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SPATIAL AUTOCORRELATION ANALYSIS OF PULMONARY TUBERCULOSIS CASES IN CENTRAL JAVA PROVINCE

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ABSTRACT

Tuberculosis is a disease that is easily transmitted and causes worry across the world. Central Java Province became one of the regions contributing the most tuberculosis cases in Indonesia in 2022, which amounted to 22,249 cases. This study aims to examine the local and global spatial autocorrelation of pulmonary tuberculosis cases in the Central Java Province in 2022. This research is an analytic observational research with an ecological study design. The unit of analysis used was 35 districts/cities. This study used secondary data from the Health Profile of Central Java Province in 2022. Data analysis used Moran's Index and Local Indicators of Spatial Associaton (LISA) methods with queen contiguity weighting in Geoda software. The results showed that Moran's index value of the global autocorrelation test on the number of pulmonary tuberculosis cases was 0.505. The results of the bivariate LISA test obtained the p value of tuberculosis cases with population, population density, and number of health facilities of 0.002, 0.449, and 0.007, respectively, with the Moran index value of 0.3111, 0.0075, and 0.2384 respectively. There are 9 spatially significant areas between population, population density, and number of health facilities with tuberculosis cases. This study concludes that there is a positive spatial autocorrelation (clustering pattern) of pulmonary tuberculosis cases in Central Java Province in 2022. In addition, there is positive spatial autocorrelation between population and number of health facilities with TB cases (clustering pattern) and there is no spatial autocorrelation between population density and TB cases.

Kata Kunci:
autokorelasi spasial,
Provinsi Jawa Tengah,
Indeks Moran,
LISA,
tuberkulosis

ABSTRAK

Tuberkulosis adalah salah satu penyakit yang mudah menular dan menjadi perhatian seluruh dunia. Provinsi Jawa Tengah menjadi salah satu wilayah penyumbang kasus tuberkulsosis terbanyak di Indonesia pada tahun 2022, yaitu sebanyak 22.249 kasus. Tujuan penelitian adalah untuk mengetahui autokorelasi spasial global dan lokal terhadap kasus tuberkulosis paru di Provinsi Jawa Tengah tahun 2022. Penelitian ini merupakan penelitian observasional analitik dengan rancangan studi ekologi. Unit analisis yang digunakan adalah kabupaten/kota sebanyak 35 wilayah. Penelitian ini menggunakan data sekunder dalam Profil Kesehatan Provinsi Jawa Tengah tahun 2022. Analisis data menggunakan metode Moran's Index dan Local Indicators of Spatial Associaton (LISA) dengan pembobotan queen continguity pada software Geoda. Hasil penelitian didapatkan nilai indeks moran uji autokorelasi secara global pada jumlah kasus tuberkulosis paru sebesar 0.505. Hasil uji bivariat LISA didapatkan p value kasus tuberkulosis dengan jumlah penduduk, kepadatan penduduk, dan jumlah fasilitas kesehatan masing-masing 0.002, 0.449, dan 0.007 dengan nilai indeks moran masing-masing 0.3111, 0.0075, dan 0.2384. Terdapat 9 wilayah yang signifikan secara spasial antara jumlah penduduk, kepadatan penduduk, dan jumlah fasilitas kesehatan dengan kasus tuberkulosis. Kesimpulan dari penelitian ini terdapat autokorelasi spasial positif (pola mengelompok) kasus tuberkulosis paru di Provinsi Jawa Tengah tahun 2022. Selain itu, terdapat autokorelasi spasial positif antara jumlah penduduk dan jumlah fasilitas kesehatan dengan kasus tuberkulosis (pola mengelompok) dan tidak terdapat keterkaitan secara spasial antara kepadatan penduduk dengan kasus tuberkulosis.

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INTRODUCTION

Pulmonary tuberculosis (TB) is an infectious disease that is of great concern to the world and is an indicator of success in the Sustainable Development Goals (SDGs), namely ending the tuberculosis epidemic by 2030 (1). The cause of this disease is the bacterium Mycobacterium tuberculosis, which can be transmitted through the patient's phlegm into the air through coughing. The results of the 2022 Global Tuberculosis Report explain that tuberculosis is the most dangerous infectious disease, ranking second in the world after COVID-19. Tuberculosis cases are the 13th leading cause of death in the world (2). The chance of being infected with tuberculosis is greater in people with HIV/AIDS (Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome), malnutrition, diabetes, smoking, and consuming alcohol (3).

The results of the 2022 Global Tuberculosis Report explain that the WHO (World Health Organization) estimates the number of tuberculosis cases in 2021 will be 10.6 million cases with an increase of 600,000 cases from 2020 which reached 10 million cases. The region contributing the most pulmonary TB cases in 2021 is Southeast Asia, namely 45% of cases and Indonesia is the second country that contributes the most pulmonary TB cases after India. Based on WHO predictions, there will be 969,000 cases of tuberculosis in Indonesia in 2021, up 17% from the 824,000 cases reported in 2020. The incidence of tuberculosis cases in Indonesia is 354 per 100,000 population, which means there are 354 people out of every 100,000 people in Indonesia, including those who have tuberculosis. The number of deaths caused by tuberculosis in Indonesia is 150,000 cases (1 person per 4 minutes) which has a death rate of 55 per 100,000 population. This figure is up 60% compared to 2020, which was 93,000 deaths due to tuberculosis (2).

Central Java Province is one of the regions that contribute the most tuberculosis cases in Indonesia. The notification rate for all tuberculosis cases in 2022 in Central Java Province is 110 per 100,000 population, a decrease from 113 per 100,000 population in 2020. This reduction figure is not yet based on the specified target, namely 65 per 100,000. Each region has different characteristics of tuberculosis risk factors. The area with the highest tuberculosis Case Notification Rate (CNR) in Central Java Province is Tegal City at 716.5 per 100,000 population. The main causes that influence the high CNR of tuberculosis in Tegal City include a) declining socioeconomic conditions in various community groups, namely lack of nutritional status, b) environmental conditions inside and outside the home that strongly support the occurrence of tuberculosis, c) demographic changes due to increasing population, namely areas with quite high density, d) the impact of the HIV pandemic, namely the factor of a person's immune system due to the influence of nutritional aspects and other infections, resulting in a decrease in the body's immune system such as HIV(4). Meanwhile, the region with the lowest CNR for tuberculosis is Karanganyar Regency, namely 33.2 per 100,000 population (5). One of the triggers for the high number of tuberculosis cases is the rapid transmission of germs. Apart from that, population density, population, households that implement clean and healthy living behavior (PHBS), pre-prosperous households, medical services, and household sanitation are factors that determine the existence of various tuberculosis cases in all regions (6).

The spatial approach to health problems is a new approach that is usually used to analyze the increase in health problems regarding health issues in an area (environment). Spatial analysis applies GIS (Geographic Information System) as a method for monitoring and surveillance of public health. One of the benefits of GIS in the health sector is that it can provide spatial descriptions of patterns and models of disease spread (7).

This research aims to analyze the relationship between regions so that we can obtain a spatial picture of the distribution of pulmonary tuberculosis cases in Central Java Province in 2022, both at the local and global levels. It is hoped that the results of this analysis can be applied at the decision-making stage in reducing the number of pulmonary tuberculosis cases in Central Java Province.

METHODS

This research is an analytical observational study that applies an ecological study design. Ecological studies are epidemiological studies that have a population

as the unit of analysis to describe the correlational relationship between disease and factors of interest to the researcher (8). This research was carried out in Central Java Province using district/city analysis units, namely 35 district/city areas. This research uses secondary data from the 2022 Central Java Province Health Profile published by the Central Java Provincial Health Service. The data used are data on pulmonary tuberculosis cases treated and registered at health facilities in each region, population, population density, and number of health facilities (hospitals and health centers).

Secondary data are collected by recording the necessary data again. Software that can be used in spatial approach analysis are OpenJump, Geoda, Geographically Weighted Regression (GWR4), and ArcView (9). This research uses Geoda software to analyze data.

Spatial autocorrelation is a spatial analysis method for determining correlation or relationship patterns between regions. There are two types of spatial autocorrelation, namely positive spatial autocorrelation and negative spatial autocorrelation. Positive spatial autocorrelation proves that there are similar values from areas that tend to be clustered and close together. Meanwhile, negative spatial autocorrelation shows that adjacent areas have different values and are more spread out (10). There are several types of testing methods for analyzing spatial autocorrelation globally and locally. This research uses two testing methods, namely the Moran's Index test to analyze global spatial autocorrelation and the LISA (Local Indicators of Spatial Association) test to analyze local spatial autocorrelation with queen contiguity weighting.

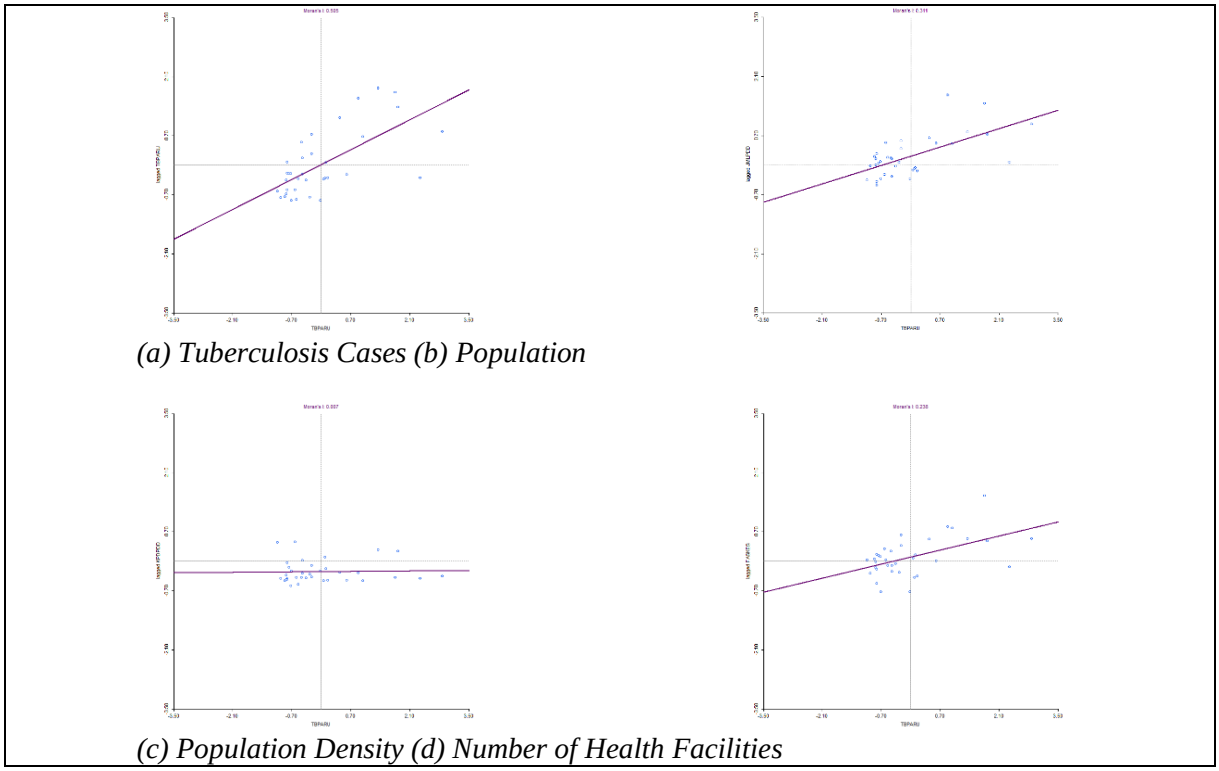
Global spatial autocorrelation can be calculated using the Moran Index (Moran's I). This method can be applied to check the emergence of spatial randomness. This shows that there are patterns that form trends in space or clusters. Meanwhile, LISA is a local index used to assess local pattern trends by displaying various forms of spatial correlation. Because local spatial relationship patterns are more likely to be ignored by the Moran index, LISA provides spatial correlation for each observed region (11). The spatial weighting matrix that considers the intersection aspects of sides and corners is the queen contiguity weighting matrix (12). If a region is located close to another region, then the queen contiguity weighting matrix has a value of 1, and a value of 0 if the regions are not close together.

RESULT

The Moran's I value was obtained from the global autocorrelation test for each variable, namely the number of pulmonary tuberculosis cases (0.505), population (0.311), population density (0.007), and number of health facilities (0.238). The Moran's I number exceeds E(I) which has a value of -0.0294. This indicates that the pattern of distribution of pulmonary tuberculosis cases in Central Java Province is clustered and has similar characteristics to neighboring areas (Figure 1).

Bivariate analysis was used to determine the spatial autocorrelation between population density, population, and number of health facilities and pulmonary tuberculosis cases in Central Java Province using the LISA test. Table 1 below displays the results of the analysis.

Based on Table 1, the results of the LISA bivariate test provide information that at a significance level of 5%, the p value is below α (0.05), namely the population variable is 0.002 and the number of health facilities is 0.007, there is spatial autocorrelation between the population and the number of facilities. health with cases of pulmonary tuberculosis. The variables population size and number of health facilities show positive autocorrelation with pulmonary tuberculosis cases because they have a Moran index I > 0 of 0.3111 and 0.2384 respectively. Apart from that, it is also known that the Moran index value of the variable population density and number of health facilities is greater than E[I] = -0.0294, which means that the pattern of relationship with pulmonary tuberculosis cases between regions is clustered. Meanwhile, the population density variable proves that there is no spatial autocorrelation with pulmonary tuberculosis cases, because the significance value is higher than the α value (0.05), with a significance value of 0.449.



(a) Tuberculosis Cases (b) Population

(c) Population Density (d) Number of Health Facilities

Figure 1. *Moran's I Scatterplot Variable*

Table 1. LISA Bivariate Analysis of Pulmonary Tuberculosis Cases in Central Java Province

Variable	Moran's I	E[I]	Elementary School	z value	p value
Total population	0.3111	-0.0294	0.1006	3,311	0.002
Population density	0.0075	-0.0294	0.0911	0.066	0.449
Number of health facilities	0.2384	-0.0294	0.0971	2,680	0.007

The results of the LISA bivariate test show that there are several districts/cities in Central Java Province that are spatially significant in terms of population density, population, and number of health facilities with cases of pulmonary tuberculosis. Figure 2(a) proves that there are five spatially significant areas between population and pulmonary tuberculosis cases with a significance value of less than 0.05 and less than 0.01. Areas with a significance value of less than 0.05 (light green) are Brebes Regency, Tegal Regency, and Tegal City. Meanwhile, for areas that have a significance value of less than 0.01 (dark green), namely Cilacap Regency and Banyumas Regency.

Figure 2(b) shows that there are three spatially significant areas between population density and pulmonary tuberculosis cases with significance figures below 0.05 and less than 0.01. Areas with a significance figure not exceeding 0.05 (light green), namely Wonosobo Regency and Rembang Regency. Meanwhile, for areas with a significance figure below 0.01 (dark green), namely Blora Regency. Figure 2(c) shows that there are three spatially significant areas between the number of health facilities and pulmonary tuberculosis cases with a significance value of less than 0.05 (light green). These areas are Cilacap Regency, Banyumas Regency, and Kebumen Regency.

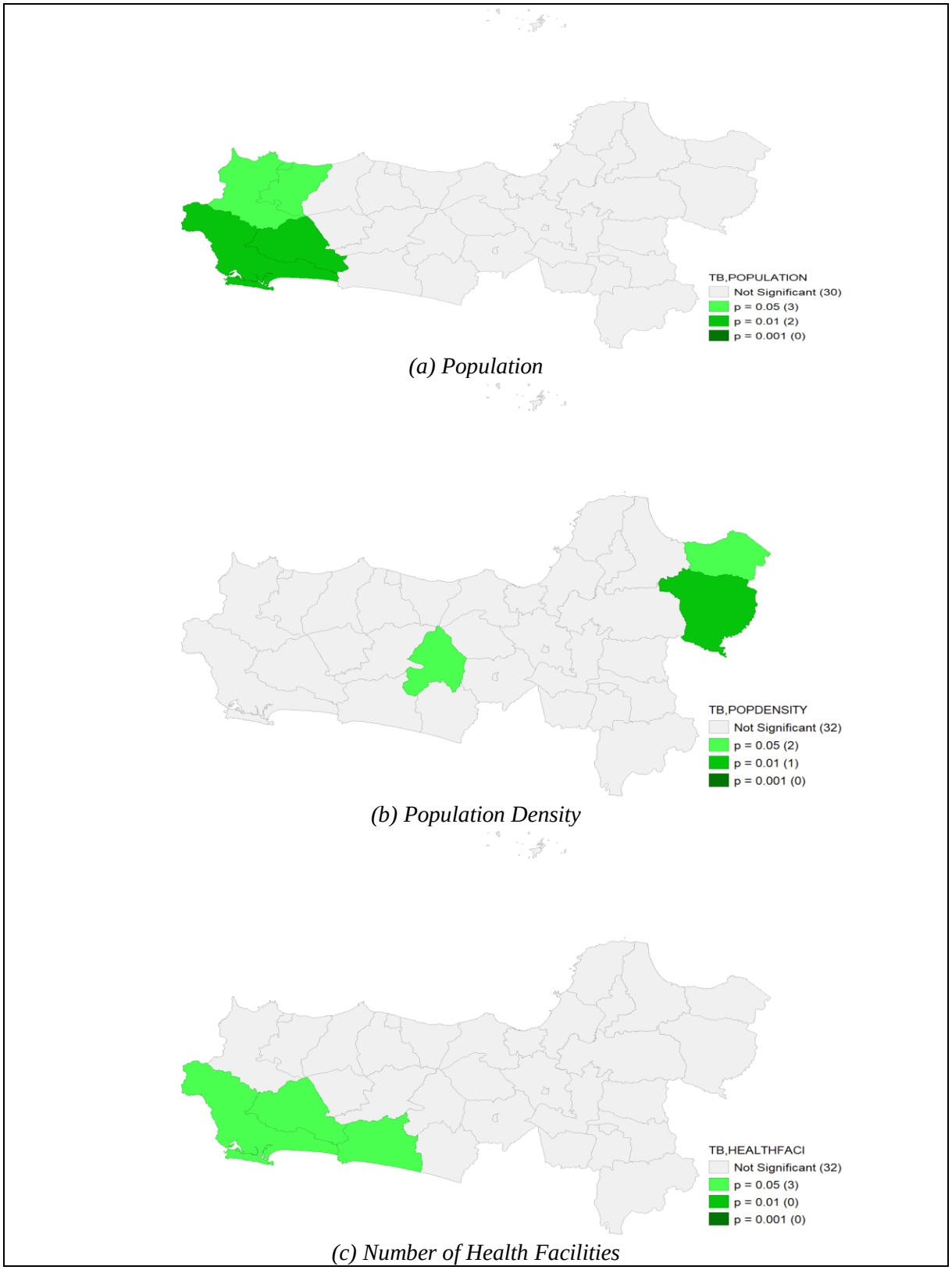


Figure 2. *Significance map* number of Population, Population Density, and Number of Health Facilities with Pulmonary Tuberculosis Cases

Apart from knowing the spatially significant areas, from the results of the LISA bivariate test you can also find out the position of the spatially significant areas through the Moran cluster map as in Figure 3. The Moran cluster map results of the correlation between population size and pulmonary tuberculosis cases are given in Figure 3(a). Quadrant I

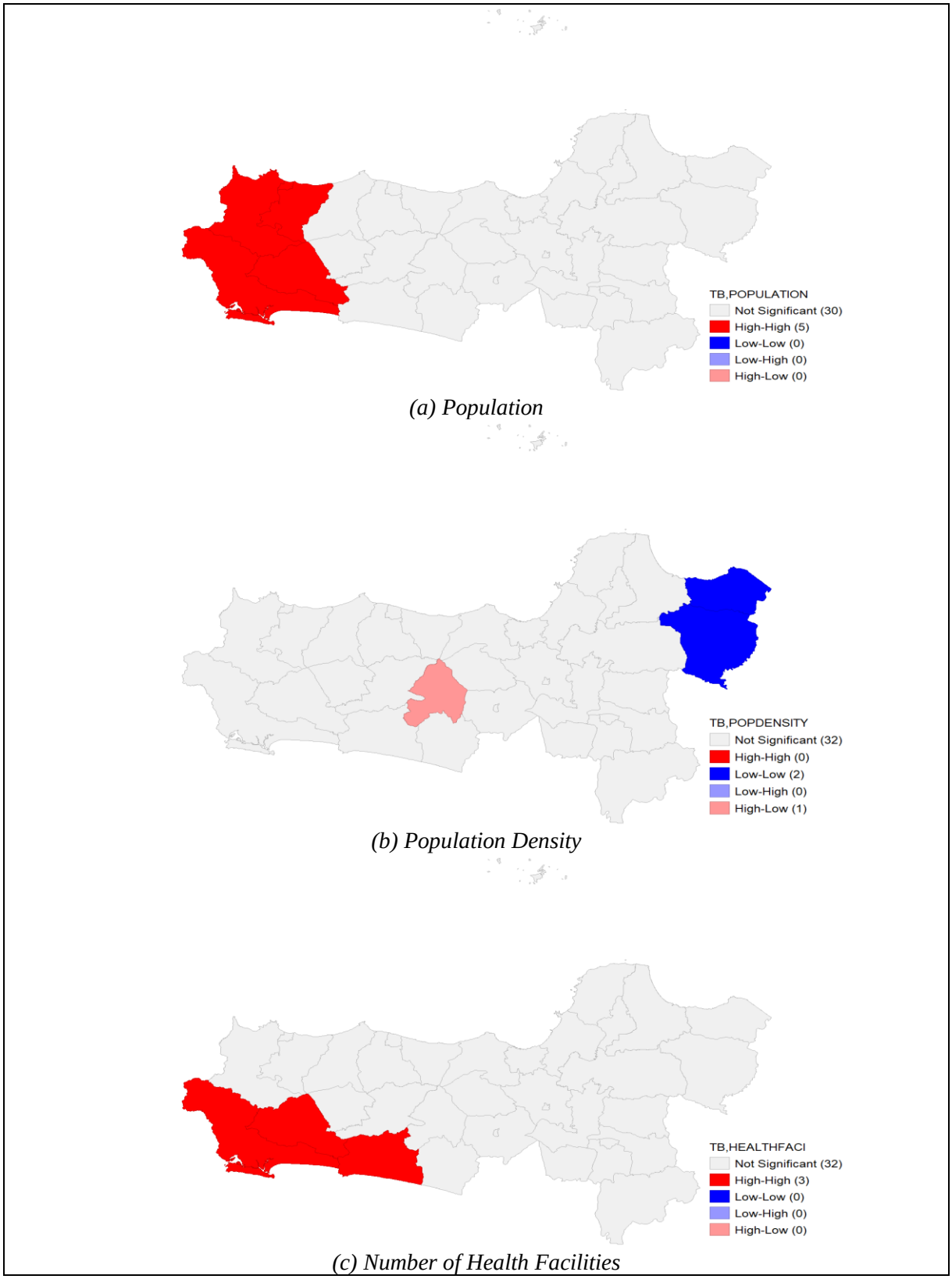


Figure 3. *Clustermap* Number of Population, Population Density, and Number of Health Facilities with Pulmonary Tuberculosis Cases

(High-High) contains five regions or hotspot areas, namely regions that have high observation values (number of cases) surrounded by other high observed values (number of cases). These areas include Tegal Regency, Brebes Regency, Tegal City, Banyumas Regency, and Cilacap Regency.

The Moran cluster map results of the relationship between population density and pulmonary tuberculosis cases in Figure 3(b) prove that there are two regions in quadrant III (Low-Low), namely Wonosobo Regency and Rembang Regency. Cold spot areas are areas in quadrant III or areas that have low observation values (number of cases) and border areas with other low observation values (number of cases). Blora Regency is the only region in quadrant IV (High-Low), which means that areas with low observation values (number of cases) surround areas with high observation values (number of cases). The Moran cluster map results of the relationship between the number of health facilities and pulmonary tuberculosis cases in Figure 3(c) prove that in quadrant I (High-High) there are three regions, namely Cilacap Regency, Banyumas Regency, and Kebumen Regency.

DISCUSSION

The research results show that there is global spatial autocorrelation in pulmonary tuberculosis cases in Central Java Province in 2022 with a clustered pattern. This shows that there is a connection between the transmission of tuberculosis between regions in Central Java Province. One of the causes is the characteristics and location of areas that directly border each other. These results are from previous research that tuberculosis cases that occurred in Jambi City in 2015–2021 formed a clustered pattern and showed a relationship between the number of tuberculosis cases between regions in Jambi City and the existence of clustering in several locations (13). Research in East Java Province also supports the results of this study, that there is positive autocorrelation in cases of pulmonary tuberculosis, which means that adjacent areas have similar characteristics (14).

Relationship between Population and Tuberculosis Cases

The bivariate LISA results show that there is positive spatial autocorrelation, thus forming a clustered pattern between population and pulmonary tuberculosis cases. This means that there is a regional link between new cases of tuberculosis and the population. Theoretically, increasing population will have a positive correlation with the number of tuberculosis cases (15). There are five regions in the hotspot area or quadrant I (High-High), namely Tegal City, Banyumas Regency, Brebes Regency, Cilacap Regency, and Tegal Regency. The Banyumas Regency region is the region with the most population (1,806,013 people) and tuberculosis cases (3,701 cases) compared to 34 other regions. Tegal City, Brebes Regency, Cilacap Regency, and Tegal Regency have characteristics that tend to be the same as Banyumas Regency, so the risks from these areas also tend to be the same because their areas are directly adjacent to each other.

These results are in line with research in Sorolangun Regency in 2022 that there is spatial autocorrelation between the population and the number of tuberculosis cases (7). This means that, as the population in an area increases, the number of tuberculosis cases also increases (13). The increasing population will make it easier for tuberculosis to spread so that it can spread more quickly to other people (16).

Relationship between Population Density and Tuberculosis Cases

The results of the LISA bivariate test show that there is no spatial autocorrelation between population density and pulmonary tuberculosis cases in Central Java Province. The results of this research show that there is one outlier area, namely Wonosobo Regency in quadrant IV (High-Low), which means that areas with low observation values (number of cases) are surrounded by areas with high observation values (number of cases).

These results are in line with research in Kendari City in 2016 which revealed that there was no significant difference in the number of tuberculosis cases between areas with high and low population density (17). Research conducted in Batang Regency in 2018 also showed the same results that the increase in the number of new tuberculosis cases was not caused by an increase in population density (18). This happens because population density is not the sole causal factor in the occurrence of pulmonary tuberculosis cases, there are other possible causal factors, such as climate, age, education, and age (19).

There are districts/cities with low population density in this study, but which have a high number of tuberculosis cases.

On the other hand, there are also districts/cities with low numbers of tuberculosis cases but high population densities. The uneven level of population distribution in Central Java Province could be one of the causes of the discrepancy in this research. Apart from that, the high number of pulmonary tuberculosis cases in areas with low population density could be due to high residential density.

The Relationship between the Number of Health Facilities and Tuberculosis Cases

The results of the LISA bivariate test prove that there is a positive spatial autocorrelation or a clustering pattern between the number of health facilities and pulmonary tuberculosis cases in Central Java Province. This means that there is a regional link between new cases of tuberculosis and the number of health facilities. Health facilities in this study are the number of hospitals (both private and government-owned) and community health centers in each district/city area. The number of tuberculosis cases will decrease with the existence of health facilities that are adequate in quality and quantity (20). A greater number of facilities play a role in the process of detecting new cases of tuberculosis and the treatment process (21). For example, the Banyumas Regency area with the largest number of health facilities (69) has the highest rate of case discovery (1,539 cases) and complete treatment (67.8%) (5).

Health facilities play a role in every behavior of tuberculosis sufferers in seeking treatment. Tuberculosis sufferers will diligently seek treatment if they get the health facilities they want. Therefore, the recovery rate for tuberculosis sufferers will increase if health facilities are well provided (22). However, in reality, some people still cannot access facilities easily. There are several barriers to accessing medical service facilities, namely 26% because there is no one to accompany them when seeking treatment, 11% due to distance to medical service facilities, and 15% due to limited costs for treatment (23). Good socio-economic status can influence reducing the number of tuberculosis cases, but a comprehensive health and prevention service system is very important to build to control current tuberculosis cases (24).

CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the results of this analysis, it can be concluded that there is global spatial autocorrelation in pulmonary tuberculosis cases in Central Java Province in 2022 with a clustered pattern. Nine of the 35 districts/cities in Central Java Province are spatially significant between population density, population, and number of health facilities and tuberculosis cases. These areas are Tegal City, Banyumas Regency, Blora Regency, Brebes Regency, Cilacap Regency, Kebumen Regency, Rembang Regency, Wonosobo Regency and Tegal Regency. The results of the local spatial autocorrelation test using the LISA test showed that there was a positive spatial autocorrelation between the population and the number of health facilities and tuberculosis cases, and there was no spatial autocorrelation between population density and tuberculosis cases.

Suggestions

It is hoped that pulmonary tuberculosis control interventions and policy programs can be prioritized at the district/city level in Central Java Province based on the special characteristics of each region and highly related risk factors. Apart from that, synergy, collaboration, and comprehensiveness are also needed in controlling risk factors and breaking the chain of transmission from all parties.

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