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Spatial analysis and risk factors associated with COVID-19 incidence modeling in Sleman Regency

Joshua Nathanael Sriadi[1] , M Lutfan Lazuardi[2]

Abstract

Purpose: This research aims to identify spatial distribution and risk factors related to the occurrence of COVID-19 in Sleman Regency. **Methods:** This study used the geographical information system (GIS) software to map the spatial distribution of COVID-19 cases. Pearson correlation and linear regression examined the relationship between the selected variables and COVID-19 incidence. The spatial autocorrelation of the COVID-19 cases was carried out using Moran's I and LISA. Geographically weighted regression (GWR) and multiscale GWR (MGWR) were used to examine the local level. **Results:** Multivariate analysis results showed that shopping facilities (coeff. =10.02; p-value <0.001) and population density (coeff. =0.0004; p-value <0.001). The spatial autocorrelation test showed a positive and significant spatial autocorrelation between the presence of public facilities (Moran's I=0.600) and population density (Moran's I=0.495) with the incidence of COVID-19 in Sleman Regency. The MGWR model has been proven to be the most appropriate in describing the incidence of COVID-19 in the Sleman Regency (adj R^2 =0.643; AIC_c =177.14). **Conclusion:** The spatial approach has been used to prevent the spread of COVID-19. For example, micro-based social restriction monitoring efforts and COVID-19 vaccination campaigns can focus more on areas with more shopping facilities and densely populated areas.

Keywords: COVID-19; GWR; MGWR; shopping facilities; population density

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[1]Department of Biostatistics, Epidemiology, and Population Health, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia

[2]Department of Health Policy and Management, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia

Correspondence:
Joshua Nathanael Sriadi
syosuanatanael@mail.ugm.ac.id

INTRODUCTION

Coronavirus Disease 19 (COVID-19) is an infectious disease caused by a new type of Coronavirus. The discovery of this new type of virus began with reports of pneumonia cases of unknown etiology in Wuhan, a city of 11 million people in Central China [1]. The Chinese government then announced that the cause of the unknown pneumonia cases was a new type of Coronavirus named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-Cov-2). Although caused by a virus from the same family, COVID-19 has proven to be more contagious than SARS and MERS [2].

Since being declared a PHEIC, COVID-19 cases have continued to increase. COVID-19 was first reported in Indonesia on March 2, 2020, with 2 cases. The COVID-19 Response and National Economic Recovery Committee (KPCPEN) report dated December 31, 2020, stated that confirmed cases of COVID-19 reached 611,097 with 22,138 deaths (CFR 3.62%). As of July 5, 2021, confirmed COVID-19 cases reached 2,313,829 with 61,140 deaths (CFR 2.64%). In the Special Region of Yogyakarta, entering July 2020, the trend of increasing cases increased significantly. The spike in positive cases continued to increase into 2021; as of June 30, 2021, there were 60,459 positive cases with 1,559 deaths (CFR 2.58%). Of the total DIY cases, Sleman Regency contributed 35,69 % of cases, with positive cases as many as 21.575 cases.

Handling COVID-19 in Sleman Regency requires mapping that can identify the risk factors of COVID-19 transmission and those related to sociodemographic conditions and the surrounding environment. Identifying risk factors associated with sociodemographics and the environment can be done by spatially utilizing the address data approach available in the COVID-19 patient register. The characteristics of COVID-19 data available at the Health Office allow for mapping with an approach analysis. Therefore, it is necessary to conduct a spatial study on COVID-19 cases to determine the spatial risk factors related to the incidence of COVID-19 in the Sleman Regency.

METHODS

This ecology study took a spatial approach and used secondary data from the COVID-19 case register of the District Health Office Sleman, Special Region of Yogyakarta. It was conducted from August to December 2021, using data from March 2020 to July 2021. In addition to COVID-19 data, sociodemographic and ecological data from several related agencies were also used. This study used 11 variables suspected of having a relationship with the incidence of COVID-19.

Analysis statistics use correlation analysis, such as Pearson Product Moment, to identify the variable with the highest correlation and the Variance Inflation Factor (VIF) to determine the connection between the variables. The spatial analysis consists of Global model calculation, autocorrelation spatial, and LISA performed on influential variables significantly using Geoda 1.16. GWR and MGWR analysis is performed using MWGR 2.2. Maps are created using QGIS 3.16.

RESULTS

To increase COVID-19 surveillance in the Regency Sleman, the Health Service uses various media as Data sources. These include applications based on the site "COVID Tracer Regency Sleman," the New All Record (NAR) Ministry of Health website, the application Please Track, and a manual recapitulation based on Google Drive. The data used in the study was sourced from the COVID Tracer Regency website Sleman.

Table 1. Characteristics of COVID-19 incident in the Regency Sleman

Characteristics	Amount (%)
Sex	
Man	18,868 (53.37)
Woman	16,482 (46.63)
Age	
0-5 years	1.111 (3.14)
6-14 years	2,341 (6.62)
15-24 years	5,077 (14.36)
25-34 years	6,512 (18.42)
35-44 years	5,681 (16.07)
45-54 years	5,747 (16.26)
55-64 years	4,450 (12.58)
>64 years	2,898 (8.20)
Without information age	1,531 (4.34)
Category symptom	
Symptom light	27,905 (78.94)
Symptom currently	1,012 (2.86)
Symptom heavy	271 (0.77)
Without symptomatic/asymptomatic	6,162 (17.43)

Based on Table 1, the characteristics of COVID-19 incidents in the Regency Sleman are the most common in cases of various sex males (53.37%). Most cases of COVID-19 occur in groups aged 25-34 years (18.42%). For the category of the most common symptom experienced is symptom light (78.95%). The distribution of spatial COVID-19 cases can seen in Figure 1. It can seen that the number highest COVID-19 incidents located in 6 villages in the Depok sub-district (Village): Caturtunggal, Condongcatur, and Maguwoharjo), Mlati (Village Sinduadi), Kalasan (Purwomartani) and Ngemplak (Wedomartan) with amount case more from 1000 in each village. The number incident lowest located in 5 villages within the sub-district area Cangkringan (Village) Umbulharjo, Kepuharjo, Glagahharjo) and Prambanan (Wukirharjo and Sambirejo) with amount case not enough of 50.

The analysis results in statistics at the village level: The average COVID-19 figure in Regency Sleman is 2.91, with a standard deviation of 1.03. The village of Sambirejo has the lowest mean COVID-19 number, at 0.61, and Singles has the highest, at 5.52.

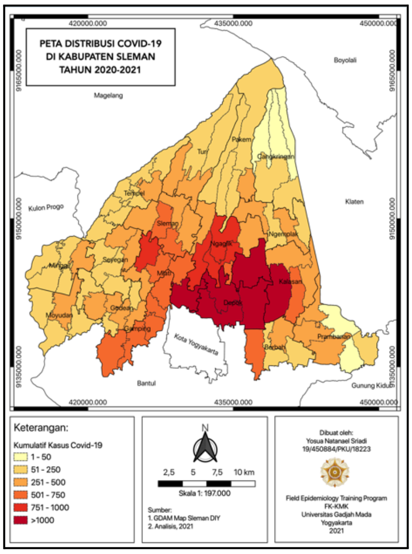

Figure 1. Distribution Map COVID-19 Cases in Regency Sleman

After going through stage analysis, six bivariate variables were obtained which had connection significant ($p<0.05$) with the number of COVID-19 incidents in the Regency Sleman, age 15-64 years, age >64 years, density population, average humidity air, altitude, level poverty, and existence facility shopping. The bivariate analysis results can be seen in Table 2.

Identification pattern spatial was done to determine the pattern distribution of COVID-19 cases. To identify patterns in spatial COVID-19 incidents, Moran's I analysis will estimate global autocorrelation and distribution of spatial COVID-19 cases and variables studied by others. Moran's I analysis results are depicted in LISA cluster maps and LISA significance maps. LISA cluster maps are used to understand the contribution of every village in analysis. Type LISA clusters are high-high (HH), low-low (LL), low-high (LH), and high-low (HL). The HH and LL clusters show cluster-significant areas surrounded by clusters with the same significant marks. Figure 2 shows the COVID-19 incident in the Regency Sleman's own correlation spatial and forming pattern cluster or clustered (Moran's I = 0.470, p = 0.001). The incidence of COVID-19 in the Regency Sleman divided in a way in 3 clusters, the HH cluster includes Depok District (Village) The LL cluster covers Prambanan District (Bokoharjo, Gayamharjo, Madurejo, Sambirejo, Sumberharjo, Wukirharjo Villages), Cangkringan (Gayamharjo, Kepuharjo Villages), and Pakem (Hargobinangun Village), and the LH cluster is in 2 villages in Berbah District.

Before GWR modeling, linear regression is done by modeling a global model with ordinary least square (OLS) estimation. Modeling linear regression begins with performing a multicollinearity test to ensure no factor is mutually risk-related, affecting the regression model and interpreting the linear regression results. The final result modeling linear regression can seen in Table 3.

Table 2. Analysis results in bivariate COVID-19 incidents in the Regency Sleman

Variable	Obs	Mean	Std. Dev.	Min	Max	r	p-value
COVID-19 rate	86	2.91	1.03	0.61	5.52	-	-
% of the population aged <15	86	20.91	1.51	11.07	23.52	0.05	0.66
% of the population aged 15-64	86	69.01	1.28	65.82	71.23	0.41	0.00
% of population aged >64	86	9.98	1.91	7.20	15.73	-0.31	0.03
Hypertension rate	25	10.26	0.08	10.13	10.41	-0.39	0.13
Diabetes mellitus rate	25	3.14	0.03	3.10	3.18	-0.38	0.13
Population density	86	2056.01	1244.99	398.74	8207.19	0.61	0.00
Temperature	19	26.51	0.53	25.65	27.87	-0.23	0.34
Humidity	19	83.45	1.94	78.52	86.17	-0.57	0.01
Altitude	86	231.67	142.55	89	667	-0.22	0.04
Index of poverty	86	10.02	3.15	2.70	18.52	-0.54	0.00
Shopping facilities rate	86	0.04	0.03	0	0.14	0.53	0.00

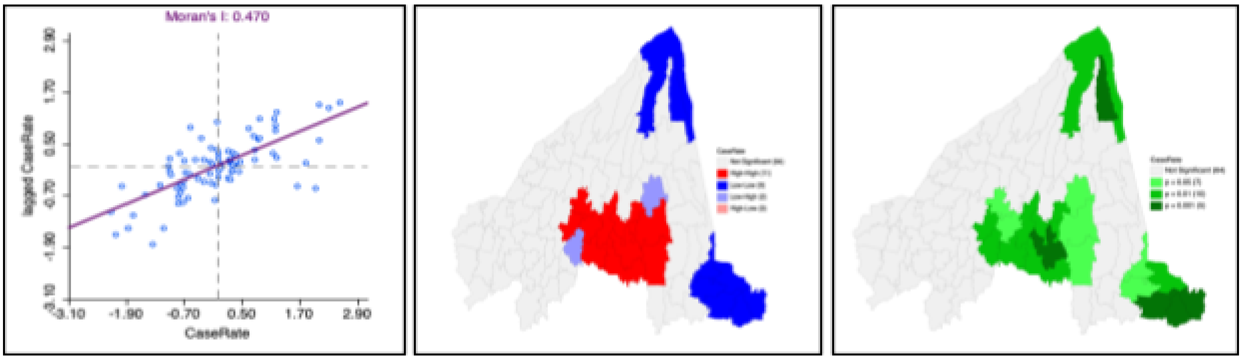

Figure 2. Results of Moran's I and LISA analysis

Table 3. Modeling results linear regression factor COVID-19 risk

Variable	Coeff.	Std. Err.	t	p>|t|	95% CI		VIF
% of the population aged 15-64	0.13	0.13	1.04	0.30	-0.12	0.39	4.23
% of population aged >64	0.13	0.08	1.52	0.13	-0.04	0.29	4.03
Population density	0.0003	0.0001	3.74	0.00	0.0002	0.0006	2.65
Altitude	0.0002	0.0007	0.24	0.81	-0.0012	0.0016	2.05
Rate of poverty	-0.05	0.04	-1.35	0.18	-0.12	0.02	1.65
Shopping facilities	9.98	3,011	3.31	0.00	3.99	15.97	1.52
_cons	-8.26	9.47	-0.87	0.39	-27.10	10.59	2.69

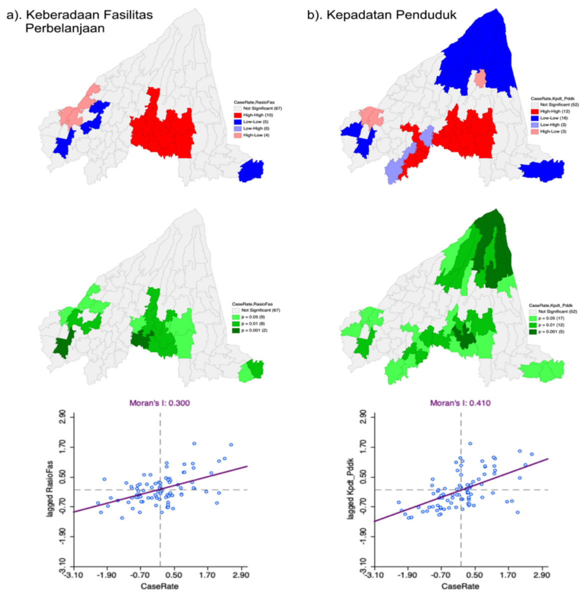

Figure 3. Cluster map and significance factor risk with COVID-19 incident; (a) the existence of shopping facility, (b) the density of resident

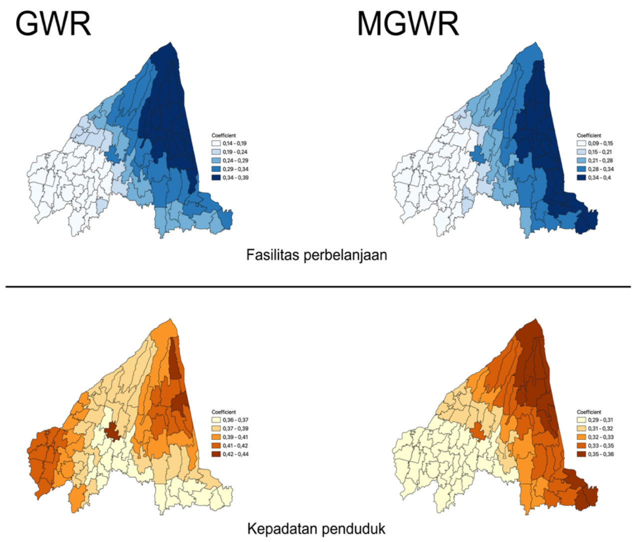

Figure 4. Impact of population density and the presence of shopping facilities on the incidence of COVID-19 using MGWR

Analysis linear regression in Table 3 shows that the factor-proven risk significantly related to the COVID-19 incident in the Regency Sleman is existence facility shopping with a mark coefficient of 9.98 (p-value <0.001; 95% CI = 3.98-15.97). This means an additional 1 unit of facility shopping can happen, improving 9.98. The analysis results also show a significant relationship at the level density resident, although with a very high coefficient (Coef = 0.0003; p-value < 0.001; 95% CI = 0.0002-0.0006).

Autocorrelation test spatial shows a positive and significant spatial autocorrelation between factor existence facility general (Moran's I=0.300) and density population (Moran's I=0.410) with COVID-19 incident in the Regency Sleman (Figure 3). The spatial analysis was done using the MGWR 2.2 application with several parameters: weighting spatial using Adaptive Gaussian, searching bandwidth using the Golden Section mode, and determining optimum bandwidth by seeing the smallest Cross-Validation (CV) value.

Table 4 shows that the MGWR model has the highest R2 value, 0.644, compared to the OLS and GWR models. This means the MGWR model can describe 64.4% of COVID-19 cases. Thus, the MGWR model is the most appropriate for describing COVID-19 incidents in Regency Sleman. The results of MGWR modeling based on the density of population and facility shopping can be seen in Figure 4.

Table 4. Comparison of Goodness of fit of OLS, GWR, and MGWR models

Variables	OLS	GWR	MGWR
R2	0.50	0.61	0.64
AIC_C	195.97	184.37	177.21

DISCUSSION

Based on the Guidelines for Prevention and Control of COVID-19 (Ministry of Health, 2020), new cases are identified and managed throughout provinces and districts/cities, and interventions are provided in cases of COVID-19. In addition, every province and district/city must be capable of map scenario transmission in its area so that data availability becomes necessary. To answer the need for this data, the Government Regency Sleman provides the "COVID Tracer Regency" application, Sleman" based on the website used to take notes of every new case and contact closely.

Along the walk time, besides COVID Tracer Regency Application Sleman, there are also some other active applications used for COVID-19 surveillance in the Sleman Regency, among them the New All Record (NAR) application that collects all result data PCR test from all over laboratory COVID-19 screening in Indonesia and Application Tracking focused on reporting case, tracking contact close as well as monitoring quarantine and isolation independent daily. Using a number of different COVID-19 apps results in a different number of cumulative COVID-19 incidents in the Regency Sleman on each application, and there is no synchronization of data at the district and provincial levels. This is in line with research in Yogyakarta, which found that systems separate applications between government central and regional, causing COVID-19 data to be inaccurate and integrated with good [3]. This also makes time data entry inefficient because data officers must simultaneously input the same data in several applications.

This research results show that the COVID-19 incidents in the Regency Sleman are the most common in cases of various sexes males (53.37%), no too different from cases in women. This is in line with Peru's research, which found that men's incidence rate is higher than that of women [4]. Meanwhile, a study in Italy found that 50.7% of COVID-19 cases were women. Another study in China found that female contacts were more likely to be infected with COVID-19 than male contacts [5]. The difference in Attack Rate (AR) between men and women is likely due to several factors. First, women play a primary role as caregivers in the family and may have closer contact and more extended contact periods with index cases in the family. Second, most healthcare workers are women. The differences in findings in these studies indicate that the characteristics of COVID-19 incidents at the local level vary widely. However, globally, men and women are at risk of being infected with the same COVID-19 [6].

COVID-19 Incidents in the Regency Sleman are the most common in groups aged 25-34 (18.42%). Based on data from the Ministry of Health (2021), most COVID-19 cases were aged 31-45 years (29%), followed by 19-30 years (22%). The results of this study indicate a significant relationship between productive age (15-64 years) and the incidence of COVID-19 in Sleman Regency. The village with the highest case also has the most considerable productive age (15-64 years) in the Sleman Regency. This group is included in terms of age mobility and high activity outside the home. The frequency and social interaction of the productive age group are also higher; this causes a greater risk of being infected with product ff, which tends to have and transmit COVID-19 than other age groups. Several serological studies have shown that young adults (especially those under 35) tend to have a high cumulative rate of COVID-19 infection in the community [7]. To prevent the transmission of COVID-19, the Sleman district government has made various efforts, including issuing instructions on implementing Micro-Based Community Activity Restrictions (PPKM) intended to reduce residents' mobility. However, this cannot wholly control the increase and spread of COVID-19, even though the PPKM has been extended several times. Results show that 78.95% of COVID-19 patients in the Regency Sleman experience symptom light. As reported by WHO, most people infected with COVID-19 will experience disease breathing light until moderate and recovering without needing maintenance. However, in some people, the condition will become severe and require medical maintenance. In older people and those who have condition medical conditions like cardiovascular disease, diabetes, disease breathing, or cancer, the condition tends to increase critical.

Hypertension more often happens along with increased age and in people with obesity and diabetes [8]. According to the Data Center Ministry of Health, only 25% of diabetes mellitus sufferers who know themselves suffer from diabetes mellitus [9]. This means that many lot diabetics do not know the status and potential severity of their illness. Condition This needs to be paid attention to. The prevalence of diabetes mellitus in the Special Region of Yogyakarta is the 2nd highest in Indonesia and is located above average prevalence nationally. In this study, the prevalence rates of hypertension and diabetes mellitus statistically showed an insignificant relationship with the incidence of COVID-19 in Sleman Regency. This condition is greatly influenced by the availability of hypertension and diabetes mellitus data, which only covers the Puskesmas level, which amounts to 25 Puskesmas. Size minimum sample that can be accepted For studies correlation is not less than 30. Data less than 30 may give inconsistent correlation results [10].

This study finds a negative and significant connection between humidity air and COVID-19 in the district of Sleman. Every increase in humidity in the air will reduce the number of COVID-19 cases. The relationship between humidity air and the occurrence of COVID-19 is also proven by research conducted in China [11]. It is known that SARS-CoV transmission is similar to the transmission of influenza, which is related to fluctuating air temperature that affects virulence or weakens the host with an incredible body or dry channel breathing. This research finds no connection between the temperature of air and the number of COVID-19 incidents. Factors influencing the relationship between temperature air and COVID-19 risk require deeper analysis. However, the differences in the characteristics of climatological data and factor data risk have become a primary constraint to the analysis. Correlation negative against COVID-19 was also found in the variable height of the area, even though it tends to be weak. This is in line with research conducted in Peru, which found that the number of COVID-19 infections declined in the tall locations where citizens stay [12]. An epidemiology analysis indicates a marked decrease in the prevalence and impact of SARS-Cov-2 infection in populations living at altitudes > 3000 masl [13].

Since early, density has been one factor affecting the speed of the spread of COVID-19 worldwide. Regions with level density residents increase the intensity of contact between individuals, which accelerates the occurrence transfer of viruses [14]. The density of resident's connection with improved income directly influences the poverty level [15]. This research results show the correlation between poverty levels and the number of COVID-19 incidents in Regency Sleman. Regions with levels of poverty have their number of COVID-19 incidents.

This study finds that the area with a high incidence of COVID-19 is densely populated in the district of Sleman, which has more shopping facilities than the region with low-density residents. Population density and facility shopping are the most influential risks to COVID-19 incidents in the Regency Sleman compared to factors that risk others. Based on data from the District Health Office Sleman, the spread of COVID-19 in the Regency Sleman originates from shopping centers and traditional markets.

In the study, this approach is spatial to see pattern distribution from factors suspected risk in connection with the number of COVID-19 incidents in the Sleman Regency. A total of 11 indicators were used in the study. After passing several stages of multicollinearity analysis and testing, two factors were obtained to associate risks in a significant way: Density Population and Presence of Facility Shopping. Some statistical models run to see the pattern of the spread of COVID-19 and its relationship in a way spatial with factor risk. The modeling results found that the Multiscale Geographically Weighted Regression (MGWR) model can explain factor risk more COVID-19 incidents accurately than other models.

This study found that the spread of COVID-19 in the Sleman Regency formed clusters and clusters. COVID-19 clusters are centered in areas with density and have an amount of facility shopping (supermarkets, shopping centers) shopping, and traditional markets) the most. This area covers subdistricts Mlati, Depok, Ngaglik, and Ngemplak. MGWR modeling shows that population density and shopping faty are highly significant in almost all villages. However, population density has a more significant impact on the incidence of COVID-19 in villages in the Cangkringan, Ngemplak, Kalasan, and Prambanan Districts. Meanwhile, shopping facilities significantly impact Pakem, Cangkringan, Ngemplak, and Prambanan District villages.

The local adjusted R2 figure is very high, showing that the existence of shopping facilities and the density of residents can explain an accurate number of COVID-19 incidents down to the village level. In addition, the coefficient of the second variable is also significant throughout the village. This information can be a material consideration to prevent the spread of

COVID-19. For example, the PPKM Monitoring Micro enhancement coverage of COVID-19 vaccination can focus more on areas with more shopping facilities and residents.

CONCLUSION

This finding shows that the existence of shopping facilities and the density of residents strongly correlate with COVID-19 incidents in Sleman Regency. The spatial approach has proven capable of preventing the spread of COVID-19. For example, efforts to monitor social restrictions based on Micro and campaigns for COVID-19 vaccination can focus more on areas with more shopping facilities and dense residents.

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