ABSTRACT

Background: Indonesia will be free of TB (Tuberculosis) in 2050, and elimination will begin in 2030. TB cases are still high in Bandar Lampung City, so efforts are needed to solve the problem. Mapping of TB cases using a Geographic Information Spatial (GIS) approach was performed in this study to evaluate the spreading patterns of TB patients so that policies can be taken to deal with TB cases in an epidemiological manner.

Methods: The research was conducted in 31 public health centers in Bandar Lampung City. The number of TB patients in this study was 879 people. Making maps for visualizing the spread of TB patients using Arcgis software, data were analyzed with Geoda and Moran’s Index to see the spatial relationship between variables.

Results: The spatial analysis using Geoda found a spatial relationship between TB patients and population density (p=0.00079) and the distance between the TB patient's house and the health center (p=0.00000). However, there was a significant relationship between the underprivileged group (p=0.21682) and topography (p= 0.29139). The Z score for the 4 variables is quite large and >20.95, so the distribution pattern of TB patients is stated to be clustered (cluster).

Conclusion: Based on the TB patients mapping and the spatial analysis, it is known that the distribution pattern of TB patients in Bandar Lampung City forms a clusters pattern, and there is an autocorrelation relationship between population density, underprivileged groups, height and distance from the TB patient's house to the health center.

Keywords: Distribution, Moran’s Index, spatial analysis, tuberculosis patient.

INTRODUCTION

Transmission of tuberculosis (TB) can be through droplets released by TB patients. A TB patient can infect 10-15 people around him. These TB bacteria usually infect the lung organs and can also be outside the lungs (extra-pulmonary). Nearly a quarter of the world’s population is infected with Mycobacterium tuberculosis, about 89% of TB affects adults, and 11% affects children. Indonesia is ranked second with the highest number of TB sufferers in the world after India. It is estimated that 9.9 million people will globally suffer from TB in 2020. The target of the Indonesian government in its TB control program is elimination starting in 2030 and being free of TB in 2050.

According to WHO data in the 2021 Global Tuberculosis Report, the TB incidence rate in Indonesia is 301 per 100,000, which decreased in 2019, namely 312 per 100,000 population. Meanwhile, the TB mortality rate in 2019 and 2020 is still the same, namely 34 per 100,000 population.

Based on the Bandar Lampung City Health Office report in 2021, there were 2,333 registered and treated TB cases out of a total of 17,810 suspected sufferers. Of these bacteriologically confirmed TB patients, there were 1,115 people. These bacteriologically confirmed TB patients were a source of transmission of TB disease to people around them, so TB patients must be educated to reduce the transmission of the disease so that TB disease can be controlled.

In Bandar Lampung City during 2019-2021, there has been a decrease in the success rate for TB patients; namely, 102 in 2019, fell to 98.6 in 2020 and in 2021 it fell again to 93.1. The decline in the success rate for TB patient treatment has an impact on the number of TB cases that continues to increase. TB transmission occurs in areas with high population density because there is a great opportunity for contact with TB patients. The pattern of spatial spread of TB tends to be high in dense areas with high poverty levels.

This increase in TB cases must be controlled so that it does not continue to increase. Spatial TB control can be geospatially based, mapping TB patients with GIS (Geographical Information System) software. The pattern and location of GIS results help the field of epidemiology to provide clues about the distribution of diseases and the most appropriate locations for providing effective health interventions.

To ensure a spatial relationship for each location, proceed with a spatial autocorrelation analysis based on the Moran Index. Global spatial autocorrelation can estimate the overall degree of dependency between TB notifications in geographic space and can determine the distribution pattern of TB cases (cluster type) in the region.

This research is one of the contributions to assist the government’s program.
towards TB elimination (2030) and TB-free (2050) in the context of TB control from all sides in Bandar Lampung City. Comprehensive geospatial management of TB disease is very important because it is part of risk factor control activities, finding and handling TB cases. Knowing the risk factors spatially and the existence of spatial transmission of TB disease can provide information for stakeholders/policy makers in making TB disease control programs in Bandar Lampung City. This study aimed to analyze the spread pattern of TB disease and spatial analysis of factors (population density, underprivileged groups, height and distance of TB patient's house to the Public Health Center) for TB cases in Bandar Lampung City in 2022.

**METHODS**

This research is a descriptive epidemiological study with a spatial approach. The study was conducted at 31 Public Health Centers in Bandar Lampung City from May to September 2022. The population in this study were all TB patients recorded in the Tuberculosis Information System (TIS) of the Bandar Lampung City Health Office from January to June 2022, totaling 943 people. The TB patient data was confirmed at each Public Health Center (31 Public Health Centers) to confirm the TB patient data. Sampling was taken by purposive sampling, with sample inclusion criteria being TB patients who live in the City of Bandar Lampung. Their home addresses can be tracked using the Google map application. The exclusion criteria were TB patients who came from outside Bandar Lampung or the TB patient's home address that could not be found using the Google map application. The number of TB patient data that met the inclusion criteria was 897.

This study used 2 types of data, namely secondary data in the form of TB patient data, population density data, data on low-income families, and topography/altitude of the area. Data on TB patients were taken from 31 Public Health Centers in Bandar Lampung City, and data on population density and low-income families were obtained from BPS and the Bandar Lampung City Civil Registry Service. The primary data is in the form of data on the coordinates of the TB patient's house and the distance between the TB patient's house and the Public Health Centers. The research was carried out in stages, namely conducting FGDs (Focus Group Discussions) involving TB Program Officers at the Community Health Centers in Bandar Lampung City and TB Program Holders at the Bandar Lampung City Health Office. Furthermore, researchers took TB patient data at the SITB (TB Information System) Bandar Lampung City Health Office. The data contained in SITB is confirmed by the Public Health Center to ensure that the TB patient data has a clear home address. According to the inclusion criteria, the coordinates of the TB patient's house address in Bandar Lampung City were taken. The distance between the patient's house and the Public Health Center was measured using the online Google map application. If the Google map application cannot find a TB patient's house, the TB patient is included in the exclusion criteria. The data is processed using the ArcGIS 10.8 application to map the geographical distribution of TB patients. Visualization of thematic maps created with the ArcGIS 10.8 application using a scale of 1:100,000. Spatial analysis used Geoda software to determine the spatial relationship between TB patients and population density, pre-prosperous group, topography/elevation and distance to the Public Health Center. The analysis was continued to determine the presence of spatial autocorrelation (Moran's Index). Moran's index value (I) ranges from -1 to 1; if the value $>1$ indicates a cluster pattern with adjacent points indicates positive spatial autocorrelation. Moran's Index value close to zero indicates a random pattern, and Moran's Index value $<-1$ indicates negative spatial autocorrelation with a dispersed pattern.

**RESULTS**

**TB patient characteristics**

This research was conducted in 31 health centers in 20 sub-districts in Bandar Lampung city, Lampung province. The total data on TB patients undergoing treatment from January to June 2022 were 943 people, and data on TB patients who met the inclusion criteria in this study were 897.

Based on Table 1 above, the percentage of male TB patients was 509 people (56.74%), more than women, namely 388 (43.26%). Based on the age of most TB patients are aged 15-65 years. In the age range of 15-24 years, therewere 159 people (17.73%), followed by 145 people (16.16%) aged 25-34 years, 143 people (15.94%) aged 45-55 years, 35-44 years as many as 140 people (15.61%). TB patients aged 1-5 years were 51 people (5.69%), and TB patients aged $<1$ year were found to be the least, namely 4 people (0.45%). Based on the frequency distribution, the average age of TB patients is 37 years, with a median age of 37 years and the lowest age is 0 years, while the highest is 89 years old, which can be seen in Table 2.

In this study, 283 TB patients (31.56%) did not work. This group of TB patients who are not working consists of housewives, infants, toddlers and TB patients who are not working. TB patients with 175 laborers (19.51%), 173 self-employed people (19.28%) and Civil Servant/BUMN employees/private employees 87 people (9.69%), while 179 students (19.96%).

**Distribution Pattern of TB Patients in Bandar Lampung City**

Bandar Lampung City is the capital of Lampung Province, located in the southern part of Lampung Province. Geographically, Bandar Lampung City is located at 50°20'50” 30’ South Latitude and 105°28’-1050 37” East Longitude. The northern and eastern regions are directly adjacent to South Lampung Regency, Lampung Bay borders the southern region, and Pesawaran Regency borders the western region. The area of Bandar Lampung City is 169.21 km² which is divided into 20 sub-districts and 31 health centers. The number of TB patients in this study was 897. The distribution of TB patients undergoing treatment in January-June 2022 in Bandar Lampung City at each health center can be seen in Figure 1.

The distribution of TB patients in Bandar Lampung City is not evenly distributed in each health center (PKM). The highest number of TB 5 patients was in PKM Kedaton (76 patients), PKM Panjang
(57 patients), PKM Pasar Ambon (50 patients), PKM Sukaraja (50 patients) and PKM Satelit (49 patients). PKM Campang Raya and PKM Permata Sukarame had the fewest patients, 3 TB patients each. The distribution of TB patients based on the coordinates of the patient’s house in Bandar Lampung City can be seen in Figure 2.

Based on the map in Figure 2, it can be seen that the distribution of TB patients in Bandar Lampung City is uneven. Some areas have accumulations of TB patients, while others appear to have little or no TB patients. Based on the overlay map with the help of Google Earth, you can see the geographical contours of the area, such as in parts of Teluk Betung Timur District, Teluk Betung Barat District and Kemiling District, which borders Pesawaran Regency, which is the Wan Abdurahman protected forest area in the form of hills with lots of big trees. Meanwhile, in a small part of Panjang District, which borders South Lampung Regency, many rocky hills are composed of large boulders, and residents do not inhabit this area.

### Spatial Analysis

In this study, to see the pattern of the spread of TB patients in Bandar Lampung City, Arcgis 10.8 software was used, namely to visualize the coordinates of TB patients’ houses. On each map, TB patients are symbolized by colored dots. Red dot color for TB patients with a High-High cluster, purple dot color for TB patients with a High-Low cluster, yellow dot color for TB patients with a Low-High cluster, green dot color for TB patients with Low-Low, and black dot color for TB patients with no significant clusters. To find out the spatial relationship between the incidence of TB disease and the research variables (population density, underprivileged families, height and distance from the TB patient’s house to the Public Health Center), Geoda software was used. Furthermore, to determine the presence of spatial autocorrelation between observation locations, spatial analysis was carried out using the Moran Index (I) and a 5% significance test to conclude whether there is a spatial autocorrelation of TB patients in the Bandar Lampung City area and the distribution pattern whether forming clusters, spreading or random. The formation of clusters is not entirely in one sub-district; even in one sub-district, one or more clusters can be formed.

If the Moran Index (I) value obtained is -1≤I<0, then it indicates a negative spatial autocorrelation, while a value of 0<I≤1 indicates a positive spatial autocorrelation, the Moran Index value is zero indicating no grouping. Then a significance test of α=5% was carried out by looking at the Z score or Z(I). The test criterion is to reject H0 at the significance level α if Z(I)>Zα, with Zα = Z0.05 = 1.645. To identify the spatial relationship between regions and to know the type of spatial relationship, the Moran Scatterplot was used. The types of spatial relationships are grouped into four quadrants: High-High, High-Low, Low-High and Low-Low. The spatial analysis results using Geoda software to see the relationship between TB patients and the variables of population density, underprivileged groups, height / topography, and the distance between TB patients’ homes and health centers can be seen in table 3.

Based on data processing with Geoda software, a significant relationship was found between the incidence of TB disease and population density (p-value 0.00079) and the distance between the TB patient’s house and health center.
patients and population density. Spatial analysis was continued with spatial autocorrelation using the Moran Index with a result of 1.122452. Moran’s index value is in the range of $0<1\leq1$, this explains the existence of a positive autocorrelation between the incidence of TB disease/TB patients and population density. The $Z$ score or $Z(I)$ obtained is 17.99799, so $Z(I) > Z_{0.05}$. Based on the $Z$ score obtained, the spatial distribution pattern of TB patients has a cluster pattern.

Spatial analysis of the distribution of TB patients based on the underprivileged population group

The distribution of pre-prosperous population in every sub-district in Bandar Lampung City is almost evenly distributed. The sub-district with the highest number of pre-prosperous populations is the Telukbetung Utara sub-district, and the least is in the Enggal sub-district. The existence of the coordinate points for TB patient houses based on the pre-prosperous population group in Bandar Lampung City is visualized on the map in Figure 4.

In the map above, it can be seen that there are 7 High-High clusters (high clusters) of TB patients based on population density, namely in parts of Kedaton, Way Halim, Bumi Waras, Central Tanjungkarang, East Tanjungkarang, South Telukbetung, and North Telukbetung districts. In addition, there are 12 Low-Low clusters (low clusters), 3 High-Low clusters outliers and 5 Low-High clusters. After conducting spatial analysis with Geoda software, the results obtained were a $p$-value of 0.21682 ($p>0.05$), which indicated no relationship between the incidence of TB disease/TB patients and the underprivileged population. Spatial analysis was continued with spatial autocorrelation using the Moran Index with a result of 0.70477. Moran’s index value is in the range $0<1\leq1$, this explains the existence of a positive autocorrelation between TB patients and the underprivileged population. The $Z$ score or $Z(I)$ obtained is 12.680953, so $Z(I) > Z_{0.05}$. This can explain the autocorrelation of TB patients based on the underprivileged population group, and the distribution pattern of TB patients is found to be clustered (clusters).

Spatial analysis of the distribution of TB patients based on population density

The distribution of the coordinates of TB patient houses based on population density in Bandar Lampung City is visualized on the map in Figure 3.

In the map above, it can be seen that there are 7 High-High clusters (high clusters) of TB patients based on population density, namely in parts of Kedaton, Way Halim, Bumi Waras, Central Tanjungkarang, East Tanjungkarang, South Telukbetung, and North Telukbetung districts. In addition, there are 12 Low-Low clusters (low clusters) and 7 High-Low clusters (outliers). Based on spatial analysis with Geoda software, the results obtained were a $p$-value of 0.00079 ($p<0.05$), which indicated a relationship between the incidence of TB disease/TB patients and population density. Spatial analysis was continued with spatial autocorrelation using the Moran Index with a result of 1.122452. Moran’s index value is in the range $0<1\leq1$, this explains the existence of a positive autocorrelation between the incidence of TB disease/TB patients and population density. The $Z$ score or $Z(I)$ obtained is 17.99799, so $Z(I) > Z_{0.05}$. Based on the $Z$ score obtained, the spatial distribution pattern of TB patients has a cluster pattern.

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On the map, it can be seen that there are 7 High-High clusters (high clusters) of TB patients based on the pre-prosperous population group, namely in parts of the sub-districts of TanjungHappy, Way Halim, Panjang, Bumi Waras, Kemiling, Sukarame and Sukabumi. In addition, there are 12 Low-Low clusters (low clusters), 3 High-Low clusters outliers and 5 Low-High clusters. After conducting spatial analysis with Geoda software, the results obtained were a $p$-value of 0.21682 ($p>0.05$), which indicated no relationship between the incidence of TB disease/TB patients and the underprivileged population. Spatial analysis was continued with spatial autocorrelation using the Moran Index with a result of 0.70477. Moran’s index value is in the range $0<1\leq1$, this explains the existence of a positive autocorrelation between TB patients and the underprivileged population. The $Z$ score or $Z(I)$ obtained is 12.680953, so $Z(I) > Z_{0.05}$. This can explain the autocorrelation of TB patients based on the underprivileged population group, and the distribution pattern of TB patients is found to be clustered (clusters).
Spatial analysis of the distribution of TB patients based on altitude/topography

Bandar Lampung city is at an altitude of 0-367.63 m above sea level. Most of the area is in the form of hills, and most are plains. The distribution of the coordinates of TB patients’ houses based on the height of the area/topography in Bandar Lampung City can be seen in Figure 5.

On the map, it can be seen that there are 13 High-High clusters (high clusters) of TB patients based on the height of the area, namely in some sub-districts of Rajabasa, TanjungHappy, Labuhan Ratu, Tanjungkarang Barat, Tanjungkarang Timur, Tanjungkarang Pusat, Way Halim, Kedaton, Langkapura, Kemiling, Enggal, South Telukbetung, and Sukabumi. In addition, there are 9 Low-Low clusters (low clusters) and 2 High-Low cluster outliers. The spatial relationship between the area’s altitude and the TB patients was analyzed using Geoda software, and the results obtained were a p-value of 0.29139 (p>0.05). This indicated no relationship between TB patients and the area’s altitude/topography. Then the analysis is continued with spatial autocorrelation using the Moran Index with a result of 0.734042. Moran's index value is 0<I≤1; this indicates a positive autocorrelation. The Z score or Z(I) obtained is 11.784010, so Z(I)>Z0.95. This can explain TB patients’ autocorrelation based on the region's height/topography. The results of this analysis show that the distribution pattern of TB patients is stated to be clustered (cluster).

Spatial analysis of the distribution of TB patients based on the distance from the TB patient’s house to the public health center

Thirty-one public health centers are located in 20 sub-districts in Bandar Lampung City. Some sub-districts have 2 -3 public health centers, but most only have 1 Public Health Center. The distribution of the coordinates of TB patients’ houses based on the distance between the TB patient’s houses and the public health center can be seen in Figure 6.

In the map below, there are 13 High-High clusters (high clusters) of TB patients based on the distance from home to the health center in some sub-districts of Rajabasa, TanjungHappy, Sukarame, West Tanjungkarang, Way Halim, Kemiling, Peace, North Telukbetung, South Telukbetung, West Telukbetung, Sukabumi, Panjang, and Earth Sane. In addition, there are 17 Low-Low clusters (low clusters), 11 High-Low cluster outliers and 7 Low-High clusters.

Spatial analysis with Geoda software was carried out to determine the relationship between TB patients and the distance from the patient’s house to the health center, with the result being a
evaluate the distribution pattern of TB patients in groups (clusters).

DISCUSSION

Characteristics of TB patients
Based on gender, the number of TB patients for the January-June 2022 period in Bandar Lampung City found 509 people (56.74%) were male TB patients and 388 people (43.26%) were female TB patients. The number of male TB patients compared to women in this study is the same as the data in the 2021 Indonesia Health Profile; namely, the number of male TB patients was 203,243 (57.75%) and 148,693 female (42.25%).

Altet N et al. reported 75.5% of male TB patients and 24.5% of female TB patients. Several factors cause more male TB patients than women, i.e., more men work outside the home than women. Hence, the level of exposure to tuberculosis bacteria is higher; besides that, there are more male TB patients who smoke.

The Murphy ME et al. study found 33%, and Altet N et al. obtained 59.3% of male TB patients who smoke. Several factors cause more male TB patients than women, i.e., more men work outside the home than women. Hence, the level of exposure to tuberculosis bacteria is higher; besides that, there are more male TB patients who smoke.

The average age of TB patients in this study was 37 years, and most were aged 15-45 years. This data is also similar to the data presented in the 2021 Indonesia Health Profile.

This study found a relatively high number of pediatric TB patients aged 0-14 years, 111 people (12.37%). Devi A et al. found several factors related to the incidence of TB disease in children, namely household contact, smoking factor and bedroom lighting factor (p <0.005). A similar thing was also found in Sutomo R et al., namely, children sleeping in a room with parents who had TB disease (52.4%) and were in an environment with cigarette smoke (28.6%). TB patients who did not work were the largest number in this study, namely 283 people (31.56%). This group includes TB patients who are not working, housewives, infants and toddlers. TB patients who work as laborers are 19.51%, and self-employed is 19.28%. Oktafiyana F et al. research results found that the work of TB patients as laborers was 32.1% and entrepreneurs were 34.8%. There was a relationship between the
work environment and the incidence of TB disease. 20 According to Dotulong JFJ et al., a dense work environment such as in offices, factories, markets, terminals and others, as well as working conditions related to large numbers of people, can cause the risk of exposure to pulmonary TB disease. 15

**Distribution Pattern and Spatial Analysis**

a. Spatial analysis of the distribution of TB patients based on population density

The population density in Bandar Lampung City varies greatly, ranging from 3,267 people/km² to 21,564 people/km². The most densely populated district is Tanjungkarang Timur. While the highest number of TB patients was in Kedaton District (76 TB patients), the spatial analysis using Geoda software yielded a value of $p = 0.00079$, which means that there is a spatial relationship between TB patients and population density. The results of the spatial autocorrelation analysis with the Moran Index get a value of $> 1$, and the positive direction indicates an autocorrelation between TB patients and population density. The distribution of TB patients based on population density produces a cluster pattern based on the Z score (17.99799). Clusters that are formed in one district can number one or more. There are 7 High-High clusters formed; this explains that a high number of TB patients is in densely populated areas surrounded by densely populated areas with a high number of TB patients, as seen in Figure 3. The results of this study are in line with the research of Andrade HLP et al., Sasmita S et al., and Wulandari F et al., who found that there is a relationship between population density and the incidence of TB. 6,12,23 Siwiendrayanti A et al. and Tipayamongkholgul M et al. who found no spatial relationship between population density and TB incidence, although clusters were found. 6,22,23 The incidence of TB is 15-20 times higher than in areas with low TB cases. 24

b. Spatial analysis of the distribution of TB patients based on the underprivileged population group

The number of pre-prosperous (poor) residents in Bandar Lampung City will reach 98.76 thousand people in 2021 and ranks 5th in the poverty level in Lampung Province. 25 Telukbetung Utara District is the sub-district with the largest number of pre-prosperous people. The seven High-High Clusters colored red on the map (figure 4) are sub-districts with a large number of TB patients and a high number of poor people, such as in Panjang, Bumi Waras, Kemiling, Tanjung Happy, Sukarame and Sukabumi sub-districts. Panjang and Bumi Waras sub-districts have a large number of TB patients, a high population density, and a high number of underprivileged people. In these two sub-districts, many residents' houses are found close together, with a damp and slum atmosphere; these conditions can provide opportunities for TB disease transmission because the TB pathogen can multiply in a humid atmosphere and lack of sunlight. 26

In this study, many TB patients worked as laborers (19.51%), were self-employed (19.28%), and had low incomes. Huang L et al. found that there was a relationship between working as a farmer and TB disease. 27 Weak socioeconomic conditions greatly affect the adequacy of daily nutrition, causing weakened physical health conditions so that they are easily exposed to TB disease. 14 People with low incomes and a lack of health knowledge facilitate the spread of TB disease. 28 Even in South Africa, a spatial relationship was found between the death of TB patients and poverty. 8 The results of this study are the same as those conducted by Andrade HLP et al. and Dhamayanti G et al., which state that there is a spatial relationship between TB patients and the underprivileged population group but are not in line with Hastuti T et al. which states that there is no relationship between the incidence of TB with poverty/pre-prosperous families. 21,26,29

c. Spatial analysis of the distribution of TB patients based on altitude/topography

Bandar Lampung city is at an altitude of 0-367 meters above sea level. Most of the area in Bandar Lampung City is plains, and a small part is hilly, such as in the Kemiling sub-district, parts of Langkapura and parts of the Bumi Waras and Panjang sub-districts. There are 13 High-High clusters on the map, namely the bright red zone. This cluster shows areas with a high number of TB patients surrounded by areas with a high number of TB patients and are located in parts of the area with an altitude of around 100-367 meters above sea level. The formation of clusters based on the height of this area can occur in 2 clusters in one sub-district because the area is wide; some are plains, and some are hilly. As in the Low-Low cluster, which numbered 9, some of the subdistricts were the same as the High-High cluster, namely Sukabumi, Enggal and South Telukbetung Districts. Other subdistricts are Panjang, East Telukbetung, West Telukbetung, North Telukbetung, Earth Sane and Peace. Although the results of the Geoda analysis showed no relationship between TB patients and regional altitude, further spatial analysis using the Moran Index revealed a spatial autocorrelation because the value I > 1 and Z score > 7.95.

The results of this study are in line with research by Li (2014) and Sun (2015) in China, which states that there is a correlation between the altitude of the area and the incidence of TB, with a p-value < 0.00. 30,31 According to Tanrikulu AC et al. transmission of TB disease in lowland areas have a risk of 3.28 times, compared to high areas. Areas with a certain altitude have differences in temperature, humidity and sunlight intensity, thus affecting the ability of TB germs to live. TB bacteria live in areas with high humidity and can last a long. If exposed to sunlight, these pathogens cannot reproduce and die, so TB patients who live in high-altitude areas must pay attention to the
Spatial analysis of the distribution of TB patients based on the distance from the TB patient’s house to the health center

The data in this study showed that the distance between the TB patient’s house and the Public Health Center was the most at a distance of 1 km to 5 km, namely 52.84% (474 patients). The shortest distance was 0-500 meters for 17.17% (154 patients), the distance from 501 meters to 1 kilometer was 25.86% (232 patients), while the farthest distance was 5.01 kilometers for 4.12% (37 patients). On the map, it can be seen that there are 13 High-High clusters based on the distance from the TB patient’s house to the nearest health center; this means that there is a high number of patients surrounded by a high number of patients based on the distance from the TB patient’s house to the health center. These High-High Clusters are marked in bright red on the map. Besides, there are low clusters, namely 17 Low-Low clusters. This grouping pattern (cluster) occurs because the Z score > $Z^*_{0.95}$ and the Moran Index value > 1 is positive, which means that there is a spatial autocorrelation between TB patients and the distance from the TB patient’s house to the nearest health center. This is also supported by the results of spatial analysis using Geoda, which obtained a p-value < 0.005 so that it was stated that there was a spatial relationship between TB patients and the distance from their house to the health center.

The results of this study are in line with Hartanto’s research (2019) which found TB patient homes close to the public health center in Semarang (<3 km). A large number of TB cases close to the health center increasingly demands the health center to provide more intensive counseling to residents in the vicinity so that there is no transmission or wider spread of TB. The results of the Salam TY study show a 5.21 times risk of dropping out of treatment compared to TB patient homes with a distance of < 5 km. The limitations of this study only used a few variables, namely population density, underprivileged population groups, topography or elevation and distance from the patient’s house to the health center. Hence, the variables directly related to TB patients were unknown, such as the condition of the patient’s house, patient income, nutritional intake, smoking habits and healthy lifestyle. For further research, it is hoped that more of these variables will be involved so that the main causes of TB disease will be known. Treatment of TB is expected to be more comprehensive to reduce the number of TB cases in the community.

CONCLUSION

Based on our study, we can conclude that the distribution pattern of TB patients in Bandar Lampung City forms a cluster pattern. There is an autocorrelation relationship between population density, underprivileged groups, height and distance from the TB patient’s house to the health center.

CONFLICT OF INTEREST

There is no competing interest regarding the manuscript.

ETHICAL CONSIDERATION

This research was registered with the Tanjungkarang Health Polytechnic Health Research Ethics Commission with number 010/KEPK-TJK/X/2022 on February 24, 2022.

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AUTHOR CONTRIBUTIONS

The authors synergize with each other in their activities, starting from planning, conducting research, analyzing data and interpreting research results. Furthermore, the authors make research articles and support each other by contributing to the substance of the research articles and their writing.

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