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Correlation between Environmental Factors, Knowledge, and Behavior towards Pulmonary Tuberculosis Incidents

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Abstract
Pulmonary tuberculosis (TB) still becomes a concern to prevent. Several factors play a role in the incidents of pulmonary TB such as external factors i.e. environmental conditions and internal factors of the individual such as knowledge and behavior. The high fact of pulmonary TB in Indonesia has become a challenge to analyze the causing factors. This research investigated the correlation of factors of environment, knowledge, and behavior towards pulmonary tuberculosis in Badung Regency, Indonesia. This research utilized a case-control study design with a population of TB-case patients in 13 Public Health Centers in Badung Regency with a sample of 146 respondents. The environmental parameters are room temperature, humidity, lighting, residential density, and building materials. The data collection used a lux meter, hygrometer, room thermometer, and questionnaire. Chi-square test was used to examine the data. The results reveal that the temperature did not meet the requirements of 97.3%, humidity did not meet the requirements of 68.7%, lighting did not meet the requirements of 60.6%, and residential density did not meet the requirements of 68.1%. Meanwhile, the building materials of walls meet the requirements of as many as 50.7%. The test obtained a significance of knowledge and behavior both in 0.001. In conclusion, there is a correlation between room temperature, humidity, lighting, residential density, knowledge, and behavior with the incidence of pulmonary TB and an absence of correlation between building materials with the case of pulmonary TB.

Keywords: Pulmonary Tuberculosis, Knowledge, Behavior, Correlation, Factors

1. Introduction

Contagious disease is a health problem causing physical pain, and disability, and leading to death. One of the contagious diseases that has committed to more than half of the world's population and contributed to 2.5% of the world's disease burden is pulmonary TB (tuberculosis). It ranked 7 as disease-causing deaths (Wulan, 2020). In 2018, 10 million people had TB with varying severity of the disease (World Health Organization, 2019). The latest cases reach less than 5 to more than 500 cases in 100,000 residents each year. The highest cases in males aged 15 years contributed 57% of the total TB cases in 2018, females contributed 32%, and the other 11% were children

under 15 years of age. Therefore, it is urgent to carry out prevention, control, and eradication effectively and efficiently.

Mycobacterium tuberculosis is the cause of TB infection in the lungs. It was named by Robert Koch when it was first discovered in 1882. The bacteria have three types of variants, namely *Humanus, Bovinus*, and *Avium* where *Humanus* is the most found in humans. Mycobacterium tuberculosis can affect human bodies but is most often found in the lungs (90%) (Agus Nurjana, 2015). The statistic in 2019 in Indonesia was found to be 543,874 cases, slightly reduced compared to 2018 with 566,623 cases. Specifically in Bali in 2020, the entire tuberculosis cases was 2,873 with three districts contributing the highest number of cases Denpasar City contributing 1,054 cases, Buleleng Regency with 502 cases, and Badung Regency with 400 cases (Dinkes Bali (Public Health Office of Bali), 2019).

Research regarding TB has revealed that the proportion of poor TB prevention practices was higher in the case group (89.2%) than in the control group (35.1%) (Imaduddin et al., 2019). The evaluation stated the Chi-Square test with a p-value of 0.001 which indicates that people who have poor TB prevention practices in the manner of not smoking, covering mouths and noses when coughing/sneezing, expelling phlegm/saliva into running water, opening house windows every day will be at danger of 15.231 times for the occurrence of TB compared to people who have good TB prevention practices. The environment of the house and family situation that does not meet the prerequisite of PHBS (Clean and Healthy Living Behavior) will cause the occurrence of pulmonary TB, causing TB germs from sufferers to settle and survive in the open air for days or even months, potentially transmitting the disease to other family members. Therefore, the behavior of sufferers who live in the house plays a role in driving the health status of their family members. The ambiance of the living environment is also important. A significant correlation between residential density, ventilation, lighting, humidity, and the occurrence of pulmonary TB was found correlated. Some articles reveal the association between the physical home environment and the incidence of pulmonary TB (Kusrianti & Said, 2019; Lolan et al., 2022; Monintja et al., 2020; Nurany et al., 2022; Oktavia et al., 2016). It shows that the physical home environment is associated with pulmonary TB ($p < 0.05$). The physical home environment includes ventilation area, density of occupants, natural lighting intensity, room humidity, and room temperature. The research conducted on each 40 patients with positive and negative smear pulmonary TB also shows that house ventilation and humidity are the first factors that contribute to TB cases with OR = 5.900 and OR = 8.414 respectively (Wulandari et al., 2023). A deeper analysis reveals that a significant correlation occurs in housing density, ventilation, lighting, and humidity with the frequency of Pulmonary TB. The risk of contracting pulmonary TB in respondents whose housing density does not meet the requirements <8m2 is 10.9 times, ventilation (<10% floor area) is 12.6 times, poor home lighting (<60 lux) is 16.15 times, and a home environment that the humidity is poor (<40% or >70%) is 7.38 times (Perdana & Putra, 2018).

An individual tends to take part in health behavior as long as it is a positive perception that believes that health is a valuable outcome. It will be easier to predict behavior with the perception of disease, experience, and factors affecting attitude (Fauzia et al., 2023). The behavioral habit is formed first by knowledge. The more knowledge that people have, the better behavior they will do. It is also proven that knowledge and behavior are interrelated (Pratiwi et al., 2022).

Prevention is a health effort intended so that everyone can avoid contracting a disease and prevent the spread of the disease. The behavior of pulmonary TB patients greatly influences the transmission of pulmonary TB, because if the patient coughs and sneezes, it can be transmitted to people around them through the air containing germs from phlegm droplets containing germs. Various studies have shown that the spread of pulmonary TB is high in the community. Therefore, the use of health education media will help clarify the information conveyed by health workers. The problem of bad behavior in patients with pulmonary TB is still a concern. Thus, it is necessary to make efforts to prevent pulmonary TB cases in the community. However, few research observed the correlation between the knowledge and behavior towards the occurrence of TB.

This study aimed to identify the parameters of environmental factors, the knowledge, and behavior of patients with pulmonary TB, and analyze the parameters towards the incidence of pulmonary TB.

2. Method

This study used an observational approach with a case-control design. The population involved pulmonary TB patients recorded in 13 health centers in Badung Regency, Bali, Indonesia. The case population was all pulmonary TB patients recorded in 13 health centers in Badung Regency. The control population was not pulmonary TB patients in 13 health centers in Badung Regency. The minimum sample was measured using Eq. (1).

$$n=\frac{\left\{Z_{1'\alpha}\sqrt{2PQ}+Z_{1'\beta}\sqrt{P_1Q_1+P_2Q_2}\right\}^2}{(P_1-P_2)^2} \quad (1)$$

The correlation of lighting and pulmonary TB is known to be P = 0.37 and OR = 2.5 (Rokot et al., 2023), then the number was entered into the sample size application, and obtained a minimum sample size of 73 people for each group. The total number of samples between cases and controls in this research was 146 people. Data collection is a research activity to collect data. Before collecting data, it is necessary to see the data collection measuring instrument to strengthen the research results. The measuring instrument can be in the form of a questionnaire, observation, interview, or a combination of the three. This research used instruments of questionnaire, observation, and interview (a combination of the three).

3. Results

The results are based on the interview conducted with the respondent as many as 146 people in the case and control groups. Table 1 shows the respondents' distribution according to gender, residential status, educational background, and employment.

Table 1: Respondents Distribution Based on Characteristics

Characteristics	Frequency	Percentage
Gender		
Male	60	41.1
Female	86	58.9
Total	146	100
Residential status		
Native	86	58.9
Immigrant	60	41.1
Total	146	100.0
Educational background		
Not attending school	10	6.8
SD (Elementary School)	47	32.2
SMP (Junior High School)	28	19.2
SMA (Senior High School)	48	32.9
PT (Higher Education)	13	8.9
Total	146	100.0
Employment		
Farmer/labor	64	43.8
Entrepreneur	45	30.8
Civil servant	1	.7
Private employee	36	24.7
Total	146	100.0

Table 1 shows 146 respondents based on gender, the most were women, 86 people (58.9%). It is noted that 60 people are immigrants which is 41.1%. This shows that immigrants are contributing factors related to quite high TB cases. The most respondents' education is high school, 48 (32.9%). Grouping from basic education, there were 85 people, or 58.2%. The people employment mostly as farmers/laborers in 43.8%.

Table 2: Home Conditions Characteristics

Home Conditions Characteristics	Frequency	Percentage
Room temperature		
Not Qualified	37	25.3
Qualified	109	74.7
Total	146	100.0
Humidity		
Not Qualified	99	67.8
Qualified	47	32.2
Total	146	100.0
Room lighting		
Not Qualified	71	48.6
Qualified	75	51.4
Total	146	100.0
Residential density		
Not Qualified	69	47.3
Qualified	77	52.7
Total	146	100.0
Building material		
Bricks	140	95.9
Other	6	4.1
Total	146	100.0

Table 2 shows that all of the home conditions characteristics both in case and control groups, did not meet all the requirements. Room temperature variables in both groups did not meet the requirements of as many as 37 rooms (25.3%). Besides, the humidity also did not meet the requirements in 99 rooms (67.8%). The lighting did not meet the requirements in 71 rooms (48.6%). The residential density also did not meet the requirements in 69 rooms (47.3%) and the building materials of the houses occupied were not made of bricks in 6 (4.1%).

An interview was performed for both groups, the case and control groups, to obtain the knowledge and behavior of the respondents about pulmonary TB. The results are shown in Table 3.

Table 3: Knowledge Level of The Respondents

Variable	Frequency	Percentage
Knowledge		
Poor	31	21.2
Fair	69	47.3
Good	46	31.5
Total	146	100.0
Behavior		
Poor	44	30.1
Fair	38	26.0
Good	64	43.8
Total	146	100.0

According to Table 3, the respondents' knowledge is carried in the fair category in 69 people (47.3%), and the respondents' behavior is included in the poor and fair categories with 82 people (56.1%).

Cross-tabulation between the variables of gender, residential status, educational background, and employment with the pulmonary TB problems can be seen in Table 4.

Table 4: Cross-Tabulation Between Variables

Variables	Pulmonary TB incidence		Total	P value
	TB Case	Non-TB Case		
Gender				
Male	35 (58.3%)	25 (41.7%)	60 (100%)	0.093
Female	38 (44.2%)	48 (55.8%)	86 (100%)	
Residential status				
Native	28 (46.7%)	32 (53.3%)	60 (100%)	0.614
Immigrant	45 (52.3%)	41 (47.7%)	86 (100%)	
Educational background				
Not attending school	6 (60.0%)	4 (40.0%)	10 (100%)	0.075
SD (Elementary School)	31 (66.0%)	16 (34.0%)	47 (100%)	
SMP (Junior High School)	11 (39.3%)	17 (60.7%)	28 (100%)	
SMA (Senior High School)	20 (41.7%)	28 (58.3%)	48 (100%)	
PT (Higher Education)	5 (38.5%)	8 (61.5%)	13 (100%)	
Employment				
Farmer/laborer	35 (54.7%)	29 (45.3%)	64 (100%)	0.195
Entrepreneur	17 (37.8%)	28 (62.2%)	45 (100%)	
Civil servants	1 (100%)	0	1 (100%)	
Private employee	20 (55.6%)	16 (44.4%)	36 (100%)	

Based on Table 4, the proportion of TB cases is higher in male gender 35 (58.3%). The residential status is mostly occupied by 45 native persons (52.3%). Regarding educational background, the highest proportion of TB is those who are elementary school educated as many as 31 people (66.0%), and the characteristics of the respondent's employment, the highest proportion of TB incidents are experienced by civil servants in 100%. The results of the chi-square test describe a significance for the gender variable 0.093, residential status 0.614, education 0.075, and employment 0.195. All the results are greater than 0.05 indicating no difference in gender, residential status, educational background, and employment between the TB case group and non-TB case groups. The requirements for similarity between case and control respondents from the variables of gender, population status, educational background, and employment are met.

Table 5: Variables of Environmental Conditions

Variables	Pulmonary TB Cases		Total	p-value
	TB Case	Non-TB Case		
Room temperature				
Not Qualified	36 (97.3%)	1 (2.7%)	37 (100%)	X2=41.849
Qualified	37 (44.2%)	48 (55.8%)	86 (100%)	0.001
Humidity				
Not Qualified	68 (68.7%)	31 (31.3%)	99 (100%)	X2= 40.665
Qualified	5 (10.60%)	42 (89.4%)	47 (100%)	0.001
Room lighting				X2=5.734
Not Qualified	43 (60.6%)	28 (39.4%)	71 (100%)	0.020
Qualified	30 (40.0%)	45 (60.0%)	75 (100%)	
Residential density				
Not Qualified	47 (68.1%)	22 (31.9%)	69 (100%)	X2=15.828
Qualified	26 (33.8%)	51 (66.2%)	77 (100%)	0.001
Building materials				
Non-bricks	2 (33.3%)	4 (66.7%)	6 (100%)	X2=708
Bricks	71 (50.7%)	69 (49.3%)	140 (100%)	0.681

Table 5 shows the proportion of pulmonary TB incidents in environmental conditions where room temperature that is below the requirements are 36 rooms (97.3%), poor humidity in 68 rooms (68.7%), poor lighting in 43 rooms (60.6%), residential density does not meet prerequisite are 47 rooms (68.1%) and building materials of

bricks or wall are 71 houses (50.7%). The chi-square statistical test obtained significant results for each variable of room temperature 0.001, humidity 0.001, lighting 0.020, and residential density 0.001. Those results are less than 0.05 meaning there is a correlation between room temperature, humidity, lighting, and residential density with the incidence of pulmonary TB. While the building material variable significance of 0.681 is greater than 0.050 meaning there is no correlation between building materials and the cases of pulmonary TB. Regarding the results of the chi-square calculation, the room temperature variable has the largest X2 count of 41.849 indicating the most dominant variable related to pulmonary TB.

Table 6: Cross Tabulation of Knowledge and Behavior Variables towards Pulmonary TB Incidence

Variables	TB Incidence		Total	P value
	TB Case	Non-TB Case		
Knowledge				
Poor	28 (90.3%)	3 (9.7%)	31 (100%)	X2= 34.871
Fair	35 (50.7%)	34 (49.3%)	69 (100%)	0.001
Good	10 (21.7%)	36 (78.3%)	46 (100%)	
Behavior				
Poor	30 (68.2%)	14 (31.8%)	44 (100%)	X2= 21.858
Fair	25 (65.8%)	13 (34.2%)	38 (100%)	0.001
Good	18 (28.1%)	46 (71.9%)	64 (100%)	

Table 6 reveals that the proportion of TB cases in the knowledge variable is mostly in the poor category as many as 28 (90.3%) and the behavior variable is mostly in the poor behavior category as many as 30 people (68.2%). The outcome of the chi-square statistical test obtained the significance of the knowledge variable with a value of 0.001 and behavior of 0.001 smaller than 0.05. These mean that there is a correlation between knowledge and behavior with the incidence of pulmonary TB. According to the chi-square calculation, the knowledge variable has the largest X2 count of 34.871, indicating the most dominant variable correlated to pulmonary TB.

4. Discussion

The conclusion of the study shows that there is a correlation between room temperature, humidity, lighting, and residential density with the cases of pulmonary TB. It was found that the temperature of the bedroom and the implementation of clean and healthy living habits were related to cases of pulmonary TB (Amallia & Adriyani, 2020). Bedroom temperatures of less than 18°C or more than 30°C have a higher risk of pulmonary TB cases compared to bedrooms with comfortable temperatures (18-30°C). It is as room temperatures of more than 30°C support the growth of *Mycobacterium tuberculosis* bacteria more optimally.

A comfortable room temperature can be created by adding air ventilation so that air circulation in the house runs optimally. The implementation of clean and healthy living habits in the form of the habit of mopping the floor using disinfectant regularly and cleaning the ceiling of the room can prevent the occurrence of TB. In addition, the habit of using masks when sick and implementing proper coughing and sneezing etiquette also need to be done to prevent TB. When building a house, the construction should follow the requirements so that the room temperature does not change much and the humidity can be maintained. The temperature difference between the walls, floor, roof, and window surfaces must not be too high (Pal et al., 2020).

The unaccommodated prerequisites of the house create a risk factor for TB. This is because sputum droplets can bear in a dark and humid environment for some hours. More than 60% of humidity enables TB bacteria to infect (Nurany et al., 2023). This issue is supported by (Isra Miharti, 2022) which presented an analysis that out of 70 respondents, the humidity was not appropriate for as many as 17 respondents (38.6%). The humidity was appropriate for as many as 43 respondents (61.4%) and data analysis obtained a correlation between the humidity of the house and the cases of pulmonary TB. By nature, TB bacteria are vulnerable to sunlight (Wijaya & Makiyah, 2020). The power of sunlight at a minimum of 60 lux enables TB bacteria to die. Lighting is a significant risk factor, as revealed in this study. Insufficient lighting causes TB germs to stay alive as with proper lighting, the germs can be killed. Therefore, the proper lighting prevents its transmission and reproduction. This study is

supported by (Sahadewa et al., 2019) which obtained results that there is a presence of correlation of lighting and pulmonary TB cases with a significance value of 0.024.

The house should be sufficient for people to live in, in other words not overloaded. Lack of oxygen will occur with the overloaded house. In consequence, the transmission of infection will be easier to expand. A healthy house is a house that meets the standards of its occupants' needs in terms of health, safety, and comfort. The causing factors of TB are various such as the housing environment consisting of the physical, biological, and social environments. The house environment has a very close correlation in terms of the transmission of TB disease because TB germs have a very strong and long-lasting resistance.

One of the conditions of the house that can allow the development and transmission of TB disease is the residential density. Research by (Ujang Effendi et al., 2020) also shows that in the residential density of 34 patients with pulmonary TB, 30 patients had an insufficient residential density and only 4 patients had a sufficient and proper housing density. There is no correlation between waste materials and the cases of pulmonary TB. The output of study is in line with (Nur Maulinda et al., 2021) which resulted in that of 114 respondents, the proportion of the existence of house walls that met the requirements for permanent building materials or brickwork was greater in the control group (43.0%) compared to the case group (37.7%). Data analysis showed that there is no correlation between house walls and the incidence of pulmonary tuberculosis in the Tanggul Health Center work area, Jember Regency with a significance value of 0.192.

The study shows that there is a correlation between knowledge and behavior with the incidence of pulmonary TB. A person’s educational background contributes to the knowledge they can understand. Information influences a person's knowledge. Not to mention, even with a low educational background, the probability of understanding information is still any. Moreover, with the ease access of to media such as television, or online media. The access to information can gain knowledge more easily. The results of this study are similar to (Zulaikhah et al., 2019) which obtained the results that knowledge in the case group was less than 55%, and in the control group 52.5%. The results of the data analysis show a correlation between knowledge and the incidence of pulmonary TB transmission in adult patients in the Bandarharjo Health Center work area with a significance value of 0.002.

Pulmonary TB disease can be overcome with several strategies from the Ministry of Health such as improving the behavior of pulmonary TB patients to lower the risk of pulmonary TB transmission. The increase in TB patients in Indonesia is partly due to the behavior of preventing the transmission of TB-to-TB patients is still lacking, namely with a prevalence of 64% (Asiah et al., 2014). The behavior of TB patients greatly influences the transmission of TB disease, because if the patient coughs and sneezes, it can be transmitted to people around them through the air containing germs from sputum droplets containing germs.

The output of study is supported by (Zulaikhah et al., 2019), which also obtained the results that the behavioral variables in the case group, most of which 55% have poor behavior. Meanwhile, the control group upper hand with good behavior is 77.5%. The results of the chi-square statistical test show that there is a correlation between behavior and the incidence of TB transmission in adult patients in the Bandarharjo Health Center work area with a significance value of 0.005.

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