir⁴, Paryany Pangeran⁵, Hairil Akbar⁶

¹Department of Public Health, Faculty of Health Sciences, Bhakti Kencana University, Bandung, Indonesia
²Department of Nursing, Faculty of Nursing, Bhakti Kencana University, Bandung, Indonesia
³Department of Medical Profession, Faculty of Medical, Khairun University, North Maluku, Indonesia
⁴Department of Medical Laboratory Technology, Poltekkes Kemenkes Maluku, Ambon, Indonesia
⁵Magister Students of Pharmacy, Faculty of Pharmacy, Gadjah Mada University, Yogyakarta, Indonesia
⁶Department of Public Health, Graha Medika Institute of Health and Technology, Kotamobagu, Indonesia

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ABSTRACT

The decline in the incidence of tuberculosis to date still looks very slow, although some efforts have been made to improve case identification and treatment adherence. This study aimed to assess the factors associated with the incidence of pulmonary tuberculosis. The research design for this study was observational analytical with a cross-sectional design. A total of 830 people suspected of tuberculosis, aged over 15 years, and not drug-resistant were selected by simple random sampling. Overall, 59.9% of people are infected with pulmonary tuberculosis. There was a significant association between age (p=0.002) (OR=1.69; 95% CI: 1.22, 2.35), smoking behavior (p=0.000) (OR=2.3; 95% CI: 1.67, 3.30), temperature (p=0.000) (OR=4.2; 95% CI: 2.84, 6.47), humidity (p=0.000) (OR=6.7; 95% CI: 4.69, 9.77), lighting (p=0.000) (OR=4.174; 95% CI: 2.94, 5.92) and incidence of pulmonary tuberculosis. The study showed that tuberculosis was more common among productive age and smokers living in homes with unqualified temperature, humidity, and lighting. Room humidity is the most associated factor with the incidence of pulmonary tuberculosis. Therefore, education on the importance of paying attention to the physical environment of the house to avoid pulmonary tuberculosis is highly recommended.

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Corresponding Author:
Agung Sutriyawan
Department of Public Health, Faculty of Health Sciences, Bhakti Kencana University
Soekarno Hatta Street No.754, Bandung City-40614, Indonesia
Email: Agung.sutriawan@bku.ac.id

1. INTRODUCTION

Tuberculosis remains a major public health problem in the world, despite efforts made to improve case identification and treatment adherence. It is the single highest contagious killer that can be cured in the world today. It is the leading cause of health disorders among millions of people every year in the world and ranks second in the cause of death from infectious diseases, after the human immunodeficiency virus (HIV). Based on the latest estimates of the World Health Organization (WHO), there were 10 million people recorded as having tuberculosis in 2019, and 1.2 million increased due to the disease [1].

Tuberculosis is a disease that attacks the lungs and is transmitted from person to person through droplets. More than 90% of people infected with tubercle bacillus will not develop into tuberculosis (TB) disease. Those at risk of developing the disease after infection with tubercle bacillus include malnourished
individuals and those with poor immune defenses, such as HIV-infected people, people with diabetes, alcoholics, leukemia patients, and patients receiving immunosuppressive therapy [2].

Indonesia ranked the second highest in tuberculosis cases globally [1]. The confirmed tuberculosis cases in 2019 totaled 543,874 cases, a decrease compared to the number of confirmed cases in 2018 of, 566,623 cases [3]. West Java Province contributed 109,463 TB cases in 2019, with a success rate in all instances of 79,943 patients (85.8%). Bandung was West Java’s second-largest contributor to pulmonary tuberculosis. With a case notification rate (CNR) of 477 per 100,000 people, Bandung City has 11,959 cases of pulmonary tuberculosis. The rise of crowded and slum areas, low-health living patterns, and a reduction in environmental health quality were all risk factors for high cases of pulmonary tuberculosis in urban places like Bandung City. At the Bandung City Health Office, a preliminary study was undertaken. Tuberculosis officials indicated that the high case of tuberculosis was likely attributable to a densely populated environment, where a substantial number of households did not match healthy housing standards. Furthermore, studies of the community’s home environment revealed densely packed settlements, residential dwellings stacked against each other, and even the terraced roofs of each house touching each other, obstructing sunlight from reaching the streets. Researchers observed that the air inside three residences of pulmonary tuberculosis patients felt stuffy, that the house lights had to be turned on when talking in the living room, and that the house windows did not open.

The decline in tuberculosis incidence to date still looks very slow, so there is new interest in finding new strategies for tuberculosis control. The management focus is strategies such as supplementing existing tuberculosis drugs, finding tuberculosis vaccines, and designing shorter specific treatment protocols (regimens). Because of the emphasis on control, the focus on prevention needs to be improved. However, some studies have helped refocus the search for tuberculosis prevention strategies in the new public health. Reported tuberculosis risk factors include sociodemographic and environmental factors, such as disease history, heredity, education, age, gender, psychic state, and endurance, HIV infection, comorbidities such as diabetes, tuberculosis contact history, absence of Bacillus Calmette Guerin (BCG) scars, smoking, alcohol use, single-marriage status, overcrowding, and poor socioeconomics [2,4–7]. The environment is the next consideration, and climate and air quality are potential regulators of TB events [8]. Another study looking at environmental factors and cases of pulmonary tuberculosis found that temperature, humidity, and lighting were important factors in tuberculosis transmission [9].

With the increasing trend of TB, especially affecting developing countries, there is a need to re-examine the characteristics of patients and understand the contributing factors, to adjust and adapt TB control policies. Indonesia’s National TB program has supported ongoing public education campaigns through the media about TB symptoms, ways of transmission, the importance of seeking treatment, the risk of multidrug resistant tuberculosis (MDR-TB), and the fact that TB can be cured. To further enhance the struggle, the government has also made many efforts to ensure the availability of adequate medicines and adequately trained staff in all government hospitals and selected missions. However, current efforts to find, treat, and cure everyone sick with the disease are not enough. Therefore, this study aimed to establish the main risk factors and risk factors that contribute to the increase in the incidence of TB. The findings in this study will help the government in an effort to improve the policy and planning for TB prevention and control in Indonesia.

2. METHOD

Observational analytical and cross-sectional designs were the research methods used. By concurrently making observations and at the same time, cross-sectional was used to analyze a relationship between the cause of illness risk and the cause of health problems. This study took place in Bandung City, especially in the three districts with the highest deaths, namely Kiaraccondong (20 deaths), Batununggal (15 deaths), and Andir (13 deaths) from January to Mei 2022. Ethical clearance was issued by the Health Research Ethics Committee, Emmanuel School of Health Sciences Bandung, with ethical approval number 132/KEPK/STIKI/VII/2022. All respondents already signed informed consent for the study.

The dependent variable was the pulmonary tuberculosis case categorized into acid-resistant bacterial pulmonary tuberculosis (BTA+/positive for acid fast bacteria) and (BTA-/negative for acid fast bacteria), where data was retrieved from the patient’s medical record data. The host factor: are age, gender, and education. There were two types of smoking behavior: smoking and non-smoking. When the respondent stayed in the same house as a tuberculosis patient, the history of household contact was classified as contacted; meanwhile, if the respondent did not live in the same place as a tuberculosis patient. Environmental considerations: temperature, humidity, lighting.

The population in this study was all male and female tuberculosis suspects. The sample size is calculated using the sample size formula for a one-sample test of proportion (level of significance 5%, power 90%). Inclusion criteria include age over 15, patients suspected of tuberculosis, drug-sensitive tuberculosis,
and cooperation and willingness to participate in the study by signing informed consent. Exclusion criteria include drug-resistant tuberculosis. This study included persons with probable tuberculosis who had laboratory tests and were reported in the Public health Center's tuberculosis report. The research sample consisted of 830 people who were chosen at random from a pool of 830 people who were on regular therapy. Questionnaires, thermal hygrometer observation sheets, and lux meters were among the tools employed.

Univariate analysis was performed to obtain an idea of the frequency distribution of each research variable, and bivariate analysis used the Chi-square test and Fisher’s exact probability test to assess the relationship between research variables. Multivariate analysis used multiple logistic regression to evaluate relationships (age, gender, education, smoking behavior, household contact history, temperature, humidity, and lighting) and incidence of pulmonary tuberculosis. Multiple logistic regression tests were used to assess the variables most associated with the incidence of pulmonary tuberculosis-statistical analysis using the established significance level p<0.05).

3. RESULTS AND DISCUSSION

Less than half of the respondents in the study were in the at-risk group (47.2%), and the majority were female (55.9%), well-educated (63.3%), and had a household contact history (57.1%). More than half of the respondents were smokers (54.3%). The results of room temperature measurements are mostly qualified (70.1%), the results of air humidity measurements are mostly unqualified (64.7%), and the effects of room lighting measurements are declared unqualified by more than half (66.6%). Dietary factors and environmental factors related to the development of pulmonary tuberculosis are age (p=0.004), smoking behavior (p=0.000), temperature (p=0.000), humidity (p=0.000), and lighting (p=0.000) are statistically significantly related to pulmonary tuberculosis in the bivariate analysis as presented in Table 1. For multivariate analysis, all variables were substantially considered to play an important role in the transmission of pulmonary tuberculosis, so all study variables were included in multivariate logistic regression.

<table>
<thead>
<tr>
<th>Table 1. Relationships between host’s factors, environmental factors, and pulmonary tuberculosis incident</th>
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</thead>
<tbody>
<tr>
<td>Risk factors</td>
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<tr>
<td></td>
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<tr>
<td>Age</td>
</tr>
<tr>
<td>Risky</td>
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<tr>
<td>No risk</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
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<tr>
<td>Female</td>
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<td>Education</td>
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<td>Low</td>
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<td>High</td>
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<tr>
<td>Smoking behaviour</td>
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<tr>
<td>Smoking</td>
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<tr>
<td>No smoking</td>
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<tr>
<td>Household contact history</td>
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<tr>
<td>Contact</td>
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<tr>
<td>No contact</td>
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<tr>
<td>Temperature</td>
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<tr>
<td>Temperature &gt;70%</td>
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<tr>
<td>40-70%</td>
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<tr>
<td>Humidity</td>
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<tr>
<td>Ineligible</td>
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<tr>
<td>Eligible</td>
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<tr>
<td>Lighting</td>
</tr>
<tr>
<td>Ineligible</td>
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<tr>
<td>Eligible</td>
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</tbody>
</table>

Humidity is most closely related to the incidence of pulmonary tuberculosis, with an Exp(B) of 6.774, as shown in Table 2. Humidity is 6.6 times more likely to affect the incidence of pulmonary tuberculosis. The resulting model satisfies the meaning of the model; This can be seen from the P value of the omnibus test (p<0.05). In a study conducted in Bangladesh, the risk of increased incidence of the highest tuberculous occurred at an average temperature of 72.2% (RR=1.26) [10]. Study in Chinese found that relative humidity (69%) can increase the risk of tuberculosis [11]. Another study in Indonesia found that the dominant factor in the incidence of tuberculosis is humidity. Houses that have ineligible humidity are at risk of developing tuberculosis by 3.1 times compared to houses that have sufficient humidity [12]. Another study in Semarang found that people living in homes with ineligible humidity are more at risk of contracting...
pulmonary tuberculosis than those living in homes with qualified temperatures (OR=5.17) [13]. Research in Vietnam found that high relative humidity for at least six months later increased tuberculosis incidence [14].

In our study, those who stayed at home with unqualified humidity had a higher risk of lung tuberculosis. According to Hong Kong research, there was a higher chance of tuberculosis notification when the relative humidity was 60.0-63.6% [15]. In a study conducted in Southwest China, minimum relative humidity was shown to be inversely associated with the frequency of tuberculosis cases [16]. One theory was that in dry conditions, the body’s mucus secretion and clearance of external pathogens were diminished, making humans more susceptible to Mycobacterium tuberculosis infection [15].

This research showed a link between age and the occurrence of pulmonary tuberculosis. This finding is consistent with prior research conducted in India, which found a those in the age group of 55 years and above had a very high prevalence of smear-positive pulmonary tuberculosis estimated [17]. Another study in Cambodia proved that prevalence tuberculosis prevalence rates were more than twice as high as case notification rates among adults older than 45 years [18]. Meanwhile, other research suggests that as a person reaches a productive age, they are more likely to contract pulmonary tuberculosis [19]. A study in Zambia found that most tuberculosis cases occurred in the age group of 2-44 years, with a peak in the age group of 35-44 years [20].

The pulmonary tuberculosis case was not significantly related to gender. This finding supports research in Iran, which found no relationship between gender and the case of pulmonary tuberculosis [21]. Another study in the Indonesian population aged 15 and above found that men were two times more likely than women to get pulmonary tuberculosis [22]. Contrary to Indian studies, it found that the incidence of pulmonary tuberculosis can be affected by gender, where women are less likely [23]. The pulmonary tuberculosis case was not significantly linked to education. This finding is different with study in Brazil that showed TB prevalence associated with low educational level, time incarcerated, productive cough, previous TB [24]. Contrary to studies in Peru that found MDR-TB patients with lower levels of education had a greater risk of death during certain treatments. Education is also recognized as a marker of economic status; In this case, low education can be associated with a lack of resources, overcrowding, and unsanitary conditions [11].

The prevalence of pulmonary tuberculosis was strongly associated with smoking habits. Previous studies have suggested that smoking was a risk factor for pulmonary TB development [25]. Furthermore, smoking could result in treatment resistance for pulmonary tuberculosis. Patients with tuberculosis with a history of smoking exposure (whether present or former smokers) were 1.57 times more likely than nonsmokers to develop treatment resistance [26]. Research in the US found an estimated relative risk for the association between smoking and tuberculosis. The relative risk of tuberculosis in smokers was higher than of nonsmokers (RR=2.3 (CI): 2.0, 2.8), and the relative risk of tuberculosis death compared smokers to non-smokers (RR=2.1, 95% CI: 1.4, 3.4) [27].

Previous household contact had no significant effect on the pulmonary tuberculosis case. This study’s findings contrasted those of Ethiopian research that revealed some evidence that having household contact enhanced the risk of developing pulmonary tuberculosis. This effect was higher when past pulmonary tuberculosis cases had a close family relationship with index pulmonary tuberculosis cases compared to unrelated household members [2]. In households with pulmonary tuberculosis cases, the risk of infection increased with social proximity to the case, according to another study, and the effect was persistently larger in first-degree relatives than in more distant relatives [28].

Temperature is significantly related to the incidence of pulmonary tuberculosis. Research in India found a correlation between minimum temperature and the number of positive BTA tuberculosis cases found to be ($r=0.64$, p-value$<0.001$). These findings suggest a strong and significant association between minimum

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Table 2. Results of multivariate logistic regression

<table>
<thead>
<tr>
<th>Variabel</th>
<th>p-value</th>
<th>Exp(B)</th>
<th>95% C.I for EXP(B)</th>
<th>Omnibus tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No risk</td>
<td>0.002</td>
<td>1.696</td>
<td>1.221</td>
<td>2.356</td>
</tr>
<tr>
<td>Risky</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No smoking</td>
<td>0.000</td>
<td>2.354</td>
<td>1.678</td>
<td>3.301</td>
</tr>
<tr>
<td>Eligible</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No smoking</td>
<td>0.000</td>
<td>4.291</td>
<td>2.845</td>
<td>6.471</td>
</tr>
<tr>
<td>Eligible</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No smoking</td>
<td>0.000</td>
<td>6.774</td>
<td>4.697</td>
<td>9.770</td>
</tr>
<tr>
<td>Eligible</td>
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<tr>
<td>Constant</td>
<td>0.000</td>
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</table>
temperatures and the number of positive BTA tuberculosis cases [29]. Another study in the United States found that the mean daily minimum temperature (which has a favorable influence) was a significant climatic element. This could be related to the negative effects of low air temperatures on the patient’s respiratory system and the lifestyle of people who lived close together in cold weather, which raised the chance of tuberculosis infection [30]. Other research has shown similar findings. Onozuka and Hagihara discovered a substantial positive link between extreme cold and tuberculosis cases in a time series analysis study in Fukuoka (Japan) [31]. Our findings were also in line with what has been discovered in China [32]. A residence should have a humidity level of 40-60%. If the humidity level was higher than 60%, actions such as installing glass tiles or using a humidifier were required to achieve the desired humidity level [13].

Lighting is significantly related to the incidence of pulmonary tuberculosis. Other studies have found a link between lighting and the occurrence of pulmonary tuberculosis, as well as a 3.5-fold increase in the risk of acquiring pulmonary tuberculosis in homes with lighting that did not match the standards [33]. Research in Bengkulu City states that a person who lives in a house with lighting that does not meet the requirements has a 2.7 times greater risk of suffering from tuberculosis than a person who lives in a house with qualified lighting [34]. Meanwhile, systematic studies found that 45% of journals stated that lighting was also a factor that had a relationship with the incidence of pulmonary tuberculosis [35].

4. CONCLUSION

This study concluded that humidity is the most influencing factor in the incidence of pulmonary tuberculosis. In addition, age, smoking behavior, temperature, and lighting also play a role in the incidence of pulmonary tuberculosis. The variables of gender, education, and household contact history showed no significant relationship. Education related to the importance of paying attention to the home’s physical environment to avoid pulmonary tuberculosis is highly recommended.

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REFERENCES


**BIOGRAPHIES OF AUTHORS**

Agung Sutriyawan is an epidemiologist/statistician, currently working as a lecturer at the Department of Public Health, Bhakti Kencana University. He is interested in identifying research on communicable diseases, disease spread, dengue hemorrhagic fever (DHF), and other public health research. He is the author of books on Medical and Health Research Methodology: Includes Guidelines for Making Research Proposals and Analysis of quantitative research data in the health sector. He can be contacted at email: agung.sutriawan@bk.uk.ac.id or agung.epid@gmail.com.
Prediction of pulmonary tuberculosis incidence based on epidemiological triad … (Agung Sutriyawan)

Anri Anri is a medical surgical nursing expert, currently working as a lecturer at the Department of Nursing at Bhakti Kencana University. Interested in identifying the relationship between work from home (WFH) in working mothers during the COVID-19 pandemic with cholesterol levels in working mothers. He can be contacted at email: anri@bku.ac.id.

Andri W J Imbar is a doctor, he is a student at the Department of Medical Profession, Khairun University, North Maluku, Indonesia. Interested in medicine, non-communicable diseases and communicable diseases. He can be contacted via email: andriimidbar5@gmail.com.

Ramdhani M. Natsir is a pharmacist, currently working as a lecturer at the Department of Medical Laboratory Technology, Health Polytechnic Ministry of Health Maluku. She is interested in pharmacology. She can be contacted at email: ramdhani_apt@yahoo.com.

Paryany Pangeran is a full-time pharmacist at Public Lung Health Center of Maluku Province and graduate student at the Faculty of Pharmacy Universitas Gadjah Mada. Interested in identifying research on applied pharmacology and lung diseases treatment including tb. She can be contacted at email: syifa.abdullah@gmail.com.

Hairil Akbar is a Lecturer at Public Health Program, Graha Medika Institute of Health and Technology, Kotamobagu, Indonesia. He is active in raising environmental health issues in Indonesia in journal publications. To discuss further related to environmental health issues. He can be contacted at email: hairil.akbarepid@gmail.com.