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The Spatial Distribution of Pulmonary Tuberculosis in Kabanjahe District, Karo Regency, Indonesia

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Abstract

BACKGROUND: Tuberculosis (Tb) is an infectious disease and global concern today.

AIM: This study aims to map the incidence of pulmonary Tb risk factors in Kabanjahe District, Karo Regency.

METHODS: This research is an ecological study with a case–control study design. This research was conducted in Kabanjahe District in January–October 2020. All people checked and declared to have Tb based on clinical symptoms to be the population in this study. The sample size was calculated with a minimum sample size of 58 for the case group and 58 for the control group with a ratio of 1:1. The distribution pattern of pulmonary Tb and environmental risk factors with the incidence of Tb was carried out using a Geographic Information System to determine the distribution of cases. Spatial analysis used average nearest neighbor, overlay, and buffer followed with logistic regression as multivariate statistical analysis.

RESULTS: The distribution pattern of pulmonary Tb in Kabanjahe District tends to group (clusters). GeoDa software found the relationship between population density and Tb incidence in Kabanjahe District with p = 0.04. There is a relationship between income, ventilation, floor conditions, humidity, and lighting with the incidence of Tb. Humidity is the most dominant variable associated with the incidence of Tb.

CONCLUSION: The incidence of Tb cases in Kabanjahe District is dominantly influenced by the humidity factor of the house which is increasingly at risk due to poor ventilation, unstable room temperature, and bad circulation.

Introduction

Pulmonary tuberculosis (Tb) is a disease of global concern, including in developing countries such as India, Indonesia, and China. The mortality incidence of pulmonary Tb has decreased as efforts. In China, since 2005 has developed an internet-based Tb Information Management System, while in Indonesia, it has implemented the Directly, Observed Treatment Short Course (DOTS) system which is still not optimally implemented in various regions. The prevalence of pulmonary Tb in Indonesia shows 4% of the total population. The world organization estimates that Tb still attacks 9.6 million people and causes 1.2 million deaths per year. In Indonesia, the highest proportion of patients was found in West Java Province (99,398 cases) followed by Central Java Province (67,063 cases). North Sumatra Province has a high proportion and ranks fifth, with 32,651 sufferers. This case is generally experienced in suburban communities which generally have low socioeconomic characteristics [1], [2], [3], [4], [5], [6].

Transmission of *Mycobacterium Tb* bacteria can occur through coughing or sneezing which is spread in the form of phlegm or droplets into the air. It means that environmental factors determine the occurrence of Tb in Indonesia. Various studies found that living in a suburban area, residential density, humidity, ventilation area, natural lighting, house temperature, house floor, work status, nutritional status, smoking habits, and history of contact with sufferers were the various risk factors of Tb [7], [8], [9], [10], [11], [12], [13], [14].

Karo Regency, Indonesia, is one of the suburban areas and has a fairly bad environment. In 2014, it was estimated that 330 new cases and the cure rate for pulmonary Tb were only 83.27%. The increase in cases occurred in 2017 which was 939 cases. The percentage of cured pulmonary Tb in Karo Regency is still below the target in the health sector, and there is a decreasing trend. It is caused by patients who died or DIVOLER (negligent use of drugs) and treatment failure. The highest cases were in Kabanjahe District, with 296 cases [15].

Area-based surveillance could help to describe the exact distribution of Tb cases as data reinforcement and epidemiological analysis. Spatial analysis through Geographic Information System (GIS) to getting the geographical map of disease distribution as base data

but still has not been implemented in Kabanjahe. The purpose of this study was to spatially map pulmonary Tb incidence in Kabanjahe and to analyze environmental risk factors that influence the incidence of pulmonary Tb.

Methods

It is an ecological survey research with a used case–control design. This research was conducted in Kabanjahe District in January–October 2020. The study population was all people who checked themselves and was declared to have Tb based on clinical symptoms of Tb and the results of a smear serology test (+) in January–June 2020.

The sample size was calculated using a sampling formula at a 95% confidence level (Z1-α/2 = 1.96) with a test power of 80% (Z1-ß = 0.842), assuming the proportion of the unexposed group (P2) 50% and an estimate of relative risk was 1.5. It needed the minimum sample size of 58 for the case group and 58 for the control group with a ratio of 1:1. The total sample obtained was 116 people distributed at Kabanjahe district [16]. Sampling was done using a simple random sampling technique [17].

Data collection was carried out through direct interviews with observation sheets as instruments supported by a rolling meter, thermo-hygrometer, and Garmin eTrex 10 GPS type, map source, Quantum GIS, and Google Earth to collect the coordinates of the houses of Tb sufferers who live in the working area of the Karo District Health Center. The statistical analysis was carried out by analyzing the average nearest neighbor, used to look at the distribution pattern of pulmonary Tb incidence in Karo Regency and conditional regression logistics with a 95% confidence level (α = 5%) [18].

Results and Discussion

Spatial analysis of the incidence of pulmonary Tb in Kabanjahe district

Residential settlements in Kabanjahe District overall have not met health standards. Dominant residential houses are still semi-permanent. The distribution of pulmonary Tb cases in the Kabanjahe District is not evenly distributed in all villages. Most cases were found in Lau Cimba village with 17 cases from 13 observed villages (Figure 1). Lau Cimba village is an area that has 245 emergency houses with the highest population density of 6347.5 per km^2, the highest compared to other areas, so there is a high possibility for the spread of pulmonary Tb disease.

Based on the average nearest neighbor analysis, the distribution pattern of pulmonary Tb shows an epidemiological phenomenon that tends to cluster with the nearest neighbor index number 0.19 (<1) with a Z score = –16.72 (p = 0.01). The spatial composition in the cluster area can explain the determination of the spread and occurrence of disease [19].

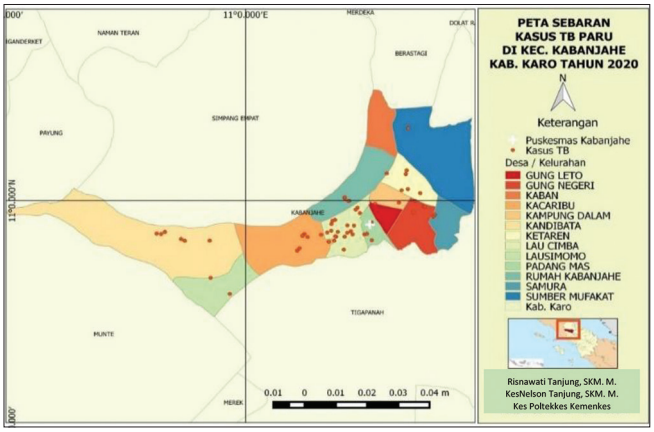
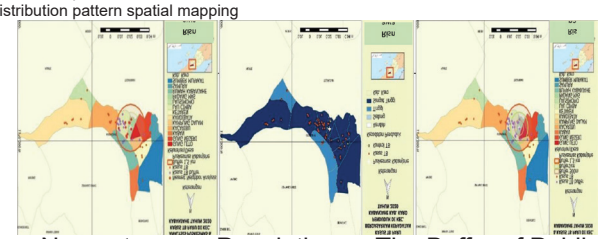


Figure 1: Map of the distribution of pulmonary tuberculosis cases in Kabanjahe District in 2020

Occupancy density has the opportunity to give a risk for the occurrence of Tb by 1.585 times greater even though it is not statistically significant (Table 1). Spatial analysis showed an odds ratio (OR) value of 1.585 CI 0.732–3.431 p = 0.329. Analysis of the GeoDa software found that the relationship between population density and the incidence of Tb showed a significant value (p = 0.04; R-squared: 0.313572; adjusted R-squared: 0.251170). Population density indicates a high proportion of underprivileged families. However, the population density is high. Low rates and a high number of poor families do not correlate but the incidence of Tb plays a more important role in individual gender. It can support Tb control programs with DOT, especially to reach at-risk populations and intensify case findings [20], [21].

Table 1: Spatial analysis of pulmonary Tb cases in Kabanjahe

Spatial parameter	2020
Jumlah titik ukur (n)	116
Nearest neighbor	0.19 (<1)
Neighbor index	
Z-score	–16.32
Population density R. square	0.313572
Adjust R. squared	0.251170
Buffer spread The closest distance	97.5 m
The average distance	505 m
Distribution pattern	Cluster
Distribution pattern spatial mapping	



Nearest Neighbor | Population Density | The Buffer of Public Health Facilities

Tb: Tuberculosis.

In general, pulmonary Tb cases are clustered in certain areas. Regional characteristics have the

potential for pulmonary Tb transmission. Areas with a dense population tend to have a high potential for the spread of pulmonary Tb, the interaction between the population and the lack of knowledge and community stigma about Tb, can trigger someone not to check themselves and seek treatment at the nearest health service center. Moreover, if the environmental conditions in the cluster formed areas tend not to have health requirements, especially for housing sanitation [22], [23], [24].

Spatial mapping from the results of case buffering spreads over an area 1–2 km from the Kabanjahe Health Center. The closest distance to the cases is 97.5, the average distance of 10 cases from the health facilities is 505 m. The zone from the buffering results for health facilities shows that the Public Health Center with the 10 closest cases is cases numbered 22, 23, 24, 26, 27, 47, 48, 49, 52, 53, and 55. The proximity of residence to health facilities can be used as an illustration in the use of health facilities by the community, especially in the treatment of pulmonary Tb which establishes a passive case-finding policy. Ease of access to health facilities offered allows a person to be more motivated to take advantage of health facilities. In addition to the relatively close distance, the pattern of treatment for pulmonary Tb patients who seek treatment at the health facilities is due to obtaining information from neighbors or close friends who have already become pulmonary Tb patients.

The distance to the health service is not a problem in the treatment of pulmonary Tb, but is more due to the ease of access to the health service. Financial considerations play an important role in determining the level of utilization of health services. The cost required will be the reason for the service.

Risk factors for Tb incidence

The spread of new cases of Tb did not show a pattern of spread following the cure rate pattern and almost entirely following the pattern of distribution of healthy home coverage. Even the change in risk of Tb cluster was linked to socioeconomic and patient care factors [25], [26]. The results showed that several risk factors for the incidence of Tb were related to income levels, lighting, humidity, floor conditions, and ventilation (Table 2).

The condition of the house floor has a very close relationship in terms of Tb transmission. The floor area of the building must be sufficient and adjusted to the number of occupants, otherwise, it will trigger the proliferation and transmission of Tb disease. It was found that from 58 Tb patients, 63.8% of the house floors did not meet health requirements and were at risk of developing Tb. The types of floors are found in many types, such as floors that are cracked or not waterproof and soil floors. It giving a risk of 2.85 times higher than the floor that meets the requirements. The unrequirement of the house floor will be a place to live and breed germs and disease vectors, making the air in the room humid, in summer, the floor becomes dry so that it can cause dust that is harmful to the occupants. The condition of the floor of the house needs to be made of water-resistant materials such as tiles, cement, or ceramics [27], [28], [29].

Table 2: The association of risk factor with pulmonary Tb in Kabanjahe District, 2020

Variable	Frequency				Total		OR	CI 95%	p-value
	Case (n)	%	Control (n)	%	n	%			
Age									
Risk	27	46.6	29	50.0	56	48.3	0.87	0.420–1.805	0.853
Un risk	31	53.4	29	50.0	60	51.7			
Economic									
Low	30	51.7	15	25.9	45	38.8	3.07	1.406–6.710	0.008
High	28	48.3	43	74.1	71	61.2			
Sex									
Male	32	55.2	30	51.7	62	53.4	1.149	0.554–2.384	0.852
Female	26	44.8	28	48.3	54	46.6			
Light									
Full requirement	13	22.4	26	44.8	39	33.6	0.356	0.159–0.796	0.018
Not requirement	45	77.6	32	55.2	77	66.4			
Floor									
Full requirement	21	36.2	38	65.5	59	50.9	0.299	0.139–0.640	0.003
Not requirement	37	63.8	20	34.5	57	49.1			
Temperature									
Full requirement	52	89.7	51	87.9	103	88.8	1.190	0.374–3.782	1.000
Not requirement	6	10.3	7	12.1	13	11.2			
Humidity									
Full requirement	46	79.3	34	58.6	80	69.0	2.706	1.189–6.160	0.027
Not requirement	12	20.7	24	41.4	36	31.0			
Density									
Full requirement	41	70.7	35	60.3	76	65.5	1.585	0.732–3.431	0.329
Not requirement	17	29.3	23	39.7	40	34.5			
Ventilation									
Full requirement	26	44.8	40	69.0	66	56.9	0.366	0.171–0.782	0.015
Not requirement	32	55.2	18	31.0	50	43.1			

Tb: Tuberculosis.

Socioeconomic conditions have a very important role in triggering the occurrence of Tb. Community income has a significant relationship as a risk factor for Tb. The low community income influences the lack of nutrition consumption and quality food among families. It can lower the body's immunity so that it is susceptible to developing Tb. Tb disease must receive proper treatment because the disease attacks regardless of the productive age group, the weak economic group, and low education. Pulmonary Tb is more common in poor areas. Because environmental factors and unsupportive income are the causes of pulmonary Tb. In fact, nutritional problems are multicomplex because not only economic factors play a role but other factors also determine [30], [31].

The results of the analysis of individual risk factors indicate that gender has the potential to be a risk factor with an OR of 1.149, women have a greater potential for death caused by pulmonary Tb due to pregnancy and childbirth compared to men where the tendency of this disease is high due to tobacco smoking and drinking alcohol so that

it can lower the body's defense system [32]. The people of Kabanjahe District generally work as farmers and have a high smoking habit. Exposure to a cold environment and humid residential conditions accompanied by the behavior of using pesticides while smoking allows the people of this area to have the potential to develop Tb. Most Tb sufferers are in the productive working age group, weak economic group, and low education [33], [34], [35], [36], [37].

A GIS can identify the distribution and clustering of Tb cases and identify risk factors that influence them. Smoking in the house and the use of cooking fuel affect the incidence of Tb [38].

Lighting is one of the factors that play a role in reducing the risk of Tb. The study found that lighting from 58 Tb patients had a 77.6 times risk of developing Tb with an OR of 0.35 with the incidence of pulmonary Tb. Tb bacteria are not resistant to sunlight. Sunlight has the power to kill bacteria, a minimum of 60 lux is entered on the condition that it is not dazzling. Lighting conditions are a significant risk factor, this can be seen from the research above, with insufficient lighting, the pulmonary Tb germs in the environment do not die because sunlight is one of the factors that can kill pulmonary Tb germs, so if the lighting is good, then transmission and reproduction of germs can be prevented [39], [40].

The factor that has a close relationship with the incidence of the disease is climate, especially the incidence of infectious diseases. Climate can be a tool for predicting various incidences of infectious diseases as a guide in regional-based disease management [41]. Temperature or climatic conditions also do not meet the requirements with the possibility of Tb 1.190 times compared to houses that have a temperature that meets the requirements. There is a significant relationship between lighting, room temperature, and humidity on the incidence of pulmonary Tb [12].

The logistic regression model shows that the variables that affect the incidence of Tb in Kabanjahe District are floor conditions, humidity, and income variables (Table 3). A higher risk factor for the incidence of Tb in Kabanjahe District is the humidity variable with Exp B 3.156 (p = 0.013, 95% CI 1.281–7.779). Houses that have humidity that does not meet the requirements have a risk of pulmonary Tb of 3.138 times compared to a house that has adequate humidity.

Table 3: Model of logistic regression of risk factor with pulmonary Tb

Variable	B	Sig	Exp (B)	95% C.I for EXP (B)
Humidity	1.149	0.013	3.156	1.281–7.779
Economic	1.067	0.013	2.907	1.253–6.744
Floor condition	–1.316	0.002	0.268	0.117–0.614

Tb: Tuberculosis.

Home humidity is the amount of water vapor contained in the room. The humidity of more than 70% is a good means for the growth of microorganisms, especially MTb because in these places, these bacteria multiply well. The level of humidity in the residence is very influential with the incidence of pulmonary Tb [42], [43].

Room temperature is not a trigger factor for the occurrence of Tb in Kabanjahe District. However, humidity greatly triggers the spread of Tb in Kabanjahe District, OR 2.70 (p = 0.02). The number of cases always increases, followed by an increase in air humidity in the subdistrict, the spatial description of temperature shows the number of cases always increases followed by an increase in air temperature [11].

House humidity that does not meet health requirements will be a good medium for the growth of various microorganisms such as bacteria, spirochetes, rickettsiae, viruses, and microorganisms that can cause respiratory infections in the occupants. Tb germs can live well in a humid environment [31], [44].

Temperature conditions can also be related to the ventilation conditions of a healthy home. The study showed that 58 Tb patients were 44.8% who did not meet the requirements. Ventilation provides an opportunity for Tb risk of 0.36 times compared to those who meet the requirements. This condition may occur because ventilation affects the air dilution process, diluting the concentration of Tb germs and other germs. Very significant ventilation dominates and gives the risk of Tb. Ventilation that does not meet the requirements, lack of or no good air exchange in the room, causing disease bacteria, especially Tb bacteria, cannot die immediately [45].

Poor ventilation has a major influence on the incidence of pulmonary Tb because the presence or absence of ventilation affects other factors that trigger Tb germs to grow and multiply properly. Room with ventilation area that does not meet the requirements (<10% floor area) causes high humidity and temperature in the room due to lack of air exchange from outside the house to provide an opportunity for Tb bacteria to survive in the room due to the nature of Tb bacteria that can survive in a dark and humid room [46].

Basically, intervention and policy programs are needed to tackle pulmonary Tb which is prioritized on the characteristics of each region and pay attention to the most correlated risk factors in each region [47].

Conclusion

Spatial analysis shows that the distribution pattern of Tb cases is uneven and tends to cluster. The incidence of Tb cases in Kabanjahe District is dominantly influenced by the humidity factor of the house which is increasingly at risk due to poor ventilation, unstable room temperature, and bad circulation of air.

Acknowledgment

The incidence of Tb is a case that is still a concern so that there is no increase in the community. The pattern of distribution of cases that were not recorded and studied spatially in this study became a model for public awareness to avoid this infectious disease. We would like to thank the Director of Poltekkes, Ministry of Health, Medan, and the Head of the Department of Environmental Health who have supported financially this research in the research program. This research was also realized for the good cooperation and support from the Karo District Health Officer, the Head of the Kabanjahe District Health Center, the community who collaborated in improving health in reducing the incidence of Tb.

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