BKM Public Health & Community Medicine
(Berita Kedokteran Masyarakat)

Volume 39 **Number** 1, 2023, **Pages** e6462
DOI: 10.22146/bkm.v39i1.6462

Spatial analysis of tuberculosis cases diffusion based on population density in Bekasi Regency in 2017-2021

Yuanita Rizky Inggarputri [1]*, Indang Trihandini[1], Prihatini Dini Novitasari[1] , Martya Rahmaniati Makful[1]

Submitted:
December 15th, 2022
Accepted:
January 13th, 2023
Published:
January 25th, 2023

[1] Public Health Science Program Study, Department of Biostatistics and Population Studies, Faculty of Public Health, Universitas Indonesia, Indonesia

***Correspondence:**
yuanita.rizky@ui.ac.id

Abstract

Purpose: This research aims to examine the spatial relationship between tuberculosis cases and population density and their spatial diffusion patterns in Bekasi Regency in 2017-2021. **Methods:** Research using an ecological study design using spatial analysis to estimate and analyze the distribution of tuberculosis prevalence related to population density in 23 sub-districts in Bekasi Regency, compare data from 2017 to 2021, and evaluate the spatial correlation. The data is taken from secondary data from the Bekasi District Health Office for 2017-2021. **Results:** This study shows a spatial autocorrelation between tuberculosis cases and population density from 2017 to 2021 (I>E; *p-value* <0,05). There is spatial diffusion of cases characterized by expanding clusters with high tuberculosis cases. High-high cluster in 2017, there was one sub-district. In 2018 there was also one sub-district. In 2019 there were two sub-districts. In 2020, there were three sub-districts. And in 2021, there were five districts. **Conclusion:** This research shows a positive spatial autocorrelation in the incidence, influenced by population density in Bekasi Regency from year to year (2017-2021) with a clustering pattern.

Keywords: spatial analysis; tuberculosis; population density

INTRODUCTION

Tuberculosis is one of the top 10 diseases that cause death and is the leading cause of a single infectious agent (above HIV/AIDS) worldwide. Tuberculosis produces a cough that lasts more than three weeks, usually has sputum, and sometimes bleeds. The disease is spread through droplets of people infected with tuberculosis bacillus [1].

According to the World Health Organization, tuberculosis (TB) is still a health problem today. In 2020, there were 10 million people worldwide suffering from tuberculosis (TB), causing 1.2 million people to die yearly. Indonesia is one of the countries with the highest TB burden in the world, with an estimated number of TB cases reaching 845,000 with a death rate of 98,000, or equivalent to 11 deaths/hour [2].

In 2021 the number of tuberculosis (TB) cases found was 397,377 cases, an increase compared to all tuberculosis cases seen in 2020, which was 351,936. The highest cases were reported from large population provinces of West Java, East Java, and Central Java [3]. Health data from West Java Province in 2021 reported that the number of tuberculosis cases in Bekasi Regency was 10,041 people, the second highest number after Bogor Regency [4].

According to research in Semarang, one of the tuberculosis cases is influenced by population density in an area [5]. This is because people living in densely populated areas are more likely to come into contact

with people with tuberculosis. As a result, densely populated regions tend to have higher cases of tuberculosis. Other research found that the spread of droplets containing Mycobacterium tuberculosis occurs faster from one host to another in areas with high population density [6].

When viewed from a regional aspect, population density affects the spread of tuberculosis cases [7]. Furthermore, a study in China found a significant spatial autocorrelation in the spread of tuberculosis cases influenced by student population density in Nanning [8]. This research used spatial statistical analysis, linking spatial relationships into calculations. Spatial statistics is needed to see the effect of correlation on estimation, prediction, and design processes using certain spatial models. Spatial analysis is needed to find the relationship between the research area and the area around the study [9].

Regional analysis in identifying the spread of tuberculosis cases and their relationship to population density can help the government identify priority areas for tuberculosis treatment. Moreover, the results of the statistical spatial analysis carried out in a time series can describe the diffusion of tuberculosis cases from year to year. Previous research on the spread of tuberculosis in Sukabumi City showed that the pattern of tuberculosis spread in 2018 and 2019 shows spatial autocorrelation with random spatial patterns [9]. When associated with population density, research in Central Java found the spread of tuberculosis cases formed a clustering pattern from year to year but was statistically spatially insignificant [10]. However, no time-series spatial research on the spread of tuberculosis and its relation to population density in the Bekasi Regency. This study examines the spatial relationship between tuberculosis cases, population density, and spatial diffusion patterns for 2017-2021.

METHODS

This study uses an ecological study design using spatial analysis to estimate and analyze the distribution of tuberculosis prevalence related to population density in 23 sub-districts in Bekasi Regency, compare data from 2017 to 2021, and evaluate spatial correlation. This study used secondary data collected from several open data access, such as TB cases variable from West Java open data and population density from health profiles of Bekasi Regency from 2017 to 2021, which are accessible on each of the institution's official websites. The data analyzed are aggregated data on the number of TB cases per year and population density per sub-district per year.

This research was conducted in Bekasi Regency, West Java, from October to December 2022, with an area of 127,388 ha of 23 sub-districts. Furthermore, this region has two topography: the lowlands in the northern and the undulating plains in the southern part [11]. The population in this study is the entire population of Bekasi Regency, spread across 23 sub-districts. The sample of this study was residents who were confirmed to have tuberculosis and recorded by the Bekasi Regency Health Office.

Spatial pattern analysis in this study used the Global Moran's Index to detect global autocorrelation and continued with Local Indicators of Spatial Autocorrelation (LISA). This analysis used GeoDa software. The null hypothesis in this study is that there is no spatial autocorrelation between sub-district areas in Bekasi Regency (I = E). As an alternative hypothesis, there is a positive spatial autocorrelation between sub-district areas in Bekasi Regency (I>E). In this study, the significance level used was 95%, so an area is said to have statistically significant spatial autocorrelation if the significance value (p-value) is less than equal to 0.05 in the Global Moran's Index results and LISA analysis.

The Global Moran's Index and LISA are statistical analyses that can measure the relationship of spatial proximity at the observation site by considering that regions with spatial proximity will have similar attribute values. The Global Moran's Index and LISA range from -1 to +1, where a negative number indicates negative autocorrelation, a value of 0 indicates no autocorrelation, and a positive value indicates positive autocorrelation. If there is a negative autocorrelation, the adjacent regions tend to have different attribute values, but space will form a chessboard-like pattern. Conversely, if positive autocorrelation exists, the adjacent region will form a cluster with almost identical characteristics and attribute values. If the Global Moran's Index assesses autocorrelation in the region in general, in this case, it is Bekasi Regency. LISA is used to assess local spatial autocorrelation between sub-districts in Bekasi Regency. This analysis produced information in the form of a BiLISA Cluster Map, BiLISA Significance Map, and Bivariate Moran's I [12].

RESULTS

Patterns of spread of tuberculosis case prevalence related to population density

Table 1 shows Moran Index Results 2017 - 2021. To determine the pattern of the spread of tuberculosis prevalence and its relationship with population density in Bekasi Regency, a global spatial analysis was carried out with the Global Moran's Index. The spread of tuberculosis cases and their relationship with

population density showed a positive spatial autocorrelation between sub-districts in Bekasi Regency from 2017 to 2021. When connected with population density, the spread of Tuberculosis cases in the region offers a clustered pattern. The value of Moran's Index indicates this> Expected index (I > E). The result statistically shows a significant positive spatial autocorrelation (the Z score was positive, and the p-value < 0.05).

Table 1. Moran index 2017 - 2021

Year	Moran's Index	Expected Index	Variance	Z-score	p-value
2017	0,156	-0,0455	0,104	1,7549	0,044
2018	0,1928	-0,0455	0,1096	2,107	0,035
2019	0,2307	-0,0455	0,1139	2,4175	0,017
2020	0,317	-0,0455	0,1184	3,0759	0,007
2021	0,2688	-0,0455	0,1231	2,4775	0,019

Based on the whole, it appears that the value of Moran's Index from 2017 to 2020 has increased, which means that its spatial autocorrelation is increasing. However, in 2021 there was a decrease in the value of Moran's Index to 0.2688.

Cluster map overview of spatial diffusion patterns and the relationship between population density and tuberculosis cases 2017 – 2021

Based on local spatial analysis using LISA, a cluster map and a map of the significance of the relationship between population density and tuberculosis spread in Figure 1 and Figure 2. In 2017, of the 23 sub-districts in Bekasi Regency, two had significant positive spatial autocorrelation (p-value <0.05), Cibitung and Cibarusah. From the cluster map, Cibitung is in quadrant I (high-high) and has a positive spatial autocorrelation associated with population density. The area has a high number of Tuberculosis cases and is surrounded by districts with an increased number of Tuberculosis cases. On the other hand, there is one sub-district in quadrant III (low-low), namely Cibarusah. This positive spatial autocorrelation is associated with population density. Cibarusah district has a low number of Tuberculosis cases and is surrounded by other sub-districts with a low number of Tuberculosis cases.

Furthermore, in 2018, two sub-districts had significant positive spatial autocorrelation, namely Cikarang Barat and Serangbaru. Cikarang Barat Sub District is in quadrant I (high-high) because when related to population density, the district has high tuberculosis cases and is surrounded by districts with high cases. On the other hand, Serangbaru District is in

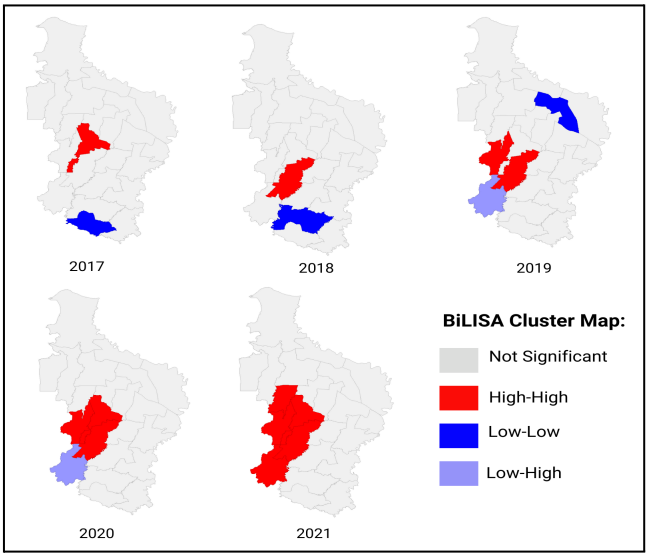

Figure 1. Cluster map of the relationship between population density and tuberculosis cases in Bekasi Regency 2017 – 2021

quadrant III (low-low) because it has low cases and is surrounded by districts that have low cases as well, if it is associated with population density.

Then, in 2019, there are four statistically significant sub-districts: Suka Karya, West Cikarang, South Tambun, and Setu. This year, there was an increase in sub-districts included in the high-high cluster, namely South Tambun District. Suka Karya, Cikarang Barat, and Tambun Selatan sub-districts have positive spatial autocorrelation, while Setu Subdistrict has negative spatial autocorrelation. Cikarang Barat and Tambun Selatan sub-districts are in Quadrant I (high-high) because if it is associated with population density, tuberculosis cases in the region are high and surrounded by areas with high cases. On the other hand, Suka Karya Subdistrict is in Quadrant III (low-low) because it has low tuberculosis cases and is surrounded by areas with low cases when connected with population density. Setu Subdistrict has a negative spatial autocorrelation and is in quadrant II (low-high) because it has relatively lower cases than the surrounding area.

In 2020, the high-high cluster is increasing, with four statistically significant sub-districts, and 3 of them are in quadrant I (high-high). The sub-districts in quadrant I are Cikarang Barat, Cibitung, and Tambun Selatan, which shows that the area has high cases surrounded by areas with high cases also if it is related to population density. The existence of this cluster seems to endanger Setu District in quadrant II (low-high) because this area still has low cases but is surrounded by areas with high cases when connected with population density.

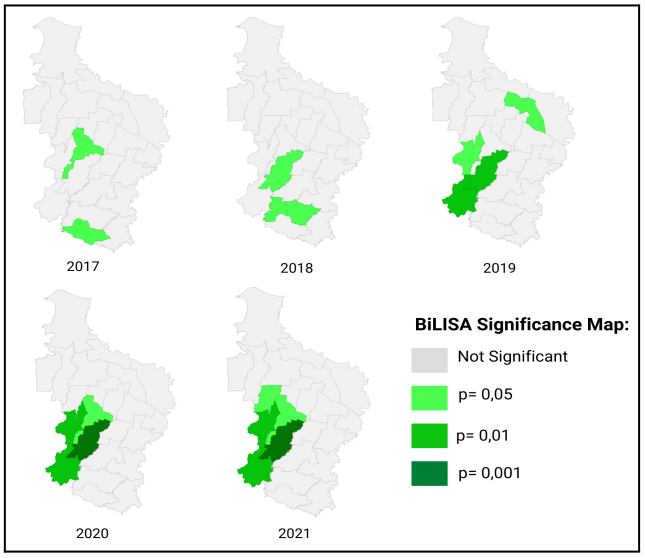

Figure 2. Map of the significance of the relationship between population density and tuberculosis cases in Bekasi Regency in 2017 - 2021

Finally, in 2021, there is an increase in high-high clusters to 5 statistically significant sub-district areas, namely Cikarang Barat, Cibitung, Tambun Selatan, Tambun Utara, and Setu. The addition comes from Setu and North Tambun Districts. In the previous year, the Setu sub-district still had a low number of cases but was surrounded by areas with high cases. In 2021 Setu District experienced an increase in cases like the surrounding area. North Tambun Sub District in previous years did not show the significance of the pattern of spreading cases. However, in 2021, the surrounding area affected the district and became significant in the high-high cluster.

DISCUSSION

Based on the results of the researchers, it was found that there was a significant positive spatial correlation between population density and tuberculosis cases in Bekasi Regency from 2017 to 2021 (p-value < 0.05). The relationship between population density and tuberculosis cases in Bekasi Regency forms a pattern that groups based on the cluster.

Furthermore, the results show that densely populated sub-districts tend to have high tuberculosis cases. Areas with high population density can potentially increase the risk of infection and facilitate disease transmission. People living in densely populated areas are easier to interact with tuberculosis sufferers so that the air mixed with droplets of tuberculosis sufferers can be more easily inhaled by healthy people [13]. In line with this finding, a study found statistically significant positive spatial autocorrelation where high tuberculosis cases were in densely populated areas [14]. Other research found that spatial autocorrelation between population density and tuberculosis is also closely related to AIDS cases in the region. On the contrary, another study suggested no significant spatial relationship between tuberculosis cases and population density [10]. In the Central Java region, BTA tuberculosis (+) is not only caused by population density, but other risk factors may be spatially significant but not included in the study.

Then, based on the significance of LISA, in 2017, Cibitung District significantly had cases, and the population density was quite high and running in harmony, where an increase in the number of cases also accompanied the increase in population density. Geographically Weighted Regression (GWR) analysis shows that an area's high population density positively correlates with the prevalence of tuberculosis in Java. On the other hand, Cibarusah has a low population density, and the tuberculosis cases found are also low and statistically show a meaningful relationship. Similarly, when a region has a low population density, the cases of tuberculosis found are also low [17].

In 2018, tuberculosis cases in West Cikarang were quite high, supported by a fairly high population density and statistically significant. We found a similar thing: areas with high population density also tend to have many tuberculosis cases [13]. In the study, the more densely populated the region, tuberculosis cases increased.

On the other hand, in 2018, significantly, Serangbaru had a low population density, and the tuberculosis cases found were also low. Whereas in the previous year, the area included in this cluster was Cibarusah. Research in Kebumen also found that every year, the areas included in the low-low cluster change [18]. When initially the area is densely populated, then experiences a decrease in density at a time, it also tends to be followed by a decrease in tuberculosis cases in the region [17].

Furthermore, in 2019, there was diffusion where clusters with tuberculosis cases and high population density increased to Cikarang Barat and Tambun Selatan. Then, in the same year, Setu Subdistrict tended to have a low population density and a fairly high number of tuberculosis cases. Still, compared to other surrounding areas, the cases tended to be lower. In Yogyakarta, areas with low densely populated but have quite high cases. Statistically, a significant correlation was found between population density and tuberculosis [19]. This condition lasted until the following year when Setu persisted with fewer cases of population density than its neighboring regions. However, that year, Cibitung experienced a significant increase in cases due to population density. Eventually,

the high-high cluster in the region became three districts. Research in China also found clusters (groupings) of regions with high tuberculosis cases, one of which was influenced by high population density [8].

Finally, in 2021, the spatial diffusion of cases in a high cluster of tuberculosis cases extends to Setu and North Tambun. From the movement of this pattern of spread of cases, it appears that the spread of tuberculosis is closely related to conditions in the surrounding area. When a region has low cases, but neighboring regions have a high prevalence of cases, especially related to infectious diseases, the region will gradually be affected, and cases will increase. Especially when there are risk factors that support the spread of the case, one of which is population density. Population density affects a person's likelihood of encountering tuberculosis sufferers, so densely populated areas tend to have a high rate of the case spreading when there is a high case of tuberculosis. In addition, areas with high population density also tend to have inadequate sanitation and poor hygiene, thereby accelerating the spread of tuberculosis [6]. Furthermore, this also affects the quality of health services obtained by sufferers. Where the area is densely populated, the possibility of the quality of health services is also limited [20].

Overall, there is an increase in territory included in the high-high quadrant every year. In 2017 and 2018, there was only one region with a high-high quadrant, but in 2019 it increased to two regions, then in 2020 to three regions, and 2021 to five regions. This is because the number of tuberculosis cases in neighboring regions influences the number of tuberculosis cases in a region. Furthermore, the more densely populated the region, the higher the number of tuberculosis cases [21]. This phenomenon encourages regions with low tuberculosis cases adjacent to high-high quadrant regions to be affected and eventually join the quadrant. Contrary to Pradana and Santosa's finding (2019), the tuberculosis group spread in Kebumen. Still, areas with high-high quadrants tend to fluctuate.

CONCLUSION

Based on this study, there was a positive spatial autocorrelation in the incidence of Tuberculosis, which was influenced by population density in Bekasi Regency from year to year (2017-2021). The spread of tuberculosis based on population density from 2017 to 2021 shows a clustered spread pattern. Furthermore, a significant relationship was found between population density and tuberculosis cases in Bekasi Regency from 2017 to 2021. If you look at the cluster mapping, which was in the high-high category in 2017, there was one sub-district area, and in 2018, there was one area. Then in 2019, there were two districts with the high-high category and one with the low-high category. In 2020 there are three districts with the high-high category, and in 2021 there are five districts with the high-high category. Clusters with the high-high category are increasing due to the high spread of tuberculosis cases. For this reason, Bekasi Regency Health Office and related stakeholders in TB disease control will focus on areas with high and low cases so that cases in these areas are not carried over to as high as the surrounding area.

REFERENCES

1. Ministry of Health. National guidelines for tuberculosis medical services. Jakarta: Ministry of Health; 2020. Available from: [Website]
2. WHO. Global tuberculosis report 2020. Vol. XLIX, Baltimore Health News. 2020. Available from: [Website]
3. Ministry of Health of the Republic of Indonesia. Indonesia's health profile in 2021. Jakarta: Ministry of Health of the Republic of Indonesia; 2021. Available from: [Website]
4. West Java Provincial Health Office. Open data west Java. 2021. Available from: [Website]
5. Hartanto TD, Saraswati LD, Adi MS, Udiyono A. Spatial analysis of the spread of pulmonary tuberculosis cases in Semarang City in 2018. Public Health Journal. 2019;7(4):2356–3346.
6. Sasmita, Junaid, Ainurafiq. Spatial pattern of incidence of positive BTA pulmonary TB in the Puuwatu public health center in 2013-2015. Scientific Journal of Public Health Students. 2017;2(6):1–10.
7. Rohman H. Spatial patterns of the spread of pulmonary tuberculosis cases against population density. Pros: National Seminar on Medical Records Health Information SNARS; 2020.
8. Yang DL, Li W, Pan MH, Su HX, Li YN, Tang MY. Spatial analysis and influencing factors of pulmonary tuberculosis among students in Nanning, during 2012–2018. PLoS One. 2022;17(5):1–14.
9. Putri ST, Sari DK. Spatial analysis of the spread of tuberculosis disease in Sukabumi City in 2018 and 2019 using the moran index. FTSP Series 2: National Seminar and Final Project Dissemination 2021.
10. Rahmawati H, Rahmaniati M. Spatial analysis of new cases of BTA Tuberculosis (+) on population density in Central Java in 2016-2018. Journal of Public Health Sciences. 2020;9(03):137–43.

11. Bekasi Regency Health Office. Bekasi Regency health profile 2021. Cikarang: Bekasi District Health Office; 2021. Available from: [Website]
12. Grekousis G. Spatial analysis methods and practice: describe–explore–explain through GIS. Vol. 66, Journal of Spatial Science. Cambridge: Cambridge University Press; 2020.
13. Srisantyorini T, Nabilla P, Herdiansyah D, Dihartawan, Fajrini F, Suherman. Analisis spasial kejadian tuberkulosis di wilayah DKI Jakarta tahun 2017-2019. Journal Kedokteran dan Kesehatan. 2022;18(2):131–8.
14. Gwitira I, Karumazondo N, Shekede MD, Sandy C, Siziba N, Chirenda J. Spatial patterns of pulmonary tuberculosis (TB) cases in Zimbabwe from 2015 to 2018. PLoS One. 2021;16(4):1–15.
15. Harling G, Castro MC. A spatial analysis of social and economic determinants of tuberculosis in Brazil. Health Place. 2014;25:56–67.
16. Putra IGNE, Rahmaniati M, Sipahutar T, Eryando T. Modeling the prevalence of tuberculosis in Java, Indonesia: an ecological study using geographically weighted regression. Journal of Population and Social Studies. 2022;30:741–63.
17. Mahara G, Karki M, Yang K, Chen S, Wang W, Guo X. Space-time cluster analysis of tuberculosis incidence in Beijing, China. Journal of Tuberculosis Research. 2018;06(04):302–19.
18. Pradana KA, Santosa PB. Spatial autocorrelation analysis of tuberculosis cases (2016-2018) in Kebumen. KnE Engineering. 2019;2019:150–7.
19. Ardiyanti M, Sulistyawati, Puratmaja Y. Spatial analysis of tuberculosis, population and housing density in Yogyakarta. Epidemiology and Society Health Review. 2021;3(1):28–35.
20. Fatikha AN, Martini M, Hestiningsih R, Kusariana N. Spatial analysis of a tuberculosis incidence in Magelang City in 2021. Disease Prevention and Public Health Journal. 2021;16(1):37–46.
21. Zebua HI, Jaya IGNM. Spatial autoregressive model of tuberculosis cases in Central Java Province in 2019. CAUCHY Jurnal Matematika Murni dan Aplikasi. 2022;7(2):240–8.