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Evaluating spatial analysis of tuberculosis prevalence to identify priority districts or municipalities that need policy attention in West Java

Emilia Pandin Madao[1]*, Ema Hermawati[1], Nur A'isyah Amalia Putri[2], Martya Rahmaniati Makful[2]

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[1]Department of Environmental Health, Faculty of Public Health, Universitas Indonesia, Indonesia

[2]Department of Biostatistics and Population Studies, Faculty of Public Health, Universitas Indonesia, Indonesia

***Correspondence:**
emilia.pandin@ui.ac.id

Abstract

Purpose: This study assesses the spatial autocorrelation of tuberculosis (TB) with population density, poverty, personal hygiene and environmental sanitation (*perilaku hidup bersih sehat*, PHBS), and housing quality to identify critical areas for targeted TB management in West Java. **Methods:** This ecological study analyzes secondary data from all TB patients across 27 regencies/cities in West Java Province for 2022. Spatial patterns were examined using the Global Moran's Index and Local Indicators of Spatial Association (LISA). **Results:** The analysis revealed significant clustering of TB prevalence with population density (p-value = 0.001) and PHBS (p-value = 0.047). At the same time, dispersion was noted with poverty (p-value = 0.355) and a non-significant clustering with housing quality (p-value = 0.270). Notably, ten regencies/cities exhibited significant local spatial autocorrelation, indicating priority areas for intervention. **Conclusion:** TB prevalence in West Java show a positive spatial correlation with population density and PHBS, indicating clustered patterns that necessitate focused policy attention. The absence of a spatial correlation between poverty and housing quality suggests different intervention strategies may be required. TB intervention should be prioritized in areas like Bekasi Regency, Bekasi City, Bogor Regency, Bogor City, Cianjur Regency, and Depok City, where TB prevalence is significantly associated with key spatial factors.

Keywords: autocorrelation; Kampung Peduli Tuberculosis (KAPITU); spatial analysis; TB elimination; tuberculosis

INTRODUCTION

Tuberculosis (TB) is an infectious disease that is the main cause of poor health and the cause of death worldwide [1]. Mycobacterium tuberculosis, which causes TB, can spread from person to person through the air. People most likely to be infected with Mycobacterium tuberculosis are people who spend a lot of time in enclosed spaces with people who have TB, such as family members, roommates, or coworkers [2].

In 2022, TB resulted in 1.3 million deaths. In addition, it is estimated that people suffering from TB

worldwide are as many as 10.6 million people, consisting of men as many as 5.8 million people, women as many as 3.5 million people, and children as many as 1.3 million people. Tuberculosis occurs in all countries and affects all age groups [3]. Tuberculosis is a disease that is the leading cause of death due to a single infectious agent and ranked above HIV/AIDS until the COVID-19 pandemic. This problem is a challenge for all people in the world. The country with the second largest TB cases in the world is Indonesia [1].

According to the Global Tuberculosis Report 2022, the incidence of TB increased by 3.6% between 2020 and 2021. India, Indonesia, and the Philippines were major contributors to TB globally between 2020 and 2021, with TB incidences increasing by around 0.4 million in all three countries. In 2021, ten countries accounted for 75% of the global gap between the reported number of people newly diagnosed with TB and the estimated incidence of TB. Indonesia is one of the top five contributors to the gap, at 13% [4]. Tuberculosis cases found in 2021 were 397,377 cases, an increase from 2020 of 351,936 cases. The highest number of cases were found in provinces with large populations in Indonesia: West Java, East Java, and Central Java, where these three provinces accounted for 44% of all TB cases in Indonesia [5].

According to the latest report, in 2021, West Java witnessed a significant increase in tuberculosis cases, which surged from 85,681 to 160,661 cases in 2022 [1]. Bogor Regency, Bandung City, and Bekasi City are the regions with the highest tuberculosis cases, accounting for 6-14% of the total number of new cases in West Java [1]. It is observed that men are more susceptible to tuberculosis [6]. Several sociodemographic and environmental factors affect the incidence of tuberculosis, such as male gender, age above 36 years, no education or out of school, marital status, low family income, and underweight BMI. Environmental factors such as the absence of artificial ventilation, lack of sunlight, the presence of more than five people in a household, and a history of contact with tuberculosis sufferers also contribute to the spread of tuberculosis [7].

A study conducted by Noerhalimah [8] revealed that household coverage of PHBS (r = 0.69, p-value = 0.01) and healthy home coverage (r = 0.68, p-value = 0.01) were positively correlated with the discovery of tuberculosis cases in West Java regencies and cities. These findings highlight the importance of promoting healthy behavior and home environments to prevent the spread of tuberculosis in the region.

The results of spatial autocorrelation analysis can be used in decision-making, experiment design, model development, and trend analysis. In addition, it also provides advantages in design and sampling strategies for optimal field monitoring [9]. Therefore, this study assesses the spatial autocorrelation of tuberculosis (TB) with population density, poverty, personal hygiene and environmental sanitation (PHBS), and housing quality to identify critical areas for targeted TB management in West Java.

METHODS

This ecological study analyzed aggregate data across 27 regencies/cities in West Java, comprising nine cities and 18 regencies, focusing on all tuberculosis cases recorded in 2022. The study's variables included TB prevalence, population density, poverty rates, conditions of healthy housing, and practices of personal hygiene and sanitation (PHBS). The data used are secondary data contained in the 2022 West Java Provincial Health Profile (https://diskes.jabarprov.go.id/), including the number of all tuberculosis cases, population density, number of healthy houses, and the number of house- holds behaving clean and healthy (PHBS) [6]. The data on the number of poor people is obtained from West Java Province in the 2023 Figures (https://jabar.bps.go.id/) [10]. Meanwhile, the digital map of West Java was obtained on https://tanahair.indonesia.go.id/. Spatial autocorrelation analysis was performed using GeoDa software version 1.22.0.2 and map generation using QGIS software version 3.22.15.

The purpose of spatial autocorrelation is to assess the level of dependence or spatial correlation between the region's observation value and adjacent neighbors' observation value [11]. Spatial analysis used the Global Moran's Index and Local Indicators of Spatial Association (LISA) on GeoDa software. Moran Index values equal to zero indicate no autocorrelation. While Moran Index values of $-1 \leq I \leq 0$ indicate a negative spatial autocorrelation, and values of $0 < I \leq 1$ indicate a positive spatial autocorrelation. Spatial relationships are categorized into four quadrants that are Quadrant I or HH (High-High), Quadrant II or LH (Low-High), Quadrant III or LL (Low-Low), and Quadrant IV or HL (High-Low) [12].

Spatial pattern analysis using Global Moran's Index aims to detect global autocorrelation, followed by LISA. Negative autocorrelation indicates that adjacent regions tend to have different attribute values and form a chessboard pattern. At the same time, positive autocorrelation shows that adjacent regions have almost the same characteristics and attribute values and make a clustered pattern. Global Moran's Index assesses the autocorrelation of a West Java in general, while LISA assesses spatial autocorrelation locally between regencies/cities in West Java. This analysis resulted in Bivariate Moran's Index, BiLISA Cluster Map, and BiLISA Significance Map [11]. BILISA is used to measure spatial

correlations locally, make cluster maps with similar behavior, and enable assessment of spatial variability and dispersion [13]. A region is declared to have significant spatial autocorrelation if the Global Moran's Index and LISA analysis results show a p-value of ≤ 0.05. The hotspot is an area that has a high response or high cluster to a disease incidence. Temporal, spatial, and space-time statistics are generally used to detect and evaluate disease clusters [14].

RESULTS

Table 1 shows TB cases with population density and number of PHBS globally have significant positive spatial autocorrelation (positive Z score and p-value < 0.05) between regencies/cities in West Java with a clustered pattern (I>E[I]). TB cases with population density and the number of PHBS between locations are interconnected, especially in neighboring regencies/cities. Meanwhile, the number of TB cases and healthy homes showed no spatial autocorrelation globally (p-value > 0.05).

The number of poor people and healthy houses between locations is not interconnected, especially in neighboring regencies/cities. TB cases with poor people have a pattern of spread (I<E[I]), while TB cases with several healthy homes have a clustered pattern (I>E[I]). Then, spatial autocorrelation locally between regencies/cities using Bi-LISA is displayed on the cluster map.

Table 1. Bivariate Moran's Index (I) of tuberculosis cases with population density, poor people, PHBS, and healthy houses in West Java Province in 2022

Variable	I	E[I]	Z-Score	p-value	Pattern
Population density	0,486	-0,039	4,253	0,001	Clustered
Number of poor people	-0,065	-0,039	-0,355	0,355	Dispersed
PHBS	0,203	-0,039	1,829	0,047	Clustered
Number of healthy houses	0,052	-0,039	0,525	0,270	Clustered

Figure 1a shows ten regencies/cities have spatial interactions between population density and TB cases. Bekasi City, Bogor City, and Depok City are in the High-High quadrant and have positive spatial autocorrelation. These three regions are areas with high TB cases and surrounded by areas with high TB cases where this condition is related to population density. Furthermore, Bekasi Regency, Bogor Regency, and Cianjur Regency are in the Low-High quadrant and have negative spatial autocorrelation. All three regions have lower TB cases than the surrounding areas, where this condition is related to population density. Ciamis Regency, Cirebon Regency, Majalengka Regency, and Tasikmalaya Regency are in the Low-Low quadrant and have positive spatial autocorrelation. All four regions have low TB cases and are surrounded by areas with low TB cases related to population density.

Figure 1b shows ten regencies/cities with spatial interactions between poor people and TB cases. Bekasi Regency, Bogor Regency, and Cianjur Regency are in the High-High quadrant and have positive spatial autocorrelation. All three regions have high TB cases and are surrounded by areas with high TB cases where the number of poor people influences this condition. Bekasi City, Bogor City, and Depok City are in the Low-High quadrant and have negative spatial autocorrelation because the three regions have lower TB cases than the surrounding areas. Ciamis Regency and Majalengka Regency are in the Low-Low quadrant and have positive spatial autocorrelation. Both regions have low TB cases and are surrounded by areas with low TB cases. Then, the Cirebon Regency and Tasikmalaya Regency include high-low and negative spatial autocorrelation. Both regions have high TB cases but are surrounded by areas with low TB cases, so neighboring regions must be careful.

Figure 1c shows ten regencies/cities with spatial interactions between PHBS and TB cases. Bekasi Regency, Bogor Regency, Cianjur Regency, and Depok City are in the High-High quadrant and have positive spatial autocorrelation. All four regions have high TB cases and are surrounded by areas with high TB cases where this condition is related to PHBS. Further, Bekasi City and Bogor City are included in low-high and negative spatial autocorrelation because they have lower TB cases than the surrounding area. Ciamis Regency, Cirebon Regency, Majalengka Regency, and Tasikmalaya Regency are in the Low-Low quadrant and positive spatial autocorrelation. The four regions and neighbors have low TB where PHBS influences this condition.

Figure 1d shows that ten regencies/cities have spatial interactions between the number of healthy houses and TB cases. Bekasi Regency, Cianjur Regency, and Bekasi City are in the High-High quadrant and have positive spatial autocorrelation. All three regions have high TB cases and are surrounded by areas with

high TB cases, which is influenced by the number of healthy homes. Furthermore, Bogor Regency, Bogor City, and Depok City are in the Low-High quadrant and have negative spatial autocorrelation because they have low TB cases compared to the surrounding area. Then, Ciamis Regency, Cirebon Regency, and Tasikmalaya Regency include Low-Low and positive spatial autocorrelation. These three regions have low TB cases and are surrounded by areas with low TB cases, where PHBS influences this condition. Majalengka Regency includes High-Low and negative spatial autocorrelation. Majalengka Regency has high TB cases but is surrounded by low TB cases, so neighboring areas must be careful.

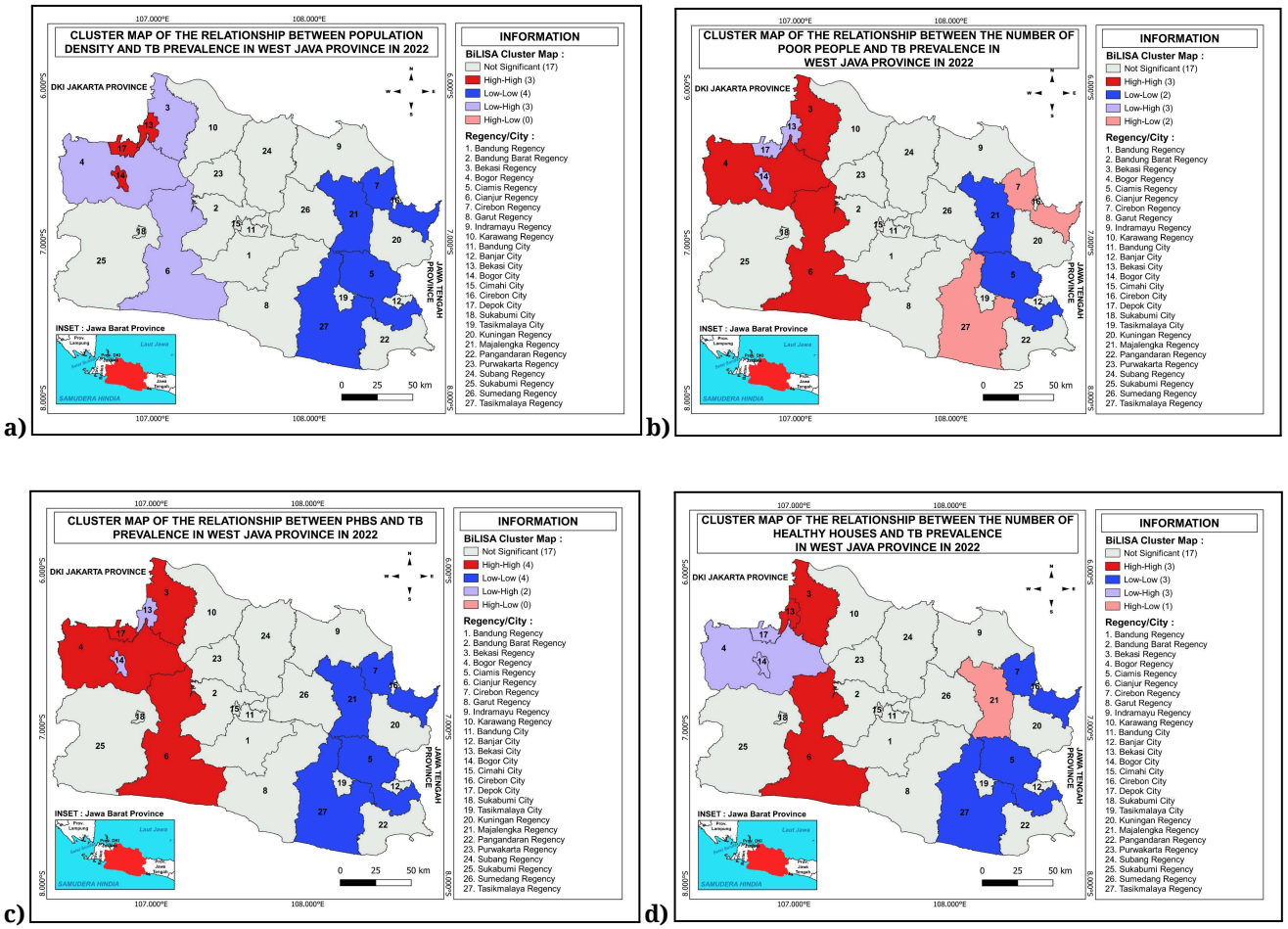

Figure 1. a) Cluster map of the relationship between population density and TB prevalence; b) Cluster Map of the relationship between the number of poor people and TB prevalence; c) Cluster map of the relationship between PHBS and TB prevalence; d) Cluster map of the relationship between the number of healthy houses and TB prevalence in West Java Province in 2022

DISCUSSION

Moran's Index results show that the spread of TB prevalence with population density and PHBS globally between regencies/cities are interconnected. There are interactions, especially neighborly. However, TB prevalence with poor people and healthy houses between regencies/towns with each other in West Java are not interconnected. Three cities are High-High (Bekasi City, Bogor City, and Depok City) based on population density. Meanwhile, based on PHBS, four regencies/cities are included in High-High (Bekasi Regency, Bogor Regency, Cianjur Regency, and Depok City).

Moran's Index does not provide information on specific spatial patterns [15]. LISA can measure spatial relationships for each location or correlation with any value close to it [16]. Cases in a location are strongly influenced by cases in neighboring locations [9]. Tobler [17] states, "Everything is related to everything else, but near things are more related than distant things." The correlation between population density and pathology has been studied using spatial autocorrelation [9]. This study's results align with research conducted by Lestari et al. [12], which showed a positive autocorrelation in TB cases with population density in 2019-2021 with a cluste red pattern. Some areas that have local spatial autocorrelation are Depok City, Bogor City, and Bekasi City,

which are in the high-high range. TB cases and population density in the surrounding area influence the region's high number of TB cases [18]. Fitria et al. [19] stated that there is no significant relationship between poor people and the incidence of pulmonary TB in Riau Province. A study reported that the factor related to the incidence of BTA+ pulmonary TB in Banyumas Regency is the number of households doing PHBS [20]. Another stated that there is a relationship bet- ween healthy homes and the incidence of tuberculosis in the Campurdarat Sub-district [21].

Spatial analysis is a region-based disease management methodology for geographic disease data analysis regarding population distribution, environmental, ecosystem, socioeconomic risk factors, and the relationships between these variables. The incidence of dis- ease is a spatial phenomenon. The term spatial describes phenomena that exist on the earth's surface and are thought to have a relationship with each other. Disease events can be associated with various objects related to the location, topography, and distribution of cases in a space [22]. The Indonesian government's commitment to tuberculosis elimination is outlined in Presidential Regulation Number 67 of 2021 concerning Tuberculosis Mitigation, which targets a decrease in TB incidence to 65 per 100,000 population and a reduction in the death rate from TB to 6 per 100,000 population by 2030 [23].

One of the densely populated cities in West Java is Depok City. Kampung Peduli Tuberculosis (KAPITU) is an innovation in tuberculosis control involving various elements of society to increase community awareness and a more holistic integrated control program in Depok City [24]. The success of the National Tuberculosis Program requires the support and involvement of Pentahelix in overcoming tuberculosis problems. Synergy and cooperation pentahelix involves government, society, academia, business actors, and mass media [25].

The indicator of the Tuberculosis Prevention Program in the Minimum Service Standards (MSS) is every suspected tuberculosis person receives health services according to standards. The tuberculosis MSS target that must be achieved at the district/city level is 100%. In 2022, 60 out of 514 districts/cities in Indonesia have completed the TB MSS target of more than 100%. However, there is also a low achievement of TB MSS in districts/cities, which shows that the contribution of local governments to TB control is still lacking. The achievement of West Java Tuberculosis MSS in 2022 is 72%. Therefore, more commitment is needed from local governments to support TB control. TB prog- ram innovations and the provision of resources can help achieve tuberculosis MSS targets in a region [25].

The MSS achievement of suspected tuberculosis suspects in Depok City in 2022 is 82.18%, which has increased from the previous year. However, the accomplishment of MSS has not reached the target set at 100% [26]. The number of tuberculosis cases in Depok City increased from 2020 to 2022 [24]. The concept of MSS changed from the past achievement of MSS, which targets more ministerial program performance, to the performance of local governments, which has reward and punishment consequences. Therefore, local governments are expected to ensure the availability of sufficient resources to support the MSS implementation process. MSS is the minimum thing that local governments must implement for their people, so the MSS target must be 100% every year [27].

CONCLUSION

This study shows a positive spatial autocorrelation of TB cases with population density and global clean and healthy living behavior. Meanwhile, TB prevalence have no spatial autocorrelation based on the number of poor people and healthy homes. The spread of TB cases based on population density, PHBS, and the number of healthy houses shows a clustered pattern. Meanwhile, the spread of TB cases based on the number of poor people shows a dispersed pattern. This study illustrates the distribution of TB cases between regencies/cities in West Java, which is influenced by population density, PHBS, the number of poor people, and the number of healthy houses so that each regency/city can be given appropriate treatment.

Regional monitoring related to TB is very important, considering that West Java has Indonesia's highest number of TB cases. Spatial handling of TB management programs in areas with high observation values: Bekasi Regency, Bekasi City, Bogor Regency, Bogor City, Cianjur Regency, and Depok City, must be prioritized TB handling so as not to spread to areas with low observation value so that TB cases can be reduced in West Java. Local governments at the provincial and district/city levels in West Java can conduct regular spatial monitoring in priority districts or municipalities of the TB program to obtain trends in fluctuations in TB cases. The spatial trend obtained is expected to decrease in cases in the priority areas of the TB program.

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