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SPATIAL AUTOCORRELATION ANALYSIS ON CORONAVIRUS TRANSMISSION AND POPULATION DENSITY IN EAST JAVA PROVINCE 2020

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ABSTRACT

Coronavirus (COVID-19) is a type of disease that spread widely during 2020. The transmission of this disease is connected by human activity and hygiene which also means that this disease might be related with population density. The goal of this study is to discover the correlation between COVID-19 transmission with population density. The research area used in this study is East Java Province during 2020. The data used for this study are COVID-19 confirmed cases and population density in 2020 East Java Province from Central Bureau of Statistics. Spatial Autocorrelation and Moran's I Methods used in this study discovered that there are some weak correlations (I=0.247) between COVID-19 cases and population density in East Java Province 2020. There are 9 areas with p value ≤0.05. These areas are Trenggalek Regency, Ngawi Regency, Madiun City with p=0.05 significance. Ponorogo Regency, Madiun Regency, Magetan Regency, Gresik Regency, Sidoarjo Regency and Surabaya City with p=0,001 significance. This discovery has some similarities with other studies.

Kata kunci:
COVID-19, kepadatan penduduk, Provinsi Jawa Timur, korelasi

ABSTRAK

Coronavirus (COVID-19) merupakan penyakit yang telah menyebar luas pada tahun 2020. Penyebaran penyakit ini berkaitan dengan aktivitas manusia dan kebersihan yang disimpulkan penyakit ini mungkin memliki kaitan dengan kepadatan penduduk. Tujuan penelitian ini untuk mengetahui hubungan penyebaran COVID-19 dan kepadatan penduduk. Wilayah pengamatan yang digunakan, yaitu Provinsi Jawa Timur pada tahun 2020. Data pengamatan yang digunakan, yaitu kasus terkonfirmasi COVID-19 dan jumlah kepadatan penduduk hingga pada akhir tahun 2020 di Provinsi Jawa Timur yang diperoleh dari Badan Pusat Stastistik. Metode Autokorelasi Spasial dan Moran's I digunakan dalam penelitian ini dan ditemukan bahwa terdapat korelasi lemah antara COVID-19 dan kepadatan penduduk di Provinsi Jawa Timur pada tahun 2020 (I=0.247). Terdapat 9 area dengan p value ≤0.05, yaitu Kabupaten Trenggalek, Kabupaten Ngawi dan Kota Madiun pada p-value=0.05. Kabupaten Ponorogo, Kabupaten Madiun, Kabupaten Magetan, Kabupaten Gresik, Kabupaten Sidoarjo dan Kota Surabaya pada p-value=0.001. Hasil penelitian memiliki kesamaan seperti hasil penelitian-penelitian sebelumnya.

INTRODUCTION

Coronavirus or known as COVID-19 is a respiratory system disease and causes death (1). COVID-19 disease is primarily known spread to through droplets of bodily fluids such as saliva or airborne droplets from an infected person. COVID-19 has spread around the world. COVID-19 disease caused a pandemic at the year 2020 and reached Indonesia in March 2020. The first case for Indonesia was found in Jakarta. Since then, it spread around the country and also reached East Java Province (2).

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By the end of the year 2020, East Java Province had become the second most COVID-19 infectious province in Indonesia (3). According to the statistic results, there were 84,152 people infected with COVID-19 in East Java Province and there were 5,827 confirmed deaths caused by COVID-19. There were 72,135 people infected with COVID-19 and 6,190 were treated (4). This data showed how much the disease spread across the province within less than a year (3).

The spread of SARS-Cov-2 or COVID-19 has greatly impacted on every aspect of human life, starting from health to economy, transportation, education and even social life (2,5). There were many people suffered because of this disease whether they received the disease itself, or the impact on the disease in everyday life. There are also many death cases because of the disease. Which is why the prevention on this disease is necessary (6).

Regencies and cities in East Java Province are quite similar in characteristics and habits (behavior) especially if they are neighboring. However, the number of COVID-19 confirmed cases in regencies and cities were different from each other (5), as an example, Pacitan Regency had 759 people infected COVID-19 and Ponorogo Regency 1,240 people. These areas were neighboring, yet there were significant difference with their confirmed cases. However, there were also neighboring areas that had relatively similar numbers of people infected with COVID-19 like Mojokerto City with 1,026 people, and Pasuruan City with 1,002 people infected (5). In conclusion, there was probably a connection or correlation between neighboring areas in East Java Province (4,7).

This article's purpose is to identify the correlation between people density with confirmed cases of COVID-19 by using spatial autocorrelation bivariate analysis that includes Moran's I and Local Index Spatial Autocorrelation (LISA). Spatial autocorrelation bivariate analysis is used to find if there is any correlation between observed areas with specified characteristics, which can also determine whether there is correlation between the said characteristics (8). Everything is related to everything else, but nearer things are usually more related than distant things (9). Meaning, some areas usually have more influence by directly neighboring with other areas rather than distant areas (10). Spatial correlation calculation is also used to identify which areas have been influenced by its surrounding areas (11). This type of analysis is usually used to determine variables such as infectious disease spread, program successful percentage between areas, etc. (12).

METHODS

The analysis type used in this article is Moran's I bivariate spatial autocorrelation analysis with Queen contiguity to identify the correlation between number of COVID-19 confirmed cases and population density in East Java Province during the year 2020. Population density means population in area per square km of the area itself. The result will be in the form of Moran's I, LISA significant map and LISA cluster map (13). The formula of Moran's index has a complicated form, but the meaning can be simplified with a normalized matrix and a standardized vector. The data used in this article are the COVID-19 confirmed cases in 2020 and population density of each regency or city (9).

Spatial autocorrelation is used to find any specified pattern or system between neighboring observed area with specific variables. If there is specific pattern found, there is spatial autocorrelation (8).

Moran's I is used to measures spatial autocorrelation based on specific locations and specific variables simultaneously (9). Given a set of features and associated attributes, it evaluates whether the pattern expressed is clustered, dispersed, or random. While bivariate means the value or variable observed are more than one. Moran's I calculation results are the Moran's I Index value, z-score and p value to assess the significance of that Index. When the p value is statistically significant, it rejects the null hypothesis (10).

Queen's contiguity matrix is used as weight for Moran's I bivariate, alluding to the chessboard. If region A and region B shares common border, the Queen's contiguity matrix is constructed with WAB=WBA=1 and treats units that share a common border as neighbors. This matrix is usually used in autocorrelation (default weight) (11).

Moran's scatterplot used to interpret Moran's I graphically by using scatterplot model. Moran's scatterplot consists of a plot

with the spatially lagged variable on the y-axis and the original variable on the x-axis (12). The slope of the linear fit to the scatter plot equals Moran's I. Moran's scatterplot shows four quadrants, which represent the areas types.

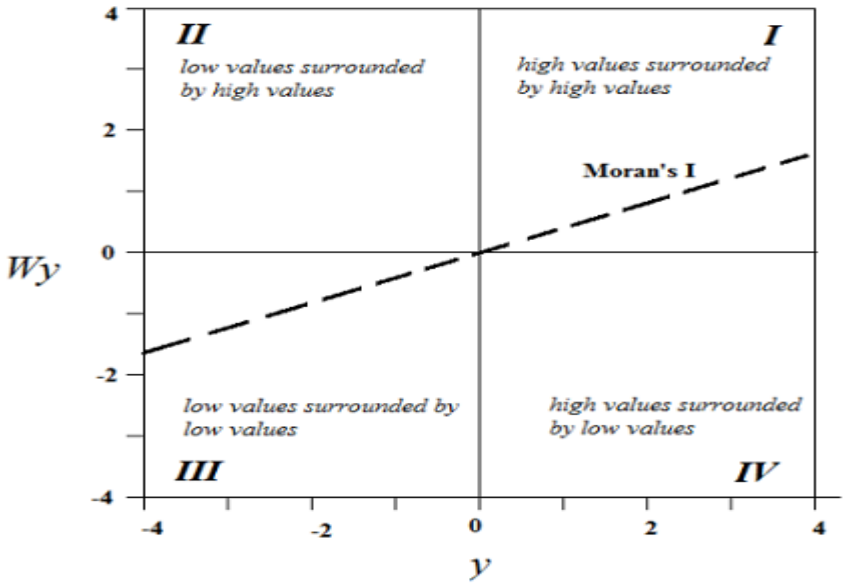

Figure 1. Moran's scatterplot basic

The first quadrant is for High-High areas. These observed areas had high concentrate variables surrounded by high concentrate areas. The second quadrant is for Low-High areas. These observed areas had low concentrate variable surrounded by high concentrate areas. The third quadrant is for Low-Low areas. These observed areas had low concentrate variable surrounded by low concentrate areas. The fourth quadrant is for High-Low areas. These observed areas had high concentrate variable surrounded by low concentrate areas. Every area has their own type of correlation. However, only significant correlation can be used since those areas can reject null hypothesis. The significant areas are determined from their p value.

RESULT

Moran's I

The data used are from Central Bureau of Statistics. These data are obtained for the use of Moran's I, Moran's scatterplot, LISA Significant map and LISA Cluster map. These data contained confirmed cases and population of each region in East Java Province by the end 2020.

Table 1. Confirmed Cases and Population of East Java Province 2020

Regencies/Cities	Confirmed Cases	Population	Population Density (per sq km)
Pacitan Regency	161	553388	422
Ponorogo Regency	467	869894	727
Trenggalek Regency	256	693104	637
Tulungagung Regency	423	1030790	1032
Blitar Regency	658	1153803	916
Kediri Regency	788	1561392	1180
Malang Regency	955	2576596	752
Lumajang Regency	634	1036823	625
Jember Regency	919	2430184	820
Banyuwangi Regency	1484	1604897	295

Regencies/Cities	Confirmed Cases	Population	Population Density (per sq km)
Bondowoso Regency	664	768912	509
Situbondo Regency	575	676703	411
Probolinggo Regency	1102	1155214	679
Pasuruan Regency	1445	1605307	1090
Sidoarjo Regency	6718	2183682	3283
Mojokerto Regency	916	1099504	1559
Jombang Regency	962	1253078	1182
Nganjuk Regency	533	1048799	902
Madiun Regency	125	679888	717
Magetan Regency	439	628609	974
Ngawi Regency	195	829899	571
Bojonegoro Regency	475	1243906	592
Tuban Regency	560	1163614	653
Lamongan Regency	730	1188478	754
Gresik Regency	3348	1285018	1101
Bangkalan Regency	540	970894	1059
Sampang Regency	266	958082	786
Pamekasan Regency	344	863004	1073
Sumenep Regency	426	1081204	563
Kediri City	205	284003	4524
Blitar City	168	139995	2679
Malang City	1862	861414	5808
Probolinggo City	522	233123	4229
Pasuruan City	662	197676	5894
Mojokerto City	576	127279	6553
Madiun City	142	176099	5754
Surabaya City	14931	2874699	8200
Batu	485	203997	1558

Moran's I table consist p value, z-value and determines whether the area is significant or not. The data used are based on COVID-19 confirmed cases and population in East Java Province area. The East Java Province area consists of regencies and cities. Significant regency and cities are determined by whether the p value <0,005.

Table 2. Moran's I Results

Regencies/Cities	*p value*	Significance
Pacitan Regency	0.372	-
Ponorogo Regency	0.0006	Significant
Trenggalek Regency	0.045	Significant
Tulungagung Regency	0.234	-
Blitar Regency	0.357	-
Kediri Regency	0.342	-
Malang Regency	0.078	-

Regencies/Cities	*p value*	Significance
Lumajang Regency	0.096	-
Jember Regency	0.083	-
Banyuwangi Regency	0.275	-
Bondowoso Regency	0.178	-
Situbondo Regency	0.237	-
Probolinggo Regency	0.484	-
Pasuruan Regency	0.458	-
Sidoarjo Regency	0.032	Significant
Mojokerto Regency	0.352	-
Jombang Regency	0.172	-
Nganjuk Regency	0.226	-
Madiun Regency	0.0009	Significant
Magetan Regency	0.0004	Significant
Ngawi Regency	0.045	Significant
Bojonegoro Regency	0.277	-
Tuban Regency	0.476	-
Lamongan Regency	0.287	-
Gresik Regency	0.0004	Significant
Bangkalan Regency	0.394	-
Sampang Regency	0.272	-
Pamekasan Regency	0.475	-
Sumenep Regency	0.327	-
Kediri City	0.127	-
Blitar City	0.439	-
Malang City	0.358	-
Probolinggo City	0.387	-
Pasuruan City	0.252	-
Mojokerto City	0.348	-
Madiun City	0.0003	Significant
Surabaya City	0.0007	Significant
Batu	0.339	-

Moran's Scatterplot

Moran's scatterplot was used on variable confirmed cases of COVID-19 and population density of each regency or city in East Java Province by the end of year 2020. These Moran's scatterplots show that most of East Java Province areas are in the 3rd quadrant which is Low-Low. It means most of East Java Province regencies and cities have low confirmed cases surrounded by areas with low population density.

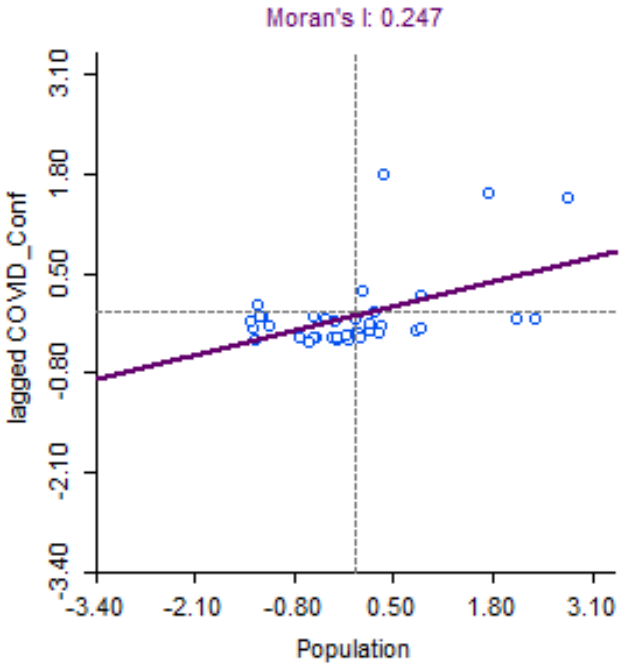

Figure 2. Moran's scatterplot of COVID-19 confirmed cases and population density

Local Index Spatial Autocorrelation (LISA) Significant Map

LISA significant map interprets Moran's I with mapping. LISA significant map shows which areas have significant correlation with the related variable. The significant areas show when the areas have p value <0.05. The significant areas are crucial for rejecting the null hypothesis, which is that the patterns of correlation are random.

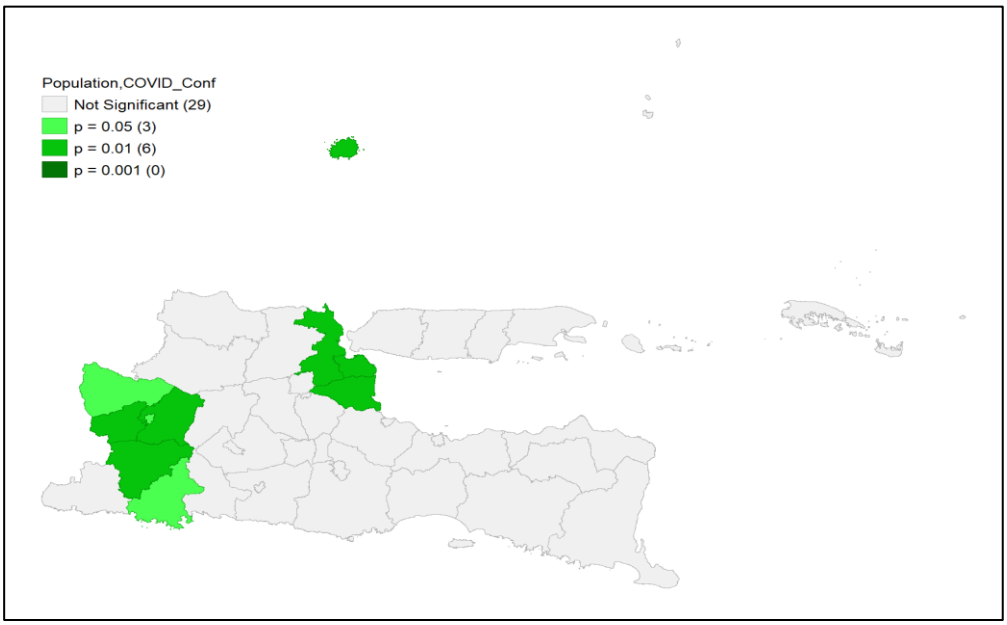

Figure 3. LISA significant map of COVID-19 confirmed cases and population density

Local Index Spatial Autocorrelation (LISA) Cluster Map

LISA Cluster map interprets Moran's scatterplot and Moran's I. The areas are shown in the map only when there are significant areas. The map shows how those significant areas correlate with the neighboring areas. The correlation is based on Moran's scatterplot results.

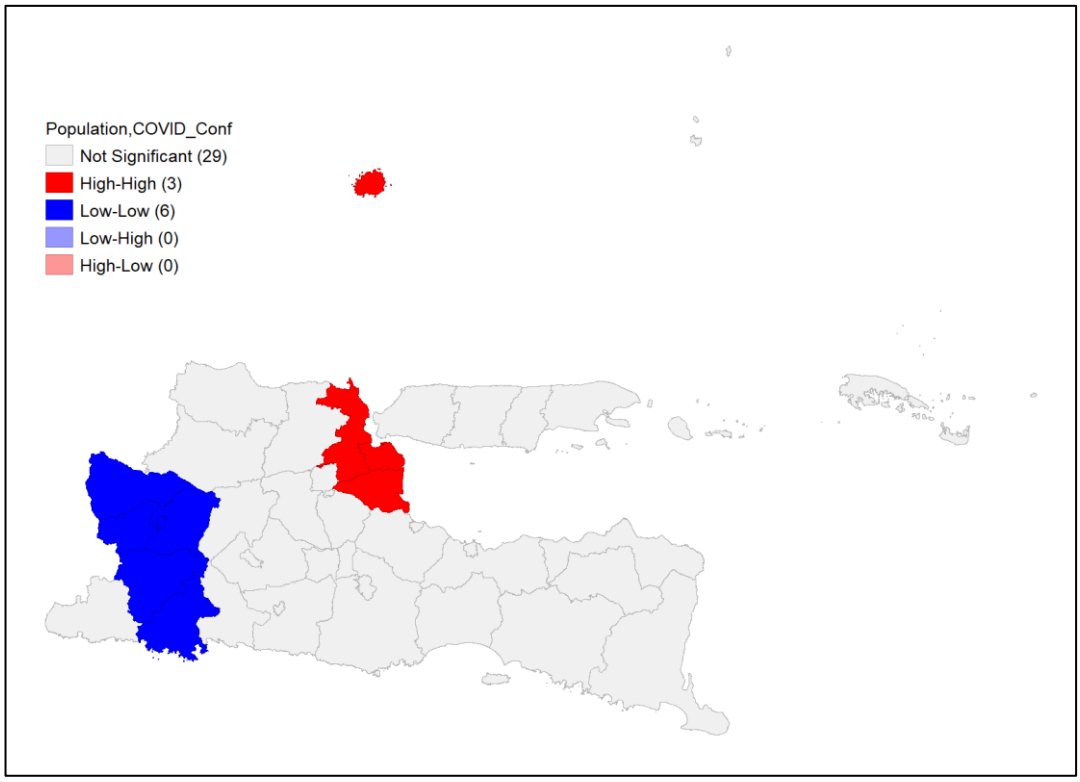

Figure 4. LISA cluster map of COVID-19 and population density

DISCUSSION

Moran's I of COVID-19 confirmed cases and population density on regencies and cities in East Java Province = 0.247 which means most areas are in quadrant I or III and have autocorrelation powers 0,247 (weak correlation). LISA significant map there are nine areas with p value ≤0.05. Those areas are Trenggalek Regency, Ngawi Regency, and Madiun City with significance p=0.05. Ponorogo Regency, Madiun Regency, Mageran Regency, Gresik Regency, Sidoarjo Regency and Surabaya City have significance p= 0.001.

According to LISA cluster map, those significant areas are divided in to two types. Low-Low (LL) type areas means low COVID-19 confirmed cases surrounded by low population density areas. The second type is High-High (HL) areas which means the high COVID-19 confirmed cases surrounded by high population density area are Gresik Regency, Sidoarjo Regency and Surabaya City in High-High type areas. These areas are considered High-High areas due to the number of confirmed cases and population density is high (>1000). Trenggalek Regency, Ngawi Regency, Madiun City, Ponorogo Regency, Madiun Regency, and Magetan Regency are in significant are Low-Low areas. These areas are considered Low-Low areas due to the number of confirmed cases and population density is low (<1000).

An article which studied correlation between COVID-19 cases and population density showed different results from August 2020 to October 2020 in Lebanon (14). However, all results are positive I with p value <0.005 , which concluded there are significant correlation between COVID-19 cases with population density in Lebanon areas 2020. This result has the same conclusion as some of the regencies and cities in East Java Province. The correlation between areas mostly consists with High-High type area. The result can be found the same with this article's conclusion with some of the areas, namely Surabaya City, Gresik Regency and Sidoarjo Regency (14).

Another study concluded that pre-Delta and Delta transmission have strong correlation with population density in Malaysia. Unlike the result from this article, it shows that there is a weak type correlation between COVID-19 transmission and population density. The areas type found in the previous article mostly consist of Low-

Low type areas which is the same in some of this article's findings. Trenggalek Regency, Madiun City, Madiun Regency, Magetan Regency, Ngawi Regency and Ponorogo Regency are in Low-Low type areas, similar with the previous study (15).

A study using regression analysis discovered moderate correlation between COVID-19 transmission with population density in India, which conclusion is almost the same as discovered by this article (16,17). But since the previous study used regression type of analysis, no information exists around types of areas correlation (18).

CONCLUSIONS AND SUGGESTIONS

Conclusion

The correlation between confirmed cases of COVID-19 and population density in regencies and cities in East Java Province shows that there is weak correlation by using Spatial Autocorrelation and Moran's I (I=0,247). LISA significant map concluded there are nine areas with p value ≤0.05. These areas are Trenggalek Regency, Ngawi Regency, Madiun City with significance p=0.05 and Ponorogo Regency, Madiun Regency, Magetan Regency, Gresik Regency, Sidoarjo Regency and Surabaya City with significance p=0,001. Gresik Regency, Sidoarjo Regency and Surabaya City are located in High-High type areas. Magetan Regency, Madiun Regency, Madiun City, Ngawi Regency, Ponorogo Regency, and Trenggalek Regency are in Low-Low type area. These discoveries have some similarity with the previous discoveries which concludes there is correlation between population density with COVID-19 cases. There are also different conclusions from previous discoveries.

Suggestion

Spatial autocorrelation was not an accurate method to search the correlation of COVID-19 transmission and population density. This research suggests to find a more accurate and thorough method with more detailed data to discover more conclusive and certain results.

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