Spatio-temporal analysis of tuberculosis in Sungai Tabuk District, South Kalimantan, 2020-2021

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Abstract. Respiratory TB is a chronic infectious disease that is still a global public health problem. One of the efforts in anticipating the threat of an explosion of tuberculosis cases is to prioritize surveillance through spatial analysis to detect clustering of cases. Geographic Information Systems (GIS) can be used to describe the spatial distribution and identify areas where tuberculosis clustering is likely to occur so that it can be a source of information for policymakers in the health sector in implementing tuberculosis control program activities. This study aims to identify spatiotemporal clusters of Respiratory TB cases in Sungai Tabuk district from 1 January 2020 to 31 December 2021. This study is a spatiotemporal retrospective study conducted in Sungai Tabuk District using data on Respiratory TB case reports obtained from the surveillance data of the Banjar District Health Office from 2020 to 2021. This study used the Poisson model with the help of the SaTScan v10.1 application and visualization of cluster patterns using the Quantum GIS 3.28 application. This study found that there are 2 clusters of Respiratory TB in Sungai Tabuk district. The cluster in 2020 during January-April showed significant results (RR = 6.78, P-value = 0.0001) with the cluster center located in Sungai Tabuk Keramat Village and a cluster radius of 7.2 km from the center point. Meanwhile, the cluster in 2021 was not significant (RR=5.03, P-value=0.141). Factors affecting TB clusters in Sungai Tabuk district are sociodemographic factors and environmental factors. Local governments can increase case-finding efforts and increase health promotion related to Respiratory TB disease, healthy homes, and clean and healthy living behaviors in areas and communities located in risky locations.

1. Introduction

Respiratory tuberculosis is a chronic infectious disease caused by Mycobacterium Tuberculosis bacteria that is still a global public health problem. The Global TB Report states that there will be an increase in the death rate due to Tuberculosis by 1.3 million deaths by 2020. Indonesia is the third highest contributor to Respiratory tuberculosis cases in the world after India and China at 8.4% (Global Tuberculosis Report, 2021). The Case Notification Rate (CNR) in Indonesia in 2020 was only 130/100.000 population from the national strategic plan target of 190/100,000 population [2].

The Tuberculosis rate in South Kalimantan in 2020 was 45.8% and the CNR rate was 77/100.000 population [3]. Banjar Regency has the second highest number of Tuberculosis cases in South Kalimantan in 2020 after Banjarmasin City at 14.4% with the highest number of deaths during Tuberculosis treatment at 19% of death cases in 2021 [4].

In 2019 the number of Tuberculosis cases in Banjar Regency was 11.5% of cases. This figure increased in 2020 to 15.4% of cases [5]. In addition, it is known that in Banjar District the CNR rate for all Tuberculosis cases is 99/100.000 population and the CNR rate for new BTA+ cases is 50/100.000 population. This indicates that the CNR rate in Banjar District is still below the district

strategic plan target of 160-180/100.000 [6]. Sungai Tabuk district has the fourth highest population density in Banjar District. Based on data from the Central Bureau of Statistics of Banjar Regency, it is known that the number of Respiratory Tuberculosis cases in Sungai Tabuk District in 2021 has increased by 77 cases compared to 72 cases in 2020 [7].

The incidence of tuberculosis can be influenced by several factors such as sociodemographic factors and environmental factors. This is because the spread of TB bacteria occurs through the air so people who are around TB patients will be at risk of TB infection. Tuberculosis can have an impact on individuals clinically, the impact on families of people with tuberculosis who are not treated can transmit Mycobacterium Tuberculosis bacteria to their families and can have an impact on the socio-economy [8]. One of the efforts that can be made is to prioritize surveillance in anticipating the threat of an explosion of tuberculosis cases. Surveillance can be conducted with spatial analysis to detect clustering of cases by space and time, distribution, and trends of tuberculosis cases [9].

Geographic Information System (GIS) is currently growing rapidly along with the development of information technology. GIS can be used to describe the spatial distribution and identify areas where Tuberculosis clustering is likely to occur. Cluster detection techniques can be a source of information for policymakers in the health sector in implementing Tuberculosis control program activities [10]. This study aims to determine the spatial and temporal cluster distribution pattern of Respiratory Tuberculosis cases in Sungai Tabuk district from 1 January 2020 to 31 December 2021.

2. Methods

This study used a spatio-temporal retrospective design conducted in Sungai Tabuk district. Sungai Tabuk is one of the districts in Banjar Regency which consists of 21 villages with an area of 147,30 km^2. The population density in Sungai Tabuk district varies from 66 to 3,922 people per sq. The samples in this study were all laboratory-confirmed Respiratory tuberculosis cases in Sungai Tabuk District in 2020-2021.

Data on Respiratory Tuberculosis cases were obtained through the report on Respiratory Tuberculosis cases by the Banjar District Health Office in 1 January 2020- 31 December 2021. Population data by urban village was obtained through the website of the Central Bureau of Statistics of Banjar Regency. Respiratory Tuberculosis data was entered into Microsoft Excel application and location coordinates were obtained using Google earth pro application. Analysis using retrospective space-time scan statistics with the Poisson model was conducted with the help of the SaTScan v10.1 application to find clusters of Respiratory Tuberculosis cases in Sungai Tabuk district in 2020-2021. To visualize the cluster pattern, the Quantum GIS 3.28 application was used.

The statistical retrospective space-time scan with a Poisson model was performed to analyze the data with the SaTScan application to find clusters of respiratory TB cases in Sungai Tabuk District from 1 January 2020 - 31 December 2021. The space-time of the scan statistics was defined by a cylindrical window with a circular geographic base and with a height appropriate for time. The window starts with a minimum radius and height at a single point and is in turn centered across a limited study area with continuously varying radius and height until it reaches an upper limit. 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. In the centering process, the Log Likelihood Ratio (LLR) of each potential cluster was formulated based on the observed and expected prevalence/incidence inside and outside the cylinder window and a p-value was assigned to it. Those with a p-value <0.05 are clusters that show an increased risk of respiratory TB. Meanwhile, the larger the LLR, the less likely the cluster was detected due to chance. In addition, Relative Risk (RR) was calculated for each statistically significant cluster, meaning its risk within the cluster in a given time and area compared to the risk outside the cluster.

3. Results and discussion

There were 49 cases of Respiratory TB reported in Sungai Tabuk sub-district in 2020 and 21 cases in 2021. The distribution of Respiratory TB cases in Sungai Tabuk sub-district in 2020 and 2021 can be seen in the map below. A darker color in an area indicates that the area has higher TB cases when compared to other areas.

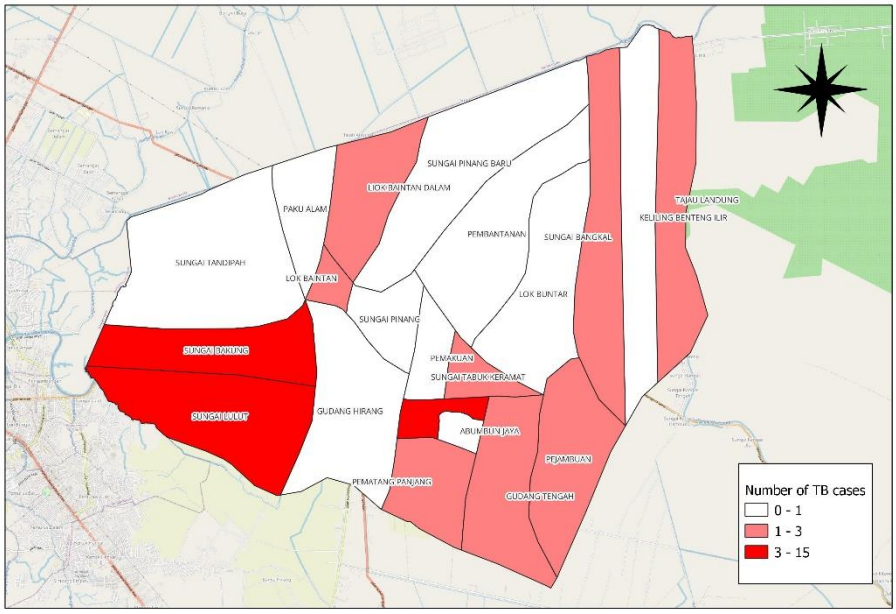

Figure 1. Distribution of Respiratory TB cases in Sungai Tabuk district in 2020

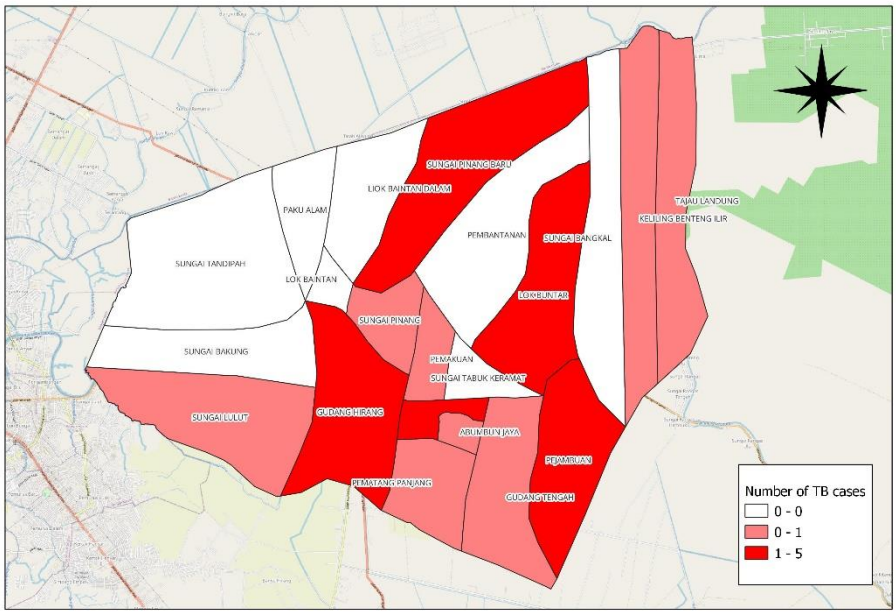

Figure 2. Distribution of Respiratory TB cases in Sungai Tabuk district in 2021

Table 1. Coordinates of each point

Year	ID	Coordinates	
		Latitude	Longitude
2020	1	-3.311404	114.730379
	2	-3.279634	114.756761
	3	-3.324684	114.717724
	4	-3.324684	114.717724
	5	-3.324684	114.717724
	6	-3.305916	114.714285
	7	-3.324684	114.717724
	8	-3.343022	114.734249
	9	-3.330364	114.735687
	10	-3.337097	114.751208
	11	-3.337097	114.751208
	12	-3.337097	114.751208
	13	-3.343595	114.714128
	14	-3.271985	114.777261
	15	-3.271985	114.777261
	16	-3.311404	114.730379
	17	-3.271985	114.777261
	18	-3.324684	114.717724
	19	-3.311404	114.730379
	20	-3.343595	114.714128
	21	-3.343595	114.714128
	22	-3.270545	114.700512
	23	-3.290239	114.669065
	24	-3.263996	114.724679
	25	-3.294474	114.703939
	26	-3.270545	114.700512
	27	-3.289995	114.689246
	28	-3.289995	114.689246
	29	-3.306268	114.646286
	30	-3.320485	114.665937
	31	-3.315080	114.631784
	32	-3.315078	114.631896
	33	-3.321135	114.633094
	34	-3.321455	114.635242
	35	-3.321455	114.635242
	36	-3.320485	114.625796
	37	-3.316603	114.640821
	38	-3.335011	114.626226
	39	-3.319822	114.662127
	40	-3.319822	114.662127
	41	-3.319406	114.658547
	42	-3.306268	114.646286
	43	-3.304685	114.646212
	44	-3.306030	114.657250
	45	-3.319818	114.645556
	46	-3.306030	114.657250
	47	-3.320485	114.665937
	48	-3.289567	114.739616
	49	-3.279634	114.756761

Year	ID	Coordinates	
		Latitude	Longitude
2021	1	-3,288524	114,740608
	2	-3,304660	114,768509
	3	-3,329274	114,718740
	4	-3,325412	114,708712
	5	-3,310789	114,712496
	6	-3,339436	114,707121
	7	-3,330570	114,746375
	8	-3,288911	114,742805
	9	-3,325271	114,710302
	10	-3,323034	114,695366
	11	-3,326434	114,709909
	12	-3,327344	114,712657
	13	-3,327028	114,712239
	14	-3,333760	114,738588
	15	-3,330017	114,748550
	16	-3,269585	114,773827
	17	-3,322378	114,690075
	18	-3,319798	114,645396
	19	-3,259539	114,716438
	20	-3,295560	114,705198
	21	-3,258354	114,730484

Clusters were determined based on the output of the SaTScan analysis, which shows the number of TB cases by site ID detected as a cluster, along with the cluster center coordinates, time span, radius, and other data summarized in table 1 below.

Table 2. Spatial Temporal Clustering of Respiratory Tuberculosis Cases in Sungai Tabuk District, 2020-2021

Year	Cluster Type	Coordinates (latitude,longitude)	Period	Radius (km)	Cases (n)	Expected Case (n)	RR	LLR	P-Value
2020	Most likely	3.311404 S, 114.730379 E	1/1/2020-30/4/2020	7.20	26	3.27	6.78	14.63	0.000
2021	Most likely	3.288524 S, 114.740608 E	1/4/2021-30/9/2021	4.72	7	1.90	5.03	4.78	0.141

The results of spatial and temporal statistical analysis of Respiratory Tuberculosis cases in 2020-2021 can be seen in Table 1. The analysis detected 2 clusters based on monthly data of Respiratory Tuberculosis cases spread across 21 urban villages in Sungai Tabuk Sub-district. The identification results show that there is only one significant cluster in 2020, while in 2021 the cluster is not significant. In the January-April cluster in 2020, it can be seen that the distribution pattern is random, with the most cases in Sungai Tabuk Kota. In the April-September cluster in 2021, it can be seen that the distribution pattern is random, with the most cases in lokbuntar, pejambuan, and sungai pinang baru.

The relative risk (RR) is higher in 2020 during January-April (RR=6.78; P-value=0.000) with the cluster center in Sungai Tabuk Keramat Village, while in 2021 during April-September (RR=5.03, P-value=0.141) with the cluster center in Lok buntar. The smallest radius is in 2021, which is 4.72 km, while in 2020 the radius is 7.2 km. This indicates that Respiratory Tuberculosis cases spread in a fairly wide location.

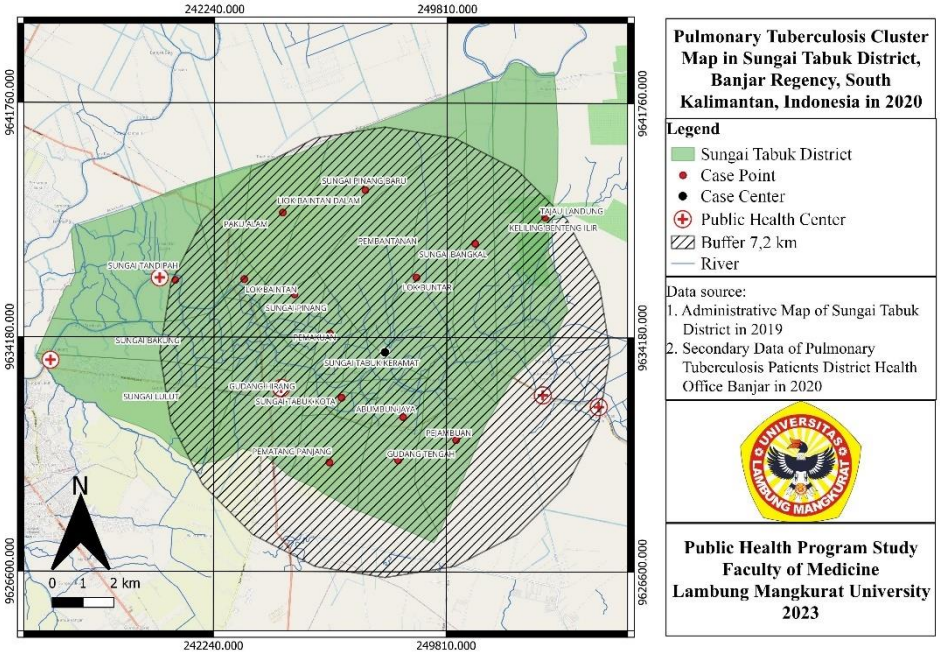

Figure 3. Respiratory TB Cluster in Sungai Tabuk district in 2020

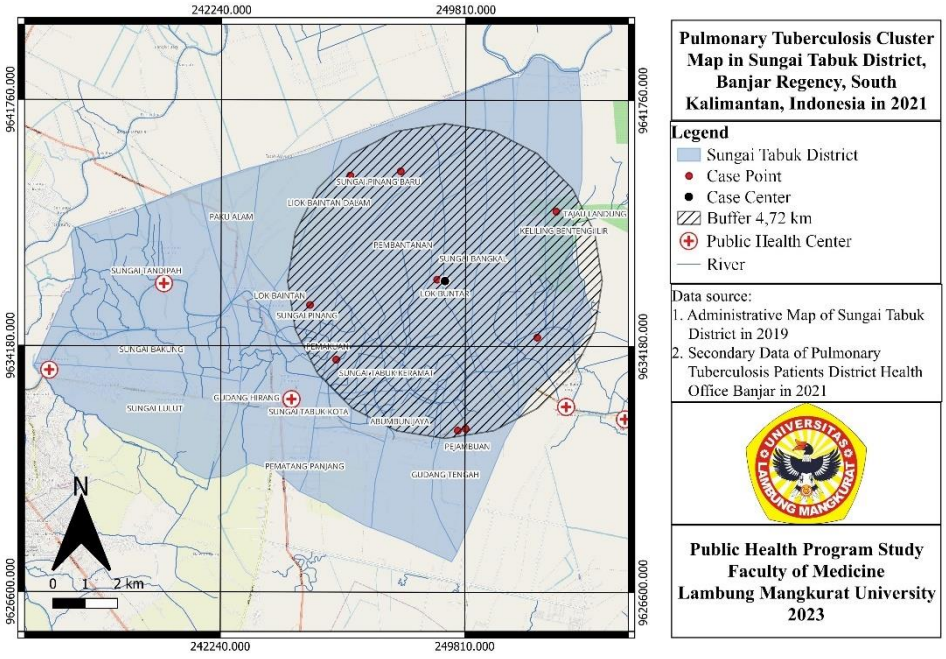

Figure 4. Respiratory TB Cluster in Sungai Tabuk district in 2021

The use of spatial analysis in assessing the incidence of Respiratory tuberculosis by place can provide more detailed and comprehensive information. Among other things, it can identify trends in the location and distribution of health problems to detect areas with a high risk of tuberculosis. The information provided can also explain spatial factors that play a role in disease occurrence and disease endemicity maps that can affect the extent of transmission to other areas [11]. Countries with high TB prevalence and low social determinants should consider using spatio-temporal TB cluster and social determinant characteristics because spatio-temporal information on TB clusters will be useful in supporting TB control programs [12].

Based on the identification results, it is known that there is only one significant cluster in January-April 2020 with a relative risk (RR) of 6.78, P-value=0.000 and a cluster radius of 7.2 km. This means that a person living within a radius of 7.2 km from the cluster center has a 6.78 times greater risk of contracting respiratory tuberculosis than someone living outside that radius. The Log Likelihood Ratio (LLR) value is known to be 14.63, the greater the LLR value, the less likely the cluster is detected by chance. The center point of this cluster is located in Sungai Tabuk Keramat Village with an area of 4 km^2 with a population of 4,042 people and a population density of 1,011 per km^2. Based on this data, it is known that Sungai Tabuk Keramat has the second densest population density after Sungai Lulut [13].

Another cluster result shows an insignificant value in April-September 2021 with a p-value=0.141. In this cluster, it is known that the Log Likelihood Ratio (LLR) value is only 4.78, indicating that there is a possibility that the cluster was detected by chance. This is because the smaller the LLR value, the more likely the cluster was detected by chance. Based on the number of respiratory TB cases in 2021, it is known to be less when compared to the number of respiratory TB cases in 2020, so the analysis results may be less representative of the population. In addition, the cluster period can be seen that the cluster exists in a fairly long period of time, namely, 6 months so that it is calculated to have a considerable distance between one case and another.

Tuberculosis patients in Sungai Tabuk Sub-district in 2020 had an average age of 47 years, with the youngest age being 9 years old and the oldest age being 90 years old. The highest cases occurred in the 46-55 year age group (early elderly) at 22.4%. Age plays a role in the incidence of Respiratory TB disease. The increasing age a person will experience physiological, pathological changes and a decrease in the immune system so that bacteria are easily exposed [14]. The higher prevalence of tuberculosis with age can be caused by reactivation of TB bacteria for someone who has had Respiratory TB and a longer duration of exposure to TB bacteria [15].

Tuberculosis patients in Sungai Tabuk Subdistrict in 2020 were found to be more prevalent in men, which amounted to 53.1%. Men are more at risk of suffering from Respiratory TB because of their high mobility compared to women so the possibility of exposure is greater, plus smoking and drinking alcoholic beverages which can cause the body's immunity to decrease so that the causative agent of Respiratory TB is more easily exposed to men [16].

Tuberculosis patients in Sungai Tabuk Subdistrict in 2020 were 44.89% unemployed, people who do not work will have more time to contact with people with respiratory TB who are at home, so it will be easier to contract or transmit respiratory TB disease. The type of work also affects family income, which will have an impact on food consumption patterns and health maintenance. People with less income are more likely to have houses that do not meet health requirements, which will facilitate the transmission of Respiratory TB disease [17].

The pattern of increase in the incidence of Respiratory tuberculosis can be influenced by environmental conditions through social interaction. Respiratory Tuberculosis has a tendency to cause clusters because most sufferers have the same social determinants and live in groups, thus increasing the risk of being infected with Tuberculosis. The incidence of Respiratory tuberculosis tends to have spatial clustering and seasonal patterns [11]. High population density can increase the risk of disease transmission, especially those related to the respiratory tract such as Respiratory tuberculosis. This is because the chance of contact with people with Respiratory tuberculosis will be greater [16].

The results of observations of climatic elements in Banjar Regency in 2020 with a significant cluster in January-April, showed that the average humidity in January was 80.55%, February was 79.79%, March was 79.11%, and April was 78.22%. Based on this data, it is known that the average humidity in January-April tends to be higher than in other months. The data also shows that the average temperature in January was 28.37°C, February was 28.53°C, March was 28.76°C and April was 29.04°C. It is also known that the amount of rainfall in January was 572.40 mm, February was 334.30 mm, March was 302.40 mm, and April was 266.40 mm. Based on this data, it is known that the average amount of rainfall in January-April tends to be higher than in the following months [13].

The results of observations of climate elements in Banjar Regency in 2021 with insignificant clusters in April-September, show that the average humidity in April is 74.5%, May is 76.3%, June is

76.5%, July is 76.5%, August is 77.3%, and September is 78%. Based on this data, it is known that the average humidity in April-September 2021 tends to be lower than other months. The data also shows that the average temperature in April was 29.1°C, May was 29.1%, June was 28.6%, July was 28.3°C, August was 28.1°C, and September was 28.1°C. It is also known that the amount of rainfall in April was 177.3 mm, May was 177 mm, June was 142.8 mm, July was 178.7 mm, August was 147.9 mm, and September was 140.9 mm. Based on this data, it is known that the average amount of rainfall in April-September 2021 tends to be lower than other months [7].

Climatic conditions are one of the factors that can affect the development of disease-causing microorganisms. Climate change will be followed by ecosystem changes that can change the pattern of interaction between the environment and humans that have an impact on health. During winter, the level of sun exposure will be lower and there will usually be more indoor activities, causing environmental conditions to become dense, humid, and decreasing air circulation which will increase the viability of Tuberculosis bacteria [18]. In addition, climate change will also affect the individual's immune system. Lack of exposure to sunlight will result in a decrease in vitamin D levels. The presence of Tuberculosis bacteria in the environment in contact with a person with poor immune conditions will facilitate the development and worsen the condition of the disease [19].

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 Respiratory tuberculosis transmission because it plays a role in the growth of tuberculosis bacteria [20]. During the rainy season, the level of sunlight exposure will be lower and there will usually be more indoor activities that cause environmental conditions to become dense, humid, and air circulation decreases, increasing the viability of TB germs [18].

Gould & Brooker (2003), there is a temperature range favored by Mycobacterium tuberculosis bacteria, in which there is an optimum temperature that allows the bacteria to grow rapidly. Mycobacterium tuberculosis is a mesophilic bacterium that grows rapidly in the range of 25°C-40°C, but the bacteria will grow optimally at 31°C-37°C. Room temperature in a house that does not meet the requirements will become a medium for the growth of pathogenic bacteria and can last a long time in the air of the house, it will be a source of disease transmission, one of which is Mycobacterium tuberculosis bacteria [21].

From the mapping results it can be seen that the number of health facilities in Sungai Tabuk district is not quite evenly distributed. There are only three villages that have one public health center each, namely Sungai Tabuk Keramat, Sungai Lulut, and Lok Baintan. Increased access to health facilities can provide significant benefits to health. Good health services have the main requirement that they are easily accessible to the community, especially in terms of access to health service arrangements. However, in reality there are still people who do not have easy access to health facilities. This is due to economic and geographical conditions such as long distances so they cannot utilize these health facilities [22].

Differences in case finding rates in each region are influenced by several conditions such as the geographical conditions of each region, sociodemographic factors, the role of program officers in case finding efforts, patient treatment preferences and ease of access to health services. Patients with BTA-positive TB are more infectious, so BTA-positive Respiratory TB cases are an indicator of the risk of TB transmission [23]. Therefore, areas that have and are surrounded by areas with high case finding should be of concern in TB control efforts. Areas with low case finding and surrounded by areas with high case finding or vice versa may be areas that receive spillover cases from neighboring areas because many patients seek treatment outside the area so the recording and reporting of cases are recorded at the place of treatment [24].

4. Conclusion

This study found that there are 2 clusters of Respiratory TB in Sungai Tabuk district. The cluster in 2020 during January-April showed significant results (RR=6.78, P-value=0.000) with the cluster center in Sungai Tabuk Keramat Village and a cluster radius of 7.2 km from the center point. Meanwhile, the cluster in 2021 was not significant (RR=5.03, P-value=0.141). Several factors

influence the TB cluster in Sungai Tabuk District including sociodemographic factors (age, gender, and occupation) and environmental factors (population density, humidity, temperature, and the presence of health centers). Areas that have and are surrounded by areas with high case finding should be a concern in TB control efforts. Local governments can increase case finding efforts, improve access to health facilities and increase health promotion related to Respiratory TB disease, healthy homes, and clean and healthy living behaviors in areas and communities located in risky locations.

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