The Distribution Pattern of Covid-19 in Indonesia: Study Using Spatial Autocorelation

Mahmudah[1], R. Azizah[2], Nunik Puspitasari[2], Warih Kusumaningtyas[3], Mohd. Talib Latif[4], Cendana Fitrahanjani[5], Fairuz Haniyah Ramadhani[5]

[1]Associate Professor, [2]Assistant Professor, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia, [3]Practitioner, Anwar Medika Hospital, Sidoarjo, Indonesia, [4]Professor, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Malaysia and Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia, [5]Researcher, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia

Abstract

COVID-19 is an infectious disease caused by the coronavirus, SARS-CoV-2. The spread of several types of diseases, including COVID-19, is influenced by location or spatial factor. The purpose of this research was to examine the spatial relationship among the spread of COVID-19 in Indonesia. Secondary data is used from the Indonesian Ministry of Health website. The data analyzed was the cumulative number of positive cases of COVID-19 in Indonesia until October 19th, 2020. Spatial Autocorrelation, Moran's Index, and Local indicators of spatial association (LISA) were used to examine these relationships. Geoda software was used in performing spatial statistical analysis. The spread of the cumulative number of COVID-19 cases in Indonesia is spatially related, with a Moran's Index value of 0.251. Four provinces have significant LISA scores, namely South Sumatra, Banten, West Java, and South Sulawesi. South Sumatera is relatively safe since it is located in the an area with relatively low COVID-19 cases. West Java is perilouse with high COVID-19 cases and surrounded by an area with a high number of cases. Banten needs to be vigilant of the high number of cases' possibility since the surrounded area can be the main influence. South Sulawesi has a very high number of COVID-19 cases, which can be the new source of infection for the surrounding areas. The Indonesian government needs to act on a regulation in order to decrease COVID-19 distribution by limiting people's commute between provinces.

Keywords: *COVID-19, Moran's Index, Local indicator of spatial association*

Introduction

Since December 2019, COVID-19 has occurred in Wuhan, and in a short time, has spread throughout China[(1)]. COVID-19 is an infectious disease caused by the coronavirus, SARS-CoV-2, a respiratory pathogen[(2)]. On March 2, 2020, two Indonesian citizens (who live in Depok) were declared positive for the SARS Cov-2 virus. This case was the first case found in Indonesia. The two people with COVID-19 had interacted with Japanese citizens known to have suffered from the disease beforehand[(3)]. The number of COVID-19 cases has spread to almost all Indonesia regions consist of 34 provinces. At the end of March, the number of confirmed positive cases of COVID-19 in Indonesia reached to 1,528 cases. This figure increased to 26,473 at the end of May, 108,403 at the end of July and 287,035 at the end of September[(4)].

The distribution of several types of diseases is influenced by location or spatial factor. Disease modeling and mapping can assist in disease management through the early detection of high-risk areas. The statistical analysis used is referred to as spatial statistics, which is spatial autocorrelation[(5)]. Spatial autocorrelation can measure the tendency of spatial grouping relationships. There are two indexes commonly used in spatial

Corresponding Author:
Mahmudah
E-mail:mahmudah@fkm.unair.ac.id

autocorrelation, namely Moran's Index and Local Indicators of Spatial Association (LISA). Moran's Index describes spatial relationships globally. The Moran Index cannot provide information on spatial patterns in a particular area. Therefore, LISA is needed; a local index is used to evaluate local spatial grouping trends[5; 6].

Several diseases were analyzed using spatial autocorrelation, including dengue fever[7], leprosy[8], tuberculosis disease[9]. Several studies about the distribution of COVID-19 also utilizing spatial autocorrelation. Research on the spatial modeling of COVID-19 had been carried out in Yogyakarta, Indonesia [10], and the spread of COVID-19 in Indonesia in April 2020 [11]. Research on the distribution of COVID-19 with spatial statistics has also been carried out in several other countries, including China[12], Kuwait[13], South Korea[14], Bangladesh[15]. Modeling and mapping is a spatial statistical approach used to take policies and actions to reduce disease spread.

Based on the description above, this study aimed to examine the spatial relationship of the spread of COVID-19 in Indonesia. In addition, the relationship between the distribution of COVID-19 in a province in Indonesia was also examined in this study.

Materials and Methods

This study uses secondary data obtained from the *Satuan Tugas* COVID-19 (Satgas COVID-19) of the Indonesian Ministry of Health website[4]. The data used in this study was the cumulative number of cases in each province in Indonesia. Indonesia is an archipelago country consists of 34 provinces with different characteristics. Provinces on Java island (Jakarta Capital Special Region, Banten, West Java, Yogyakarta Special Region, Central Java, East Java) are characterized by high population density and mobility. The data used in this article was the data until October 19th, 2020. In addition to data, Indonesia's map and the required attributes were also considered taken into account[16].

The spatial statistics used in this study are spatial autocorrelation, Moran's Index, and LISA. Moran's Index is an index used to determine the presence or absence of a spatial relationship. Moran's Index only looks at the global connection; for this reason, LISA is used, which can provide information on spatial patterns in certain areas. Geoda software was used to perform spatial statistics Moran's Index, then calculated using a form

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Where:

x = the data to be calculated is the index value of moran, xi and xj, where i ≠ j

n = sum of data

w_{ij} = spatial weighting

i = 1,2,...,n

j = 1,2,...,n

$$I_i = \frac{Z_i}{m_2}\sum_{j=1}^{n} w_{ij}z_j$$ ing a formula:

Where:

$$z_i = (x_i - \bar{x})$$

$$m_2 = \sum_{i=1}^{n}\frac{(x_i - \bar{x})^2}{n-1}$$

Results and Discussion

Covid-19 has spread to all provinces in Indonesia. The distribution of positive cumulative cases of Covid-19 until October 19th 2020 has not been evenly distributed. Provinces with a very high number of cumulative cases were Riau, North Sumatra, West Java, the Special Capital Region of Jakarta, Central Java, East Java, East Kalimantan, and South Sulawesi. Provinces with a high cumulative number of cases included Aceh, West Sumatra, South Sumatra, Banten, Bali, South Kalimantan, Southeast Sulawesi, North Sulawesi, and Papua. Provinces with a moderate cumulative number of cases included Riau Islands, Yogyakarta Special Region, West Kalimantan, Central Kalimantan, West Nusa Tenggara, Gorontalo, Maluku, North Maluku, and West Papua. Provinces with a low cumulative number of cases include Lampung, Jambi, Bangka Belitung, North Kalimantan, Central Sulawesi, West Sulawesi, and East Nusa Tenggara.

From the total 364,915 COVID-19 positive cases, it turned out that 288,965 (79.2%) could be cured. East Java had very high cumulative cases, but the proportion/ the cure rate was also very high. Other provinces with a very high cure rate were Bangka Belitung, Bali, West Kalimantan, South Kalimantan, North Kalimantan, Gorontalo, and North Maluku. Provinces with low cure rates are Riau, West Sumatra, Jambi, Lampung, West Java, Papua, Central Sulawesi, and Southeast Sulawesi.

Of the 364,915 positive cases of COVID-19, 12,612 (3.456%) had died. Provinces with very high mortality rates are North Sumatra, South Sumatra, Bengkulu, Central Java, East Java, East Nusa Tenggara, South Kalimantan, and Central Sulawesi. Provinces that have good mortality rates, which are quite low, are Bangka Belitung, West Kalimantan, North Kalimantan, East Nusa Tenggara, West Sulawesi Papua, West Papua, and Maluku. Figure 3 shows in more detail an illustration of the patients' proportion who died from COVID-19.

Moran's Index

Moran's Index value of 0.251 is statistically significant. It was obtained a Z value of 2.1769 and a p-value of 0.044; if an α value of 5% is used, then the p-value is smaller than the α value, which means there is a spatial relationship in the spread of COVID-19 in Indonesia. In the spread of COVID-19, there is a positive spatial autocorrelation; this is indicated by the E [I] value of -0.0345, smaller than the Moran's Index value (0.251). The Moran's Index value is 0.251, indicating that the distribution of COVID-19 has a significant relationship with regions, but the relationship is not too strong. These results were the same as the research results on the spread of COVID-19 in Indonesia using data on the number of cumulative cases of COVID-19 until April 29th, 2020, with the earned value Moran's Index 0.269 (p=0.0004)[12]. This result showed the use of the Moran's Index value Index was relatively stable, even though the analyzed data was different in time. The spread of COVID-19 in Hubei, China, was also spatially related[13]. The cumulative number of confirmed COVID-19 cases in South Korea had a strong spatial autocorrelation with a Moran's Index value of 0.784 (p = 0.0001). Moran's Index Overview, Figure 1 shows the Moran Scatterplot of the cumulative number of confirmed COVID-19 cases in Indonesia.

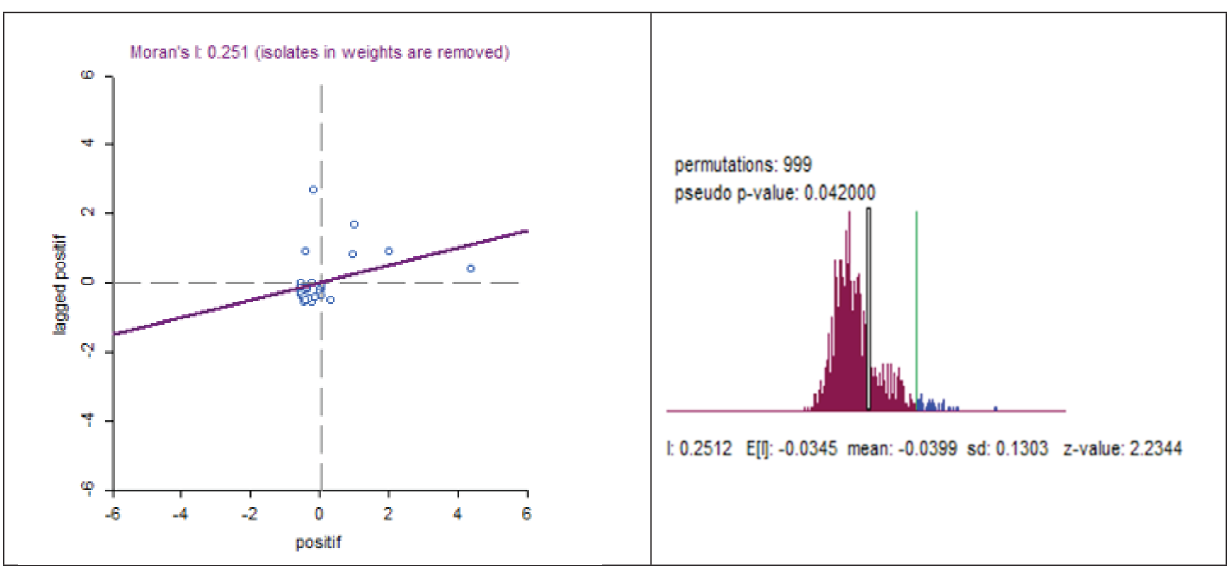

Figure 1. Moran's Scatterplot for The cumulative number of confirmed COVID-19-19 cases in Indonesia on October 19th, 2020

The distribution of provinces in Indonesia based on Moran's Index can be seen in the following table 1. Quadrant I (High-High) was the provinces with a high number of cumulative COVID-19 cases, and the surrounding provinces also had a high cumulative number of COVID-19 cases. Quadrant II (Low-High) was the provinces with a low cumulative number of COVID-19 cases and the surrounding provinces with high cumulative COVID-19 cases. Quadrant III (Low-Low) was the provinces with a low cumulative number of COVID-19 cases and the neighboring provinces with a low cumulative number of COVID-19 cases. Quadrant IV (High-Low) was the provinces with a high cumulative number of COVID-19 cases, and the surrounding provinces with a low cumulative number of COVID-19 cases.

Table 1. Distribution of the cumulative number of confirmed COVID-19 cases in provinces in Indonesia based on the Moran Index (Moran Standart, Moran Lag)

Quadrant II (Low-High) 1. The Special Region of Aceh (-0.26,0.02) 2. The Special Region of Yogyakarta (-0.44,0.93) 3. Banten (-0.2,0.69) 4. North Kalimantan(-0.57,0.02)	Quadrant I (High-High) 1. The Special Capital Region of Jakarta (4.38,0.40) 2. West Java(1.00,1.70) 3. Central Java (0.93,0.84) 4. East Java (1.97,0.93)
Quadrant III (Low-Low) 1. West Sumatra(-0.02,-0.27) 10. Southeast Sulawesi(-0.39,-0.13) 2. South Sumatra (-0.23,-0.55) 11. North Sulawesi (-0.35,-0.45) 3. Bengkulu (-0.56,-0.34) 12. West Sulawesi(-0.56,-0.13) 4. Riau Islands (-0.46,-0.56) 13. Central Sulawesi 5. Lampung (-0.54,0.40) 14. Gorontalo(-0.45, -0.46) 6. Jambi (-0.56,-0.25) 15. North Maluku(-0.5,-0.42) 7. South Kalimantan (-0.01,-0.19) 16. Maluku(-0.42,-0.5) 8. West Kalimantan(-0.54,0.19) 17. Papua(-0.18,-0.42) 9. Central Kalimantan(-0.39,-0.18) 18. West Papua(-0.42,-0.18) ,	Quadrant IV (High-Low) 1. Riau (0.01,-0.19) 2. North Sumatra (0.02,-0.09) 3. South Sulawesi (0.31,-0.51) 4. East Kalimantan (0.02,-0.38)

It can be seen that provinces in Java Island were clustered in Quandrant 1, which consisted of provinces with a high cumulative number of COVID-19 cases followed by high risk from the surrounding areas. This finding was different from the previous research which illustrated the situation on April 29th, 2020 where the high-risked provinces were West Java, Jakarta Special Capital Region, Gorontalo, and South Sulawesi[11]. The density of the population and high mobility allowed COVID-19 to spread quickly. A recent study found a correlation between population mobility (in and out town) and the spread of COVID-19-19 in Jakarta. Based on population mobility data, people entering Jakarta mostly from West Java, Banten, and Central Java[17].

Local Indicator of Spatial Association (LISA)

LISA is a local index used to evaluate the tendency of local spatial groupings. From the 30 provinces analyzed, only four provinces had significant LISA scores. The LISA Index values for four significant provinces are as follows presented in Table 2.

Table 2. LISA Index of Significant cumulative number of confirmed COVID-19-19 cases in Indonesia on October 19, 2020

Province	LISA Index	p-value
West Java	1.7026	0.017
Banten	-0.5364	0.014
South Sumatra	0.1297	0.003
South Sulawesi	-0.1596	0.041

Table 2 result shows that some of the LISA indices have p-values smaller than α, which means a significant spatial relationship in certain areas. It can be concluded that the spread of COVID-19 in Indonesia is related to spatially, locally, and forming clusters. Research in Dhaka city found that the spread of COVID-19 has also significantly formed clusters [15].

In Quadrant I (High-high), West Java was the province that had a significant LISA Index, with an index value of 1.7026 and a p-value of 0.017. The risk of spreading COVID-19 in West Java was perilous. West Java has a very high number of COVID-19 cases, and the provinces around West Java have a very high number of COVID-19 cases, namely The Special Capital Region of Jakarta, East Java, and Central Java.

In Quadrant II (Low-high), Banten had a significant LISA Index, with an index value of -0.5364 and a p-value of 0.014. The cumulative number of COVID-19 cases in Banten is relatively low. However, Banten should be vigilant because COVID-19 cases may become very high in Banten due to the surrounding provinces' influence. This result was because Banten is located around the provinces with many COVID-19 cases, namely DKI Jakarta and West Java.

In Quadrant III (Low-low), North Sumatra had a significant LISA Index, with an index value of 0.1297 and a p-value of 0.003. South Sumatra was safe since South Sumatra had low number of COVID-19 cases and is located around provinces with relatively low numbers of COVID-19 cases (Jambi, Bengkulu and Lampung).

In Quadrant IV (High-low), South Sulawesi had a significant LISA Index, with an index value of -0.1596 and a p-value of 0.041. South Sulawesi Province had a relatively high number of COVID-19 cases. Since South Sulawesi had many COVID-19 cases, the surrounding provinces, namely West Sulawesi, Central Sulawesi, and Southeast Sulawesi had to be cautious. South Sulawesi could be a source of new COVID-19 infections in its region.

The analysis identified several provinces that must be alert to the risk of spreading COVID-19 due to the other provinces surrounding it. Between the nearby provinces, there is a high possibility of population mobilization. At the same time, community mobilization is one indicator of COVID-19 infections[18]. Therefore, it is necessary to have regulations limiting people's mobility and commute both between cities and between provinces.

Conclusions

The spread of the cumulative number of COVID-19 cases in Indonesia is spatially related, with a Moran's Index value of 0.251. Four provinces had a significant LISA index, namely, West Java with a LISA index of 1.7026, Banten with a LISA index of -0.5364, South Sumatra with a LISA index 0.1297, and South Sulawesi with a LISA index of -0.1596.

South Sumatra Province was safe with a relatively low number of COVID-19 cases. Banten should be alert; COVID-19 cases may become very high because of the surrounding provinces' influence. West Java was perilous, the number of COVID-19 cases was very high, and the provinces around West Java had a very high number of COVID-19 cases as well. South Sulawesi had a very high number of COVID-19 cases, which could be a source of new COVID-19 infections for the surrounding areas.

The magnitude of COVID-19 spread influence in a province towards the surrounding provinces should be taken into consideration in regulations making to solve COVID-19 pandemic situation. People's mobility and commute limitation between provinces might need to be applied with full attention to the socio-economic condition of the local citizens.

Ethical Clearance: The study was based on data available in public domain, therefore no ethical issue is involved.

Conflict of Interest: There were no conflicts of interest to declare.

Source of Funding: This research was supported by the Airlangga University, Anwar Medika Hospital, Sidoarjo, and Universiti Kebangsaan Malaysia.

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