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Regional Case Study

Spatiotemporal Evaluation of Pulmonary Tuberculosis Case in Karang Intan District, South Kalimantan, 2020-2021

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Abstract

Pulmonary Tuberculosis, hereinafter abbreviated as pulmonary TB, is an infectious disease caused by a group of acid-resistant bacteria, namely Mycobacterium tuberculosis. Pulmonary TB is also still a major health problem in Banjar District, South Kalimantan Province, Indonesia. This research is a descriptive study that aims to identify spatial and temporal clusters of pulmonary TB cases in Karang Intan District, Banjar Regency during 2020 – 2021. The statistical retrospective space-time scan with a Poisson probability model was performed to analyzed the data. The spatial units analyzed in this study included 26 villages in Karang Intan District, with a time unit of 2 years, namely 2020 – 2021. The results of the analysis show that there were 3 clusters of pulmonary TB detected and spread across 26 villages in Karang Intan District. There were 2 clusters in 2020, and 1 cluster in 2021. The transmission of pulmonary TB clusters during 2020-2021 was mostly found in areas with relatively medium or high population density. However, the three detected clusters show a P-value > 0,05 which indicates that the clusters are not statistically significant.

Keywords: Tuberculosis; cluster; space-time; SaTScan

1. Introduction

Pulmonary Tuberculosis, hereinafter abbreviated as pulmonary TB, is an infectious disease caused by a group of acid-resistant bacteria (BTA), namely *Mycobacterium tuberculosis*. Apart from *M. tuberculosis*, there are several species of *Mycobacterium* such as *M. leprae*, *M. bovis*, and *M. africanum*. Symptoms that can be experienced by pulmonary TB patients are coughing up phlegm for 2 weeks or more, sputum mixed with blood, coughing up blood, shortness of breath, chest pain, night sweats without physical activity, chills and fever for more than one month, body weakness, decrease of appetite, and weight loss. Pulmonary TB infection is the most common infection in the world (Dwipayana, 2022).

It is estimated that around 2 billion people (about a quarter of the world's population) are infected with TB. Every year, 10 million people experience TB and 1,6 million of them die (Dwipayana, 2022). TB occurs in every part of the world. In 2020, the largest number of new TB cases occurred in the WHO South-East Asian Region, with 43% of new cases, followed by the WHO Africa Region with 25% of new cases and WHO Western Pacific with 18%. By 2020, 86% of new cases was found in 30 countries with a high TB burden. Eight countries account for two-thirds of new TB cases namely China, India, Indonesia, Pakistan, Philippines, Nigeria, South Africa and Bangladesh (Nortajulu, Susianti, & Hermawan, 2022).

Indonesia is one of the countries along with 13 other countries with high burden TB, which based on 3 indicators namely TBC, TBC/HIV, and MDRTBC so that TB is a big proplem to face for Indonesia. This is proven by increase in cases of tuberculosis in Indonesia from year to year. In 2014 there were 324,539 cases of tuberculosis with a prevalence of 660 per 100,000 population, in 2015 there were

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330,910 of tuberculosis cases with prevalence of 643 per 100,000 population, in 2016 there were there were 351,893 cases of tuberculosis with a prevalence of 628 per 100,000 inhabitants, and in 2017 there were 425,089 new cases of tuberculosis in Indonesia with a prevalence of 619 per 100,000 inhabitants (Pitaloka & Siyam, 2020).

TB is also still a major health problem in Banjar District, South Kalimantan Province, Indonesia. One of the indicators used in TB control is the Case Notification Rate (CNR), which is a number that shows the total number of TB patients found and recorded in 100.000 residents in a certain area. Based on the 2020 Banjar Regency Health Profile, the CNR of all TB cases in Banjar Regency from 2016 to 2020 respectively in 2016 was 191,8 per 100.000 population (1080 cases), 2017 was 186,15 per 100.000 population (1064 cases) and 2018 was 225,33 per 100.000 population (1307 cases), in 2019 it was 291,77 per 100.000 population (1719 cases) and in 2020 it was 99,44 per 100.000 population (Dinas Kesehatan Kabupaten Banjar, 2021).

Geographic Information System (GIS) is currently growing rapidly along with the development of information technology. The existence of GIS allows the distribution of a disease to be mapped easily, and spatial relationships can be reported with statistical significance (Thurston et al., 2017). The incorporation of data mining (gathering important information from big data) in geographic studies presents potential benefits for epidemiological and health studies (Shi & Pun-Cheng, 2019). Data mining also offers new opportunities and challenges to discover valuable patterns of information in data sets, such as the analysis of spatiotemporal information. Spatiotemporal approaches can be used for monitoring areas of high epidemiological risk, detection of disease clusters, evaluation of spatial variations in temporal trends, early detection of epidemics and identification of disease risk factors (Galeana-Pizaña et al., 2022). The design of this research has not been carried out, especially in Banjar Regency, South Kalimantan. The readers can find out the spatiotemporal description of pulmonary TB in Karang Intan.

Mapping TB cases using GIS will provide an overview of the distribution or geographical grouping of TB cases, so as to provide information about risky locations for TB incidents to occur. The use of GIS to describe spatial distribution and identify areas where there is a possibility of TB clustering is carried out for routine monitoring of TB events. Cluster detection techniques can be a source of information for policy makers in the health sector in implementing TB control program activities (Hasan & Hartono, 2018). This study analyses the incidence of TB with environmental conditions. This study aims to analyse spatiotemporal of pulmonary TB incidence in Karang Intan.

2. Methods

This research is a descriptive study carried out in Karang Intan District. Karang Intan District is one of the sub-districts located in Banjar Regency, South Kalimantan Province. Karang Intan District has a population of 35.667 in 2021, with an average population density of 165,62 km². Karang Intan District consists of 26 villages. Karang Intan District is located at 114,9252 East Longitude and 34,352 South Latitude with an area of 215,35 km².

The data used in this study came from pulmonary TB case reports from 1 January 2020 to 31 December 2021 obtained from the Banjar District Health Office. Number of population is obtained from the website of the Banjar Regency Central Statistics Agency which can be accessed free of charge. The coordinates of the cases location were obtained using the Google Maps application which represents the location of each case.

The statistical retrospective space-time scan with a Poisson probability model was performed to analyzed the data with the help of the SaTScan application to find clusters of pulmonary TB cases in Karang Intan District from 2020 – 2021. Under the Poisson distribution assumption, for each location and size of scanning windows, the alternative hypothesis was that there was an elevated risk within the window as compared to outside. The likelihood function calculated to define clusters, likelihood function was maximized overall scanned windows, maximum log-likelihood ratio (LLR) correspond the most likely

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cluster, which means the least likely to have occurred by chance; meanwhile, other ordinal statistically significant LLRs were matched to secondary clusters. A P-value < 0,05 indicates a significantly high risk inside of the scan window, which might be a potential cluster of a high risk of TB. The relative risk (RR) defined with the risk within scanned window compared to risk outside the scan window, RR represents how much more common disease was in this location and time period compared to the baseline (Chen et al., 2019). Previous studies that used similar methods include the research conducted by Rao H, et al (2017) in order detect spatio-temporal clusters of tuberculosis in Qinghai Province, China during 2009 – 2016, and a research conducted by Fahdhienie F and Sitepu FY to detect clusters of TB incidence during 2019 – 2021 in North Aceh District, Indonesia (Fahdhienie & Sitepu, 2022; Rao, Shi, & Zhang, 2017).

The spatial units analyzed in this study included 26 villages in Karang Intan District, with a time unit of 2 years, namely 2020 – 2021. Clusters are considered statistically significant if the P-value < 0.05. The most likely cluster is determined based on the largest LLR (likelihood ratio) value, while other clusters with lower LLRs are considered secondary clusters. To visualize cluster patterns, the Quantum GIS 3.22 application is used.

3. Result and Discussion

There were 71 cases of pulmonary TB reported in Karang Intan District in 2020 – 2021. The distribution of pulmonary TB cases in Karang Intan District can be seen in the map below (figure 2). The darker color of an area indicates that the area has high TB cases. From the map, it can be seen that villages with relatively high TB cases include Bi'ih, Karang Intan, Lihung, Pulau Nyiur, Sungai Alang, Mandi Angin Barat and Awang Bangkal Barat. Lihung Village is the village with the most pulmonary TB cases during 2020 – 2021.

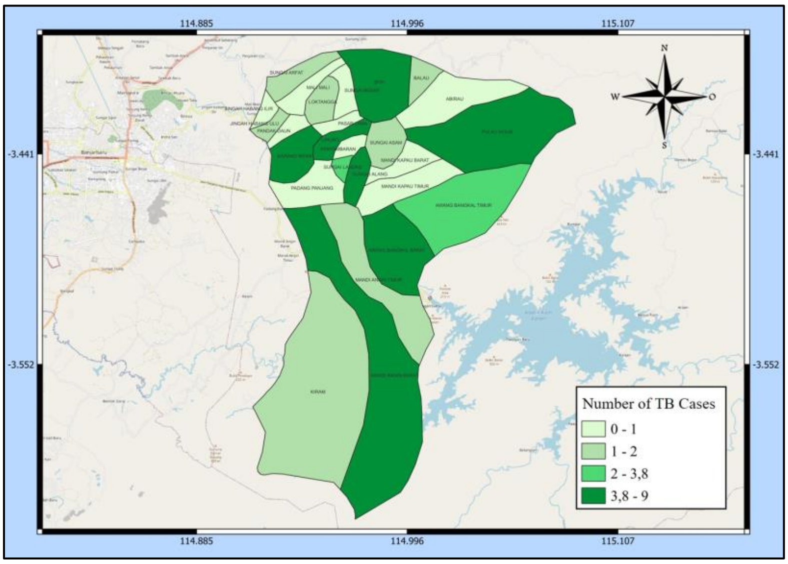

Figure 1. Distribution of pulmonary tb cases in karang intan district in 2020 – 2021

The clusters determined by the output of SaTScan analysis, which shows a number of TB cases based on their location ID which are detected as a cluster, together with the coordinates of the cluster center, time frame, radius, and other data which are summarized in table 1 below.

Table 1. Spatiotemporal clusters of pulmonary tb cases in karang intan district, 2021-2021

Year	Cluster type	Coordinates (latitude, longitude)	Period	Radius (km)	Cases (n)	Expected cases (n)	RR	LLR	P
2020	Most likely	3.435064 S, 114.984932 E	2020/1/1 to 2020/5/31	5.93	11	5.13	2.65	3.12	0.60

Year	Cluster type	Coordinates (latitude, longitude)	Period	Radius (km)	Cases (n)	Expected cases (n)	RR	LLR	P
	Secondary	3.509677 S, 114.998754 E	2020/1/1 to 2020/3/31	0	3	0.69	4.63	2,16	0.88
2021	Most likely	3.437232 S, 114.965036 E	2021/7/1 to 2021/12/31	2.79	2	0.56	3.75	1.14	1.00

The likelihood function calculated to define clusters, likelihood function was maximized overall scanned windows, maximum log-likelihood ratio (LLR) correspond the most likely cluster, which means the least likely to have occurred by chance; meanwhile, other ordinal statistically significant LLRs were matched to secondary clusters. Coordinates respresents the center of each clusters. Period shows the time frame at which the clusters was formed. Radius indicates the distance from the center coordinate where the cluster is detected. Cases shows the observed number of cases within the cluster, meanwhile expected cases shows expected number of cases within the cluster. The relative risk (RR) represents how much more common disease was in this location and time period compared to the baseline. A P-value < 0.05 indicates a significantly high risk inside of the scan window, which might be a potential cluster of a high risk of TB.

The results of the analysis show that there were 3 clusters of pulmonary TB detected and spread across 26 villages in Karang Intan District. There were 2 clusters in 2020, and 1 cluster in 2021. However, the three detected clusters show a P-value > 0.05 which indicates that the clusters are not statistically significant.

The highest relative risk (RR) was found in the secondary cluster in 2020 during January – March (RR = 4.63 P-value = 0.88), followed by the most likely cluster in 2021 during July – December (RR = 3.75 P-value = 1.00), and the lowest relative risk is in the most likely cluster in 2020 during January – May (RR = 2.65 P-value = 0.60). The cluster with the smallest radius was found in 2020 (0 km) indicating that pulmonary TB cases spread with high frequency in the same location.

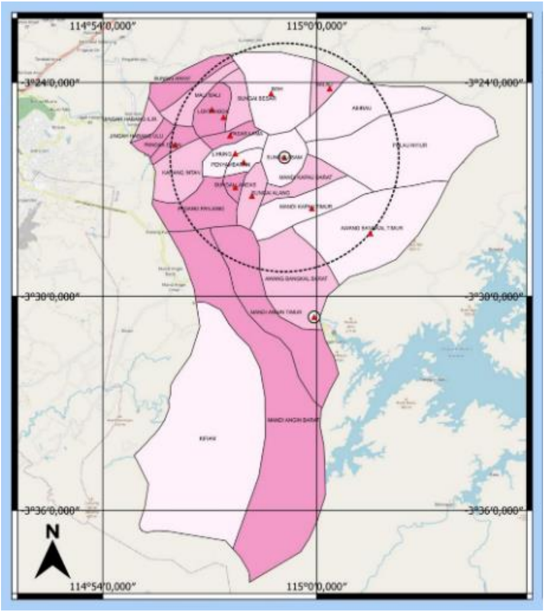

Figure 2. Cluster map of pulmonary tb cases in karang intan district in 2020

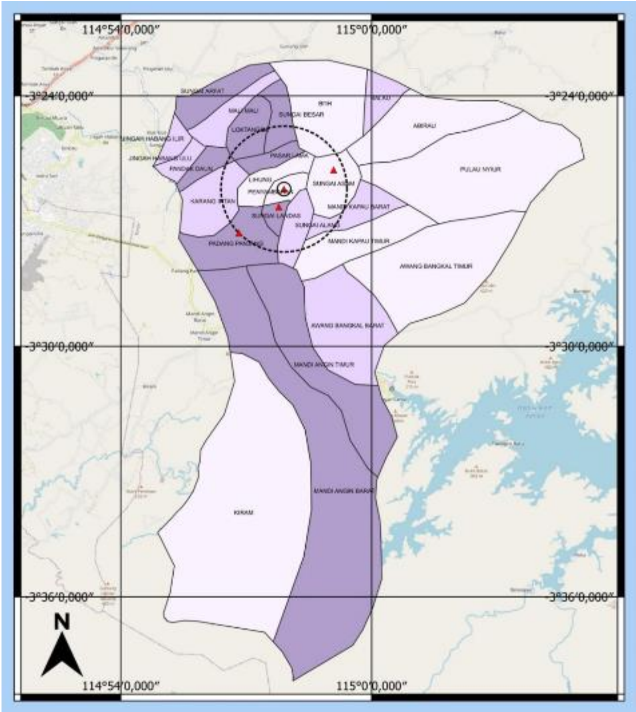

Figure 3. Cluster map of Pulmonary TB Cases in Karang Intan District, 2021

Spatially, transmission of pulmonary TB clusters in 2020 is indicated to be in the northwestern and eastern regions. Whereas in 2021, clusters are only found in the northwestern area. The most likely clusters that are formed in either 2020 or 2021 tend to gather in the northwestern regions, where most of the areas have relatively moderate or high population densities. Meanwhile, the secondary cluster found in 2020 is in the eastern region which has a moderate population density.

29 The results of this study shows that the transmission of pulmonary TB clusters during 2020-2021
18 in Karang Intan District was mostly found in areas with relatively medium or high population density. Areas with high population density have the potential for higher TB transmission than areas with low population density. The areas of high population density tends to have houses that close together, a slum environment, and poor sanitation so that if there are people who are exposed to TB disease, it will be easy for the process of transmission from one human to another (Suryani & Ibad, 2022).

The results of this study also shows that the clusters formed in 2020 are in the first half of the
10 year (January – May), while the clusters formed in 2021 are in the second (July – December). The seasonality of TB incidence has been widely reported in different parts of the world, and understanding season-specific risk factors for active TB can help in developing national TB control policies. However, the exact mechanisms underlying the fluctuation of TB during particular times of the year remain unclear, several studies have suggested that environmental factors and social factors contribute to the seasonality of TB incidence (Manabe, Takasaki, & Kudo, 2019).

30 The incidence of TB can be influenced by biotic and abiotic environmental factors. Biotic environmental factors such as in humans, for example socio-economic. Socio-economic factors, namely
17 the proportion of the illiterate population aged 15 years and over, income per capita in rural areas, the number of health workers per 1000 population, and urban population density, are related to the incidence of TB. It is necessary to further investigate the socio-economic factors that influence TB in each TB cluster (Wang et al., 2019) . In 2020, Karang Intan District was 215.35 km² with a population of 34,459 people, the total population density in Karang Intan District was 160.01 people/km², this figure is still in the medium category, namely population density between 151-200 people/ha but exceeds Indonesia's population density in 2023 of 141 people/km². Then in 2021, the population density increased to 162 people/km² (BPS

Kabupaten Banjar, 2020-2021). The number of TB patients in Banjar District in 2021 was 9,526 people or 94.04 per 100,000 population (Dinas Kesehatan Kabupaten Banjar, 2022).

The Poverty Line (GK) in Kabupaten Banjar in 2021 (IDR 517,293) increased by 4.35% compared to the GK in 2020 (IDR 495,715). Meanwhile, in 2016 the Poverty Line in Kabupaten Banjar was (IDR 380,647). The open unemployment rate (TPT) in Kabupaten Banjar in 2021 is 3.98%, which means that out of 100 people in the labor force in Kabupaten Banjar who are categorized as unemployed, there are around 3 - 4 people. This figure has increased compared to 2020 which amounted to 3.87%. This is partly due to the fact that many employers have been affected by the Covid-19 pandemic and have been forced to lay off their employees or even their companies have been unable to survive and have closed (Pemerintah Kabupaten Banjar, 2022).

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 (Tanjung et al., 2021).

1 High population density would be expected to increase the rate of tuberculosis bacillus spread through increased contact between infectious and susceptible individuals; low socioeconomic individuals may have poorer immune defence profiles, making them less able to suppress tuberculosis replication and thus avoid active disease; and poorer individuals are likely to be less able to afford or reach a setting in which they will be diagnosed (Harling & Castro, 2014).

42 The results of a spatial analysis conducted by Srisantyorini et al (2022) in DKI Jakarta show that the distribution of new cases of pulmonary TB tends to follow the distribution of population density. The results of the correlation and regression analysis between population density in 2017-2019 and new cases of pulmonary TB in 2017-2019 show a strong correlation (r = 0.700) and have a positive pattern, meaning that as the population density increases, the number of new TB cases also increases. Population density can accelerate the disease transmission from one person to another, especially in diseases that can be transmitted through the air or droplets. With a dense population, the bacteria in the air can be inhaled easily by many people (Srisantyorini, Nabilla, Herdiansyah, Fajrini, & Suherman, 2022).

39 Meanwhile, a study conducted by Xu et al (2020) showed that abiotic environments such as temperature and humidity can influence TB epidemics. The existence of TB clusters can be caused by homogeneous temperature and humidity in adjacent areas (Xu et al., 2020). Temperature and humidity can be influenced by several factors including rainfall and solar irradiation. The amount of rainfall throughout 2021 in Karang Intan Sub-district is 3,141.5 mm with an average of 261.79 mm. Meanwhile, the average sunshine is 58.45% (BPS Kabupaten Banjar, 2021).

The average temperature in Karang Intan Sub-district in 2021 is 28.62oC, the temperature at which Mycobacterium tuberculosis bacteria thrive in the range of 25-40oC. Meanwhile, the average maximum temperature in Karang Intan Sub-district is 34.40oC, the bacteria that cause TB will grow
40 optimally in the temperature range of 31-37oC (BPS Kabupaten Banjar, 2021). Temperature is a risk factor
33 for pulmonary TB. Temperature plays an important role in the growth of Mycobacterium tuberculosis, where the growth rate of the bacteria is determined based on the surrounding air temperature. The temperature conditions in the room are closely related to the air circulation in the house. The existence of good air circulation is expected to control the temperature in the house so that it can minimize the transmission of pulmonary tuberculosis in the house (Mardianti, Muslim, & Setyowati, 2020). Besides, Mycobacterium tuberculosis cannot survive in a hot room or in direct sunlight. Based on the guidelines for indoor air hygiene, the room temperature that meets the requirements is 18-30° C (Zulaikhah, Ratnawati, Sulastri, Nurkhikmah, & Lestari, 2019). The results of the research by Ruhban et al (2020)

22 showed that there was a significant relationship between temperature and the incidence of pulmonary TB with a P-value = 0,0001 (p < 0,05) (Ruhban, Lestary, & Rakhmansya, 2020).

Humidity above 60% can make TB bacteria survive for several hours and can infect residents of the house. The average humidity in Karang Intan Sub-district in 2021 was 77.76% (BPS Kabupaten Banjar, 2021). Humidity in a house depends on the temperature inside. The lower the room temperature, the more humid the room will be (Rustam & Mayasari, 2019). A room that is rarely opened and not exposed to the sun can also cause high humidity so that the walls can grow microorganisms such as Mycobacterium tuberculosis, and residents of houses who have less immunity will immediately be easily attacked by tuberculosis bacteria (Monica, 2022). Humidity that is too high or low can cause the growth of micro-organisms. Qualified humidity is 40-60% (Zulaikhah et al., 2019). More than 70% humidity is high humidity that can increase the growth of bacteria. Tuberculosis bacteria can survive in dark and humid places for months. Therefore, high humidity has a relationship to pulmonary TB transmission
41 because it plays a role in the growth of tuberculosis bacteria (H. H.D. Lasari, Medyna, Fadillah, Rosadi, &
27 Fakhriadi, 2023). The results of research by Nurdiana et al (2018) showed that there was a significant relationship between humidity and the transmission of pulmonary TB in family members with a P-value = 0,017 (p < 0,05) (Nurdiana, Haidah, & Nerawati, 2018).

15 Other factors that play a role in the spread of TB bacteria is the environmental conditions in the house such as room lighting, roof, walls, floor of the house, and space density. The condition of the environment in the house that does not meet the requirements is a suitable place for the spread of TB bacteria (Alchamdani & Ningsi, 2022). Research shows that respondents who experienced pulmonary TB with lighting conditions that did not meet the requirements were 22 cases (73.3%) 19 and as many as 8 cases (26.7%) fulfilled the requirements. Meanwhile, there were 39 respondents (65%) in the control group with lighting conditions who did not meet the requirements and 21 respondents (35%) who met the requirements (Hadrianti H D Lasari & Rosadi, 2022). Data shows that the number of uninhabitable houses in Banjar Regency in 2021 was 5,313 units (Banjar Regency Government, 2022).

A healthy house requires sufficient sunlight. Lack of sunlight entering the house can cause discomfort and can be a good medium for disease propagation. The intensity of lighting that enters the house will affect the development of Mycobacterium tuberculosis. This germ is not resistant to sunlight. Natural light from the sun is very important, because it can kill pathogenic bacteria in the house such as tuberculosis bacilli (Monintja, Warouw, & Pinontoan, 2020). The lighting intensity that meets the requirements is at least 60 lux. High intensity lighting (> 60 lux) that enters the house can kill the development of these germs, thereby reducing the risk of pulmonary tuberculosis (Mardianti et al., 2020).
8 The results of the study by Raditya et al (2018) showed that there was a relationship between lighting and the incidence of pulmonary TB with P-value = 0,038 (p < 0,05), OR = 3,455 and 95% CI = 1,195 < OR < 9,990, so it can be concluded that respondents with houses that lighting conditions do not meet the
26 requirements are at risk of contracting pulmonary TB 3,455 times compared to respondents with houses that have good lighting (Raditya, Subagiyo, & Hilal, 2018).

Based on Lasari and Rosadi (2022) research, shows that there were 6 cases (20%) of respondents who had pulmonary TB with floor type conditions that did not meet the requirements and 24 cases (80%) met the requirements. Meanwhile, there were 5 respondents (8,3%) in the control group who did not meet the requirements and 55 respondents (91,7%) who met the requirements. A floor made of waterproof material is a good floor. A damp floor can be a good breeding ground for bacteria (Rustam & Mayasari,
9 2019). The results of the study by Kurniasih et al (2017) showed that there was a significant relationship
8 between the condition of the floor of the house and the incidence of pulmonary TB with a p-value = 0,017 (p < 0,05) and OR = 4,840. This shows that people who live in houses with non-compliant floors have a risk of suffering from pulmonary TB 4,840 times greater than those who live in houses with floor conditions that meet the requirements (Kurniasih, Triyantoro, & Widyanto, 2017).

House walls that are rarely cleaned, contain lots of dust, and are damp are a good breeding grounds for bacteria, including Mycobacterium tuberculosis. The results of Rustam and Mayasari's

9 research (2019) showed that there was a significant relationship between the type of house wall and the
8 incidence of pulmonary TB with a P-value = 0,010 (p < 0,05), OR = 0,404, and 95% CI = 0,197 – 0,830 (Rustam & Mayasari, 2019). The walls of the house must be equipped with adequate ventilation, because inadequate ventilation can cause the walls of the house to become damp. Walls that have a good surface are smooth or flat, easy to clean and do not absorb water (Monintja et al., 2020). Research shows that respondents who experienced pulmonary TB with lighting conditions that did not meet the requirements were 22 cases (73.3%) 19 and as many as 8 cases (26.7%) fulfilled the requirements. Meanwhile, there were 39 respondents (65%) in the control group with lighting conditions who did not meet the requirements and 21 respondents (35%) who met the requirements.

Residential density is the ratio between the number of occupants of the house and the area of the house, at least 8 m²/person (Zulaikhah et al., 2019). Residential density is one indicator triggering high transmission rates of pulmonary TB. The area of the house that is not proportional to the number of inhabitants will cause overcrowded. This is unhealthy because if one of the family member has an infectious disease, especially tuberculosis, it will be easily spread to other family members (Alamsyah, Siregar, & Wau, 2020). The more the number of room occupants, the faster the air in the room becomes polluted and the number of bacteria in the air will increase (Mardianti et al., 2020). Residential density that does not meet the requirements will also affect the oxygen levels in the room, as well as water vapor levels and air temperature due to the large number of occupants in the house. With increasing CO_2 levels in the air in the house, it will provide more opportunities for Mycobacterium tuberculosis to grow and reproduce, so that more and more germs are inhaled by the occupants of the house through the
24 respiratory tract (Monica, 2022). The results of research by Zulaikhah et al (2019) showed that there was a significant relationship between resedential density and the incidence of pulmonary TB transmission,
35 with a P-value = 0,000 (p < 0.05), OR = 6,67, 95%, and CI = 2.44-18.21. This shows that respondents who
34 live in a house with an unsatisfactory density of occupancy have a 6,67 times greater risk of developing pulmonary tuberculosis compared to respondents who live in a house with an adequate density of occupancy (Zulaikhah et al., 2019).

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
38 each region (Tanjung et al., 2021). Communication, resources and Standars Operating Procedure have an important role on the success of pulmonary TB control programs, especially in case detection of pulmonary TB patients (Syakbania & Wahyuningsih, 2020).

4. Conclusions

There were 71 cases of pulmonary TB reported in Karang Intan District in 2020 - 2021. Lihung Village was the village with the most pulmonary TB cases during 2020 - 2021. There were 3 clusters of pulmonary TB in Karang Intan District which were detected during 2020-2021. The clusters formed were
10 found both at the beginning and end of the year. The seasonality of TB incidence has been widely reported in different parts of the world. However, the exact mechanisms underlying the fluctuation of TB during
15 particular times of the year remain unclear. Several risk factors that play a role in the spread of TB bacteria include the environment of the house. Spatially, transmission of pulmonary TB clusters during 2020-2021
18 was mostly found in areas with relatively moderate or high population density. Areas with high population density can increase the transmission of TB bacteria from one human to another. Further research is expected to cover a wider area and a longer time span to detect clusters of pulmonary TB that statistically significant.

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