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Spatial Pattern of Covid-19 In West Java and DKI Jakarta

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ABSTRACT: This study aims to analyze the spatial pattern of COVID-19 in West Java and DKI Jakarta and identify areas with high case concentrations using spatial analysis methods. The data used is the number of COVID-19 cases. Moran's I analysis was conducted to determine spatial autocorrelation, while Local Indicators of Spatial Association (LISA) was used to identify local spatial patterns. This study used COVID-19 case data from all districts/cities in West Java and DKI Jakarta as the unit of analysis. Moran's I analysis showed a strong positive spatial autocorrelation with a value of 0.661, indicating that areas with a high number of cases tend to cluster with other areas that also have a high number of cases. The results of the LISA analysis identified Jakarta, Bekasi, and Depok as areas with the High-High (HH) category, which means there is a high concentration of cases. Meanwhile, Bekasi Regency is categorized as Low-High (LH), which indicates a low number of cases even though it borders a high-incidence area.

KEYWORDS: Covid-19,LISA, Moran's I, spatial pattern

I. INTRODUCTION

In December 2019 in Wuhan Cuty, Hubei Province, China, a new virus was discovered that spread from wild animals to humans, and was reported to cause pneumonia. The first place the virus was found was around the Huanan seafood wholesale market.Next the virus is called *Severe Acute Respiratory Syndrome Coronavirus 2* (*SARS-CoV-2*) which is currently known as COVID-19.This disease developed very rapidly and causing pandemics throughout the world [1], [2], [3].

In Indonesia, the first case of COVID-19 was discovered on March 2, 2020, with the discovery of two confirmed positive sufferers from Jakarta [4]. This incident began with the infection of two Indonesian citizens who had direct contact with a Japanese citizen infected with COVID-19. In a short time, the spread of COVID-19 in Indonesia has increased, with the most COVID sufferers in Indonesia being found in the province West Java and DKI Jakarta [5]. Kompas Daily reported as of December 8 2021, a total of 4,258,340 cases of COVID-19 were recorded. DKI Jakarta is the province with the most COVID-19 cases, followed by West Java, Central Java and East Java [6].

DKI Jakarta and West Java province are densely populated provinces with high mobility, allowing the COVID-19 virus to spread rapidly in both provinces. To facilitate minimizing and controlling the spread of COVID-19 in these two provinces, it is necessary to understand the pattern of COVID-19 spread in these two provinces. The pattern of COVID-19 distribution can be seen by observing the spatial pattern of the disease. Spatial patterns are how geographical phenomena are distributed and how they compare with other phenomena. Spatial patterns can be shown how objects are placed or arranged on the earth's surface. Every change in spatial patterns illustrates spatial processes influenced by cultural and environmental factors [7]. there are three types of spatial patterns: random, clustered, and uniform [8] [9].

Apart from paying attention to the spatial pattern of Covid 19 distribution, it can also be known through spatial autocorrelation. Spatial autocorrelation is a technique in spatial analysis to measure the level of relationship between observational objects influenced by regions [10]. Spatial autocorrelation makes it easy to identify relationships between attributes of adjacent regions and whether attribute values in a particular region form a particular pattern based on their geographic proximity [11]. In general, spatial autocorrelation is divided into two, namely global spatial autocorrelation and local spatial autocorrelation. Global autocorrelation aims to detect overall spatial patterns, while local spatial autocorrelation can specifically analyze highly correlated and low correlated regions. Methods that are often used to identify global spatial autocorrelation are the Moran's I Test, and for local spatial autocorrelation using LISA - Local Indicators of Spatial Association.

This study aims to identify spatial patterns of COVID-19 transmission in West Java Province and Jakarta. By understanding these spatial patterns, it is hoped that relevant agencies can formulate appropriate policies to address the spread of COVID-19 in their regions.

Research previously, there had been a lot of Covid-19 distribution, including: [12] examining the spatial dependence of COVID-19 infections in mainland China with Moran's statistics and using several types of spatial neighborhoods. The results of the study showed that most models, except for the medical care-based connection model, showed a significant spatial association of COVID-19 infections since around January 22, 2020. Another study [13] used the Moran Index and the Local Indicator of Spatial Autocorrelation (LISA) to see the spatial autocorrelation of the spread of COVID-19 in DKI Jakarta. The results of this study were the existence of spatial autocorrelation in the pattern of the spread of COVID-19 between villages and spatially the distribution pattern was clustered.

II. RESEARCH METHOD

The data used is secondary data obtained from the West Java and DKI Jakarta Provincial Health Services in 2021. The data used is confirmed positive COVID-19 data in districts/cities of West Java and DKI Jakarta Provinces. This study covered 33 units, namely 33 districts/cities in West Java and DKI Jakarta Provinces.

1) Create a COVID-19 Distribution Map using thematic maps
2) determine global autocorrelation with moran's I

According [7] Moran's I is a test used to identify autocorrelations between observation regions globally.

Test hypothesis:

$H_0: I = 0$ (no autocorrelation between regions)

$H_1: I \neq 0$ (there is autocorrelation between regions)

The test statistics used were as follows.

$$Z = \frac{I - E(I)}{\sqrt{var\ (I)}}$$

Where

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\left(\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}\right) \sum_{i=1}^{n} (x_i - \bar{x})^2}, \text{ and } E(I) = I_0 = -\frac{1}{n-1}$$

I : Moran's index

x_i : the data for the i-th region variable (i=1,2,…,n)

x_j : the data for the j-th region variable (j=1,2,…,n)

$\bar{x}$: variable average x

n : number of incident locations

w_{ij} : elements of the spatial weighting matrix

var (I): the variance of Moran's I

Next, based on the value I of the spatial pattern formed, presented in Table 1, below

Table 1. Spatial patterns formed based on Moran's I value

Moran	***Description***
I > 0	Clustered Pattern
I < 0	Uniform Pattern
I = 0	Random Pattern

Source: [14]

3) Determine Moran's Scatter plot

The grouping and distribution patterns between regions can be presented using the Moran Scatterplot. The Moran Scatterplot shows the relationship between the observed values in a region and the observed values from the regions neighboring the region concerned

Quadrant II Low-High	Quadrant I High-High
Quadrant III Low-Low	Quadrant High-Low

Figure 1. Moran's I Scatterrplot [7]

4) Perform local autocorrelation with local indicator of spatial autocorrelation (LISA)

Local Indicator of Spatial Autocorrelation (LISA) required for know region and his neighbor yang have value above the joint average *(hotspot)* or below the joint average *(coldspot)* with source from Index Moran.

With Moran's I Scatter, areas that have positive spatial autocorrelation can be identified, namely those located in quadrant I (high-high) or quadrant III (low-low), as well as if many points are located in quadrant II (low-high) or quadrant IV (high-low) indicates negative spatial autocorrelation.

5) Result interpretation

III. RESULTS AND DISCUSSION

A. Thematic Map of the Distribution of Covid-19 in West Java and DKI Jakarta

Using Geoda software, the map of the distribution of COVID-19 in DKI Jakarta and West Java Province in 2021 can be seen in Figure 2

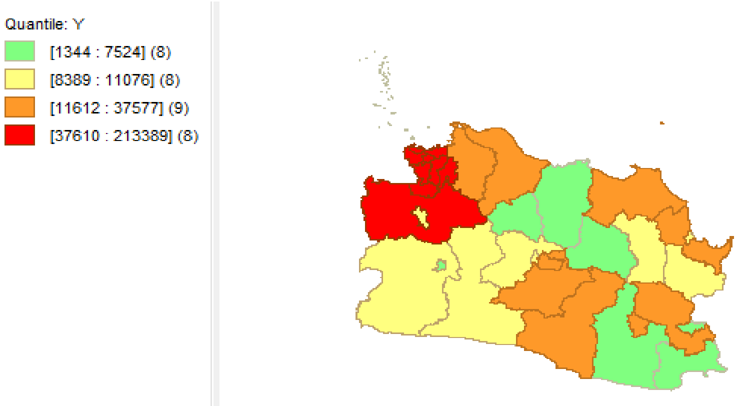

Figure 2. Distribution of Covid-19 in West Java and DKI Jakarta

The red districts/cities group is a group of high COVID-19 incident areas, namely West Jakarta, Central Jakarta, South Jakarta, East Jakarta, North Jakarta, Bogor Regency, Bekasi City and Depok City. The yellow district/city group is a group of areas where COVID 19 occurred, namely West Bandung Regency, Kuningan Regency, Majalengka Regency, Sukabumi Regency, Cianjur Regency, Bogor City, Cimahi City and Cirebon City. The orange district/city group is a group of vulnerable COVID-19 incident areas, namely Bandung Regency, Bekasi Regency, Ciamis Regency, Cirebon Regency, Garut Regency, Indramayu Regency, Karawang Regency, Bandung City and Tasikmalaya City. The green district/city group is the lowest COVID 19 incident area group, namely the Thousand Islands, Banjar City, Sukabumi City, Pangandaran Regency, Purwakarta Regency, Subang Regency, Sumedang Regency and Tasikmalaya Regency.

The yellow city of Bogor on the map while the red neighboring area shows higher COVID-19 cases in neighboring areas, this is due to stricter policies in controlling COVID-19, such as the implementation of health protocols and a higher level of community compliance compared to the surrounding area. The city of Bogor has lower density or more controlled population movements, so the virus is more limited. Apart from that, Bogor City has a health worker system yang better at detecting, reporting and managing COVID-19 cases so that transmission can be controlled [15]

The number of COVID-19 cases in Sukabumi City is lower than the surrounding area, because Sukabumi City has a smaller population compared to the surrounding area so the potential for the spread of the virus is more limited. Sukabumi City also implements health protocols with a better case detection and isolation system, so that the distribution rate tends to be low compared to the surrounding area compared to the surrounding area[16]

B. MORAN'S I

By using Moran's I, the distribution pattern of Covid-19 in West Java Province and DKI Jakarta can be determined. The calculation results obtained a value of I=0. 0.661, which showed a positive spatial autocorrelation so that according to table 1 the distribution pattern of Covid 19 in the districts/cities in the two provinces grouped. Districts/cities with high Covid cases will be close to districts/cities with high cases, and vice versa, districts/cities with low Covid cases will be close to areas with low Covid cases. Next, to see how the grouping of these areas can be seen based on the results of the Moran scatter plot

C. Moran Scatter plot

Before creating a Moran scatterplot, the first thing to do is create a spatial weighting matrix using the queen contiguity method. The principle of queen contiguity is that a unit or region is considered a neighbor of another region if both have shared sides or angles.

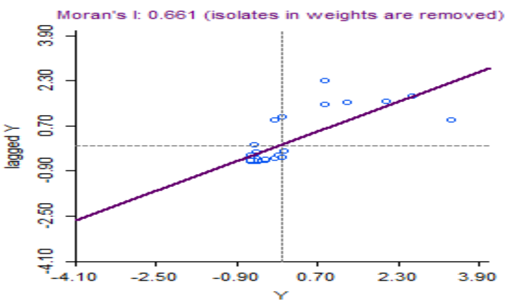

Figure 3. Moran Scatterplot

Spatial Pattern of Covid-19 In West Java and DKI Jakarta

From figure 3, information was obtained on Covid 19 cases in districts/cities in the provinces of Java Baraat and DKI Jakarta grouped into 4 quadrants. Results pattern of relationship between the number of COVID-19 cases in a particular region and the average number of cases in neighboring regions. Presented in Table 2.

Table 2. Districts/citiesby quadrant in the Moran Scatter Plot

Quadrant	Districts/cities
I	South Jakarta, East Jakarta, Central Jakarta, West Jakarta, North Jakarta, Bekasi City, Depok City
II	Bekasi, Bogor City
III	Bandung, West Bandung, Ciamis, Cianjur, Cirebon, Garut, Indramayu, Karawang, Banjar City, Cimahi City, Cirebon City, Sukabumi City, Tasikmalaya City, Kuningan, Majalengka, Pangandaran, Purwakarta, Subang, Sukabumi, Sumedang, Tasikmalaya,
IV	Bogor, Bandung City

Source: data processed

Based on Table 2. areas in the quadrant *high-high* (HH) such as South Jakarta, East Jakarta, Central Jakarta, West Jakarta, North Jakarta, East Jakarta City and Depok City have a high number of COVID-19 cases, which are also close to other areas with a high prevalence of cases. This trend can be explained by several factors, one of which is high population density, because the area is a residential center with intense economic activity. In addition, high population mobility between regions can also increase the risk of spreading the virus. The transportation system integrated, such as KRL, MRT and TransJakarta, help accelerate population movements between regions, especially in neighboring areas. The combination of these factors leads to regions in categories *high-high* (HH) experienced a pattern of concentrated and mutually reinforcing spread of COVID-19 [17]

Districts/cities in the quadrant *low-high* (LH), such as Bekasi Regency and Bogor City, have lower COVID-19 cases than neighboring areas with a higher number of cases. One of the main factors leading to this situation is the demographic characteristics of this region. The region is large and has a relatively low population density compared to the cities in the quadrant *high-high* (HH) [18]. Additionally, Increasing green open spaces can reduce the risk of infection compared to urban and densely populated areas. Another factor is the different patterns of population movement. Although Bekasi Regency and Bogor City are Jakarta's buffer areas, many residents worked and moved from home during the pandemic, reducing the possibility of face-to-face interaction [19]. In addition, the existence of administrative boundaries and regional policies, such as entry and exit restrictions in some areas and close supervision of immigrants from areas with high infection rates, can help contain the rate of spread of the virus. The combination of these factors causes Bekasi Regency and Bogor City to continue to experience a low number of cases even though they are located close to areas with high transmission rates [20].

Districts/cities in the quadrant *low-low* (LL) such as Bandung, West Bandung, Ciamis, Cianjur, Cirebon, Garut, Indramayu, Karawang, Banjar City, Cimahi City, Cirebon City, Sukabumi City, Tasikmalaya City, Kuningan, Majalengka, Pangandaran, Purwakarta, Subang, Sukabumi, Sumedang, Tasikmalaya have low COVID-19 cases and are surrounded by other districts with a low number of cases. One of the main factors contributing to this status is lower population density compared to the Jakarta area, which results in more limited human interaction and a lower risk of virus transmission. In addition, the region has less economic activity than major cities such as Jakarta and Bekasi, resulting in lower population mobility, which also helps contain the rate of spread of COVID-19. Spacious countryside and leafy open spaces also help reduce close contact between people. In addition, public awareness and compliance with health protocols in several regions is already very high, especially regarding distancing and limiting social activities.. The combination of these factors means that regions in the LL quadrant have fewer cases and are less affected by regions with higher case rates [18] .

Districts/cities in the quadrant *high-low* (HL), such as Bogor Regency and Bandung City, experienced a high number of COVID-19 cases even though they were surrounded by areas with a relatively low number of cases. One of the main factors behind this situation is the strong mobility of the population in these two cities [21].The city of Bandung is an educational, tourist and commercial center in West Java Province which attracts many immigrants from various regions, thereby increasing the risk of spreading the virus. Likewise with Bogor Regency, which has a high number of daily passengers, especially workers in the capital. In addition, the existence of public transportation centers, such as stations and bus terminals, can speed up movement between humans and neighboring areas and bring viruses to these areas. Meanwhile, surrounding areas such as Bandung City and Bogor Regency, which have more rural areas and green open spaces, tend to have lower cases because community interaction is more limited. These factors cause a high number of cases in the cities of Bandung and Bogor, even though the number of cases in neighboring areas is low.

Spatial Pattern of Covid-19 In West Java and DKI Jakarta

Based on the results of Moran's I analysis, it was previously shown that there was a positive spatial autocorrelation in the spread of COVID-19 cases in West Java and DKI Jakarta in 2021. To understand how these clustering patterns occur at the local level, analysis is needed that can identify specific locations that are high case clusters (*hot spots*) or low cases (*cold spot*).

Therefore, method *Local Indicators of Spatial Association* (LISA) is used to measure the extent to which a region has a significant relationship with the surrounding region. Through the LISA cluster map, it can depict spatial patterns which help in understanding how the spread of COVID-19 occurs in various areas in districts/cities in West Java and DKI Jakarta

D. LISA

LISA is a method used to identify and analyze spatial patterns in data. LISA measures the extent to which a location has significant associations with other nearby locations, which can reflect clustering patterns in data distribution. Using this method, we can identify areas with environmental values different, such as high value (*hot spots*) or low value (*cold spot*). The results of the LISA analysis can be visualized as a LISA cluster map, showing areas with significant spatial patterns.

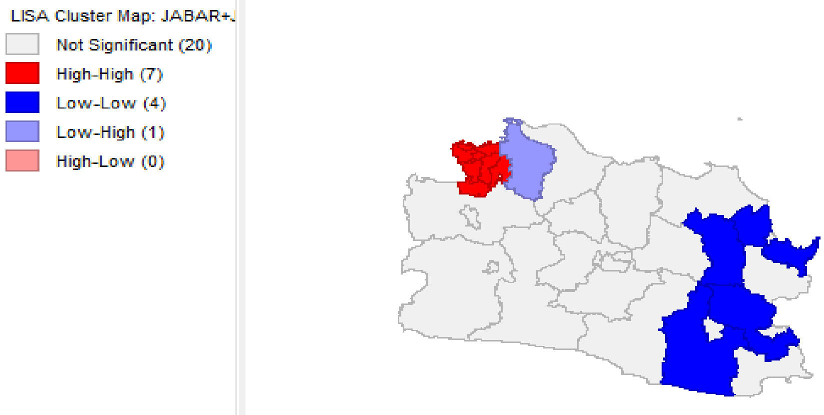

Figure 4. LISA *Clusters* districts/cities map in West Java and DKI Jakarta

Based on Figure 4. there are 20 regions where spatial autocorrelation is not significant and there are no regions with a high-low category. 7 regions are in the H-H category, namely hot spots for the spread of Covid-19. These regions are the cities of Bekasi, Depok, and all cities in DKI Jakarta. The high spread of COVID-19 in these areas is influenced by high population mobility, especially in cities like Jakarta and Depok, which serve as economic centers and buffer zones for Jakarta. Intense mobility, both for work and business purposes, increases the risk of COVID-19 transmission between regions, resulting in persistently high cases in surrounding areas[17].

There are four regions in the L-L category, which are considered cold spots for the spread of COVID-19. These regions are: Cirebon, Ciamis, Majalengka and Tasikmalaya. Several factors lie behind this trend, including that the population density in these districts is lower than in urban areas such as Bandung and Jakarta. Apart from that - districts such as Cirebon, Ciamis, Majalengka and Tasikmalaya have many rural and hilly areas which naturally limit inter-regional mobility. With a more dispersed population and large areas, the spread of COVID-19 will be slower than in dense urban areas [18] .

Only 1 region with category L-H, namely Bekasi district. There are several factors behind this trend, including the fact that Bekasi Regency has more distinctive characteristics as a semi-urban area compared to the DKI Jakarta area [22]. Bekasi Regency borders areas with high infection rates, such as Bekasi City and DKI Jakarta. However, some areas in Bekasi Regency have lower population densities compared to these cities. More limited access to public transportation compared to DKI Jakarta and Bekasi City can also reduce population mobility and limit exposure to high-risk areas. Although Bekasi Regency has a large area, its population density is lower compared to neighboring areas. This caused the spread of the virus in Bekasi Regency to become more controlled.

IV. CONCLUSION

The spatial pattern of COVID-19 spread in the districts /cities of West Java Province and DKI Jakarta shows a significant spatial pattern, with a tendency for positive spatial autocorrelation. Areas with high cases are adjacent to neighbors with high cases, and areas with low cases are also adjacent to low cases. Low-High (L-H) areas such as Bekasi Regency are areas with low COVID-19 cases but border areas with high incidence, which can be explained by lower population density and limited access to public transportation. Local governments in Jakarta, Bekasi City, and Depok City need to tighten social restriction policies and increase the effectiveness of health protocols in areas with high cases. In addition, increasing access to vaccination for residents who have not yet received the full dose of the vaccine and educational campaigns regarding compliance with health protocols are needed to prevent an increase in cases in the next wave of the pandemic.

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