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ENVIRONMENTAL AND HEALTH SERVICES FACTORS ASSOCIATED WITH NEW COVID19 CASE IN CENTRAL JAVA PROVINCE: A SPATIAL ANALYSIS

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Abstract

Introduction: *At the end of December 2020, there were 93,035 Covid19 cases reported in Central Java. The spatial analysis is useful for assessing the association of environmental and health services factors with new Covid19 cases.* ***Methods:*** *This study was conducted to identify a spatial autocorrelation between environmental conditions and health services on new Covid19 cases in Central Java Province in 2020. The data were obtained from Central Java Profile Published in 2021 with a cross-sectional design. This autocorrelation regression technique was used to determine the relationship between districts/cities for new Covid19 cases. The independent variables in this study were environmental factors such as access to quality drinking water, access to quality sanitation, percentage of Open Defecation Free (ODF) villages, and percentage of healthy food management places. In addition, the independent variables also covered health service factors such as the number of public health centers, hospitals, medical personnel, and population density.* ***Results and Discussion:*** *The findings found that in Central Java province, the factors that influenced new Covid19 cases included population density (p-value 0.0001; Morran I -0.032) and the number of medical personnel (p-value 0.0001; Morrans I 0.021).* ***Conclusion****: The new cases of Covid19 in Central Java Province formed a clustered pattern. Factors significantly influencing the regression test are population density and the number of medical personnel. Besides that, spatial autocorrelation was also found in other variables in this study but was not significant.*

INTRODUCTION

Corona Virus Disease 2019 (Covid19) is one of the diseases that has claimed nearly 4 million people worldwide. Covid19 triggers respiratory problems due to infection with the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus. According to the World Health Organization's records, until the end of 2022, the disease has spread to 232 countries, infecting around 175 million people and causing 6,341,647 deaths (2.16%). Until mid-2022, there were 6,100,671 people in Indonesia infected with the SARS-CoV-2 virus, with 156,770 people dying, or 2.56% of the death rate (1). Central Java Province, one of the provinces with a high population in Indonesia, needs attention, considering that from the data obtained by the Central Java Provincial Health Office, this province has always been in the top 3 cases during 2020 and 2021. At the end of 2020 in Central Java, it was recorded that 93,030 people were infected, with 5,729 people dying or 6.16% of the mortality rate; in that year, Central Java Province recorded a Case Fatality Rate (CFR) of 4.4% and was above the national CFR of 3.0% (2). By the end of the year, Covid19 cases had spread evenly to 35 districts/cities in Central Java, with Semarang City being the city with the highest number of cases, with 11,038 cases, and Salatiga City being the lowest city with 908 cases.

A systematic review study explains that various factors are suspected to be the cause of the increased rate of Covid19 transmission in many areas, and one of them is the geographical factor of an area experiencing

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a pandemic (3), environmental factors (4), and health system support factors (5-6) in the region. Research in Spain found that the Covid19 outbreak that occurred so quickly would get worse if it was not supported by a qualified health system. In that country, within the first 17 days of the attack, 11,000 cases occurred and caused the death of 491 (4.4%) residents infected. This number is undoubtedly astonishing for an extraordinary case of disease (5). Geographical factors include area size and population density, while environmental health factors include access to drinking water and proper sanitation (7–9). Overall a study in sub-Saharan desert countries revealed that having access to standard sanitation, safe water sources, and standard toilets above 74% increased 17% the prevention of infectious disease transmission (8). In a study, it was observed that there were at least 20 countries that reported 10,000 cases of Covid19 infection, namely countries with 5-26% of the population practicing open defecation (10). Health service factors include the number of hospitals and the number of Public Health Centres (PHC) (11), and the number of health workers (12). Other studies in several countries explain that areas with high population density have a higher risk of spreading the SARS-Cov-2 virus than areas with low population density (13–15).

Several works of literature explain the close relationship between environmental factors and the spread of Covid19. SARS-CoV-2 is a virus that can transmit high and fast between humans through air media contaminated with droplets from coughing sufferers or when talking in a loud voice and can also be through solid objects around which are contaminated with the SARS-CoV-2 virus. The impact of Covid19 becomes more severe if the infected patient has co-morbidities such as diabetes mellitus, hypertension, cardiovascular disease, and kidney dysfunction. The concept of epidemiology explains that viruses, the environment, and hosts play a significant role in the transmission and spread of infectious diseases, including in the case of Covid19. A study describes that the interdependence of the community with the environment will affect the area's health and can be a guide for dealing with Covid19 from an environmental health perspective (4). The health care system is a factor that cannot be separated from improving the quality of public health in certain areas. The stability of the built system will greatly assist the community in maintaining the quality of their health in terms of preventive, curative, and rehabilitative. Research in Spain during the pandemic delineated the importance of the availability of health facilities and health workers in handling outbreaks and emergencies (5). The availability of ideal health facilities and health workers is a determining factor for the success of handling outbreaks in an area and the coordination factor between parties responsible for an area. This condition explains that the process of developing a health system is an essential benchmark in improving the quality of public health.

Adequacy of the health service system will help accelerate the detection of Covid19 in the community, which will ultimately help to reduce the spread of the disease. The speed of detection of Covid19 will help prevent and control the epidemic in general. This condition was described in a study that concluded that the prognosis of prevention and recovery of Covid19 patients would depend on the speed of detection of Covid19 patients. Therefore the faster ability to detect Covid19 will increase the chances of the patient's recovery (16-17). The patients' recovery process will affect the ability to prevent the spread of Covid19 in the community.

The availability of health workers is a component that needs attention in strengthening the health system to control disease during an outbreak or pandemic. Because health workers, apart from being able to accelerate the handling of patients, can also function as educators in health promotion efforts in handling Covid19, primarily related to the dissemination of knowledge and information about the risk factors for Covid19, how to prevent it, sanitation in the environment, the use of masks and other related matters (18).

In Indonesia, many studies related to the risk factors for Covid19 have been carried out. However, many have not seen this factor spatially and compared it between districts/cities. A critical approach is considered to see and find problems that occur between regions considering that each region has different geographical, environmental, and health service characteristics. Spatial aspects need to be observed and studied, considering that many scientific studies can explain the relationship between the distribution of disease and different geographical and environmental conditions between regions (19). One of the crucial aspects of spatial epidemiology is the existence of potential risk factors that affect the incidence of disease in an area (20). Based on the explanation above, it can be concluded that Covid19 is closely related to geographical conditions and the environment of a region. In addition, the disease is still potentially infectious in the future with a high transmission speed and impacts the number of population deaths, so a location-based study is needed (21). This research aimed to determine the effect of several potential factors related to geography, environment, and health system in an area on the incidence of Covid19 if they were related spatially and to help raise awareness of the importance of looking at different aspects of location and assist the

development of strategies for spreading future outbreak risks.

METHODS

This research was conducted in Central Java Province by utilizing 2020 data with a cross-sectional approach and analysis technique using spatial regression analysis. This autocorrelation regression technique was used to determine the relationship between districts/ cities in Central Java Province for new cases of Covid19. Spatial Auto Regression analysis was used to find out the most influential variables of all tested variables, then determine variables that could describe the risk factors for new Covid19 cases. The data used in this study were secondary data obtained from official sources and retrospectives. The data included the number of new cases of Covid19 in 2020 from the official report of the Health Service and the Central Agency on Statistics for the local area. Furthermore, multivariate spatial analysis was carried out on the data to determine the relationship between the independent and the dependent variables. The results would show the global regression equation in one province and its relationship based on the p-value ($p<0.05$).

RESULTS

Data on the number of new Covid19 cases and several variables are displayed per district for Central Java Province (Table 1). The data can be obtained from the official source of the Health Service and Central Agency on Statistics (CAS) Central Java Province. The dependent variables were new cases of Covid19. The independent variables consisted of population density, access to quality drinking water, access to quality sanitation, Number of Public health centers, Hospitals, Medical Personnel, ODF villages, and Health Food Management Places.

The city of Semarang was recorded as the area with the highest number of new cases of Covid19 in Central Java, with 11,038 new cases throughout 2020. There were nine districts/cities with a relatively high number of new cases, with more than 3,000 cases in 2020, namely Magelang Regency, Kebumen, Wonosobo, Kendal, Banyuman, and Jepara. Cilacap Regency is the largest district in Central Java Province, with an area of 2124.47 km^2, while Surakarta City is the city with the most populous population, with a density of 11,353 people/ km^2.

Table 1. The Covid19 Incidence Data in Central Java Province

Districts	Covid19 Incidence	Population Density (people/ square kilometre)	Acces to Quality Drinking water (%)	Acces to Quality of Sanitation (%)	Number of Public Health Center	Number 0f Hospital	Number of Medical Personnel	Open Defication Free Village (%)	Healty Food Management Places (%)
Banjarnegara	1,334	994	86	46	35	4	1,652	47.5	54.9
Banyumas	3,793	1,331	93	75	40	23	4,835	77	67
Batang	2,139	1,017	98	68	21	3	1,454	27.4	65.1
Blora	2,786	490	92	87	26	6	1,931	100	34.7
Boyolali	2,198	1,054	95	93	26	11	2,008	100	55.7
Brebes	1,415	1,040	93	74	39	14	3,128	72.1	76.3
Cilacap	2,948	915	93	81	39	12	3,304	59.5	67.7
Demak	3,181	1,338	96	92	27	4	1,740	75.9	70.1
Grobogan	1,081	722	82	87	31	9	2,981	100	64.9
Jepara	3,719	1,119	84	64	21	6	2,334	100	68.3
Karanganyar	2,313	1,202	99	97	22	8	1,768	100	68.1
Kebumen	4,116	1,114	88	92	35	11	3,272	89.6	82.2
Kendal	3,985	911	96	85	30	5	2,221	100	68.5
Klaten	2,327	1,915	98	95	35	12	3,119	100	71.6
Magelang City	1,008	7,567	100	86	5	8	2,034	17.6	95.8
Pekalongan City	1,394	6,788	100	88	14	9	1,609	77.8	91.7
Salatiga City	908	3,353	99	95	6	6	1,258	100	56
Semarang City	11,038	4,424	99	94	35	29	9,118	100	84.4
Surakarta City	1,998	11,353	99	90	17	19	5,852	100	94.9
Tegal City	972	6,901	100	91	8	4	1,718	88.9	75.8
Kudus	3,542	1,997	98	92	20	10	3,031	89.4	75.7
Magelang	4,418	1,179	91	77	29	6	1,515	86	79.6
Pati	1,712	889	95	92	30	10	3,082	100	63.6
Pekalongan	1,545	1,157	97	77	27	4	1,592	26	61.4
Pemalang	2,529	1,316	93	78	25	9	2,108	81.1	58.6
Purbalingga	1,865	1,474	95	81	22	8	1,995	63.6	55.6
Purworejo	1,798	705	87	84	27	12	1,782	39.1	60
Rembang	1,463	727	97	93	17	3	1,683	100	76.4
Semarang	2,487	1,108	98	90	26	5	1.901	100	89.8

Districts	Covid19 Incidence	Population Density (people/ square kilometre)	Acces to Quality Drinking water (%)	Acces to Quality of Sanitation (%)	Number of Public Health Center	Number 0f Hospital	Number of Medical Personnel	Open Defication Free Village (%)	Healty Food Management Places (%)
Sragen	2,720	1,038	98	93	28	11	2,701	100	37.1
Sukoharjo	2,545	1,856	99	97	13	10	3,323	100	53.1
Tegal	2,656	1,823	97	82	31	9	2,926	100	66.9
Temanggung	2,631	943	93	69	26	4	1,661	100	73.5
Wonogiri	1,182	582	97	94	39	9	2,105	100	64.3
Wonosobo	3,999	896	98	48	24	4	1,271	34.3	69.1

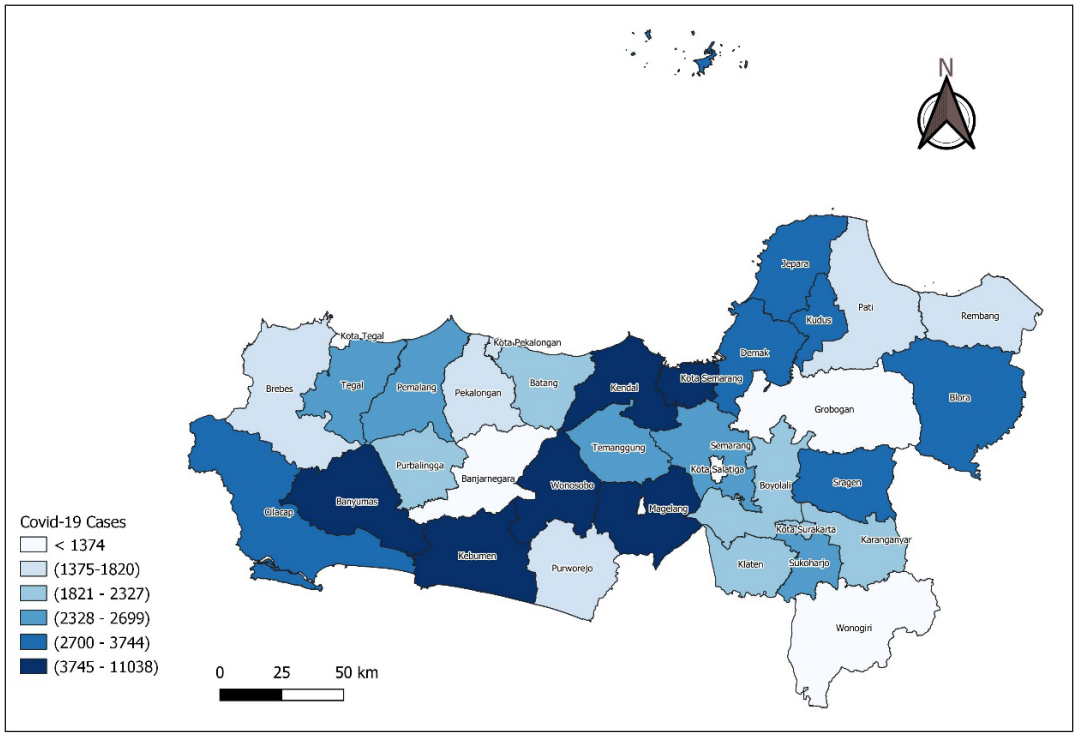

Figure 1. Distribution Map of New Cases of Covid19 in Central Java in 2020

The city of Semarang, the capital city of Central Java Province, is the city with the highest number of hospitals (29 units), medical personnel (9,118 people), and Percent of ODF villages (100%) in Central Java.

The multicollinearity test results statistically showed that all independent variables had a VIF value below 10 (VIF <10), indicating no multicollinearity between independent variables. These conditions indicated that the analysis could be continued to the next stage, the spatial autocorrelation test, to find variables that could potentially have special patterns in an area. If I > Io was found, the pattern formed a positive autocorrelation or group, whereas if I < Io, a diffuse pattern or negative autocorrelation was formed.

The Morans Index method analysis results are shown in Table 2, explaining that all variables were found to have spatial autocorrelation. New cases of Covid19 had a negative autocorrelation with population density and the number of public health centers or patterns of spread. Meanwhile, area size, access to quality drinking water, quality of sanitation, Number of Hospitals, Number of Medical Personnel, Percentage of ODF villages, and Health Food Management Places had positive autocorrelation or a clustering pattern.

Table 2. The Morans Index Test Results

Variable	I	Io	Remark
W-y (Covid-19 Incidence)	0.077		Positive autocorrelation
Area (km^2)	0.096		Positive autocorrelation
Population Density (people/ km^2)	-0.032		Negative autocorrelation
Access to quality drinking water (%)	0.067		Positive autocorrelation
Access to quality of sanitation (%)	0.360	-0.111	Positive autocorrelation
Number of Public health centers	-0.037		Negative autocorrelation
Number of Hospitals	0.037		Positive autocorrelation
Number of Medical Personnel	0.021		Positive autocorrelation
Percentage of ODF village	0.398		Positive autocorrelation
Healthy Food Management Places (%)	0.002		Positive autocorrelation

Furthermore, to advance to the SAR test stage, a homoscedasticity assumption test with Breusch-Pagan was carried out first, followed by a normality test with JarqeuBera, and a Lagrange Multiplier. In the

homoscedasticity assumption test and the normality test, it was found that p > 0.05, indicating that both met the requirements. Furthermore, the Lagrange Multiplier value was below 0.05, meaning the data met the assumptions to continue to the SAR test stage.

The stages of the Spatial Auto Regression Test (Table 3) show the results of the autocorrelation regression of all the variables involved. However, some variables were insignificant, so the independent variables that showed insignificant results must be removed.

Table 3. The SAR Test Results with a Complete Model

Variables	Coefficient	P-Value	R squared
W-y (Covid19 Incidence)	0.180	0.313	
Area (square kilometres)	-1.490	0.003	
Population Density (people/km^2)	-0.453	0.000	
Access to quality drinking water (%)	23.167	0.616	
Access to quality of sanitation (%)	-21.199	0.255	0.722
Number of Public health centers	19.194	0.298	
Number of Hospitals	-71.791	0.327	
Number of Medical Personnel	1.190	0.000	
Number of ODF villages (%)	4.049	0.618	
Healthy Food Management Places (%)	12.177	0.420	

Table 4 describes the final model of the analysis stages carried out. The W-y variable showed a relationship between the number of new Covid19 cases between adjacent regencies/cities, with a p-value of 0.151 and a coefficient of 0.256. A positive coefficient value indicated that new cases of Covid19 in a region contributed to an increase in neighboring regions. Furthermore, the p-value on the variable population density and number of medical personnel (0.000) showed significant results. The coefficient value of the population density variable was negative (-0.226), which means that the higher the population density, the higher the number of new cases of Covid19, and vice versa. In contrast, the coefficient value of the variable number of medical personnel (0.932) was positive, which means that the fewer the number of medical personnel, the greater the number of new Covid19 cases in Central Java. The R Square value of 0.585 or 58.5% of new Covid19 cases can be explained by the population density variable and the number of medical personnel, while other factors explain the rest.

Table 4. Final Results of the SAR Test After

Variables	Coefficient	P-Value	R squared
W-y (Covid19 incidence)	0.256	0.151	
Population density (people/km^2)	-0.226	0.008	0.585
Number of Medical Personnel	0.932	0.000	

Using data through a spatial approach is fundamental to mapping the pattern of the spread of the disease to help make decisions quickly in handling health problems. Controlling the identified risk factors is a potential strategy for controlling infectious diseases and efforts to reduce them. In this study, the final analysis showed that the proximity coefficient had a positive value. This means that new cases of Covid19 in adjacent areas contributed to the increase in the region. This condition was reinforced by evidence that all districts/cities in Central Java Province were in the high quadrant, where all districts/cities had a high number of new Covid19 cases and did not differ much from each other.

DISCUSSION

Coronavirus is a pathogen that infects humans and targets the human respiratory system. The rapid and massive spread of Covid19 has made this disease a new pandemic. Various factors are suspected of causing the increasing number of Covid19 transmissions in many regions, such as environmental factors (4) and factors supporting the region's health system (5). Environmental factors and the health system are inseparable factors in preventing the spread of Covid19.

In this study, it was found that the proximity coefficient (W-y) had a positive coefficient which means that new cases of Covid19 in adjacent areas contributed to an increase in that area. This condition was also strengthened by Moran's analysis, which states that all the factors tested had spatial autocorrelation. After going through two Spatial Autocorrelation tests of the nine factors tested in this study, it was found that only two factors had a significant influence, population density and the number of health workers.

The study's results showed a correlation between density and the incidence of new cases of Covid19 in Central Java Province. This is in line with research that explains that population is highly correlated with population mobilization, which can increase the spread of respiratory infectious diseases if not prevented and controlled (22-23). Several studies have shown that areas with high population densities have a higher risk of Covid19 transmission than areas with less dense populations (13,24). Areas with high population density, such as urban areas with many densely populated residential points and high urbanization flow every year, are the main scourge of the spread of various infectious diseases such as Covid19 (22). Besides that, population density is highly correlated with the movement of the population in the area triggered by economic factors and public transportation around the area (25-26). Urban areas with high density are usually economic centers with a high number of migrant workers who have a high potential for Covid19 transmission (27).

Semarang City was the area with the highest number of new cases of Covid19 in Central Java, with 11,038 new cases in 2020. Concerning population density, the city is one of the areas with a high population density of 4,424 people/km^2. Covid19 is an infectious disease with a close relationship with population density, so areas with high population density will have a high potential for disease transmission due to the high possibility of interaction between residents (20). Population density will also give rise to crowded centers such as markets, supermarkets, cafeterias, and the like, thereby increasing the transmission rate (13). Research in the United States in 2020 and 2021 described that the potential for population density at the district level also affected the transmission of Covid19 disease in the country (28-29).

Based on several studies, population density is a factor that can affect the transmission and spread of Covid19 disease from one person to another (28) and even occurs in several countries (13,30-31). Economic growth will increase the population's urbanization rate, making an area more densely populated. Areas with high density will be accompanied by high population movement and mobility, increasing the interactions between residents and Covid19 transmission (32-33). Research in Turkiye in 2021 found a positive correlation between population density and new cases of Covid19 in a province. The more densely populated area can increase the susceptibility of transmission between people for Covid19 disease in it (34).

Research in China in 2020 had different findings related to population density and the incidence of Covid19. The study found that population density was not the primary variable in the spread of Covid19 in the country. The disease transmission can be controlled even in high-density areas (15). Another study in the same country in 2021 showed that in 31 regions in Hubei Province, population density did not have a relationship with the mortality rate of Covid19 sufferers but had a close correlation with Covid19 sufferers. It can be interpreted that the death rate of Covid19 sufferers can be reduced by increasing other variables, such as implementing the lockdown policy and strengthening the health service system. However, it was explained that population density correlated with the increase in Covid19 sufferers in the research area (35). Similar studies in 2020 also had almost the same findings that in India, the population density was found to be a moderator variable in the spread of Covid19 (31). Population density is a determinant factor for the spread of Covid19 because it closely relates to population movements. However, this can be prevented by speeding up local government policymaking and education about the dangers of Covid19 to build awareness of the population to reduce their activities (17,36).

Another variable that has an autocorrelation with the incidence of new cases of Covid19 in Central Java Province besides population density is the number of health workers. Healthcare workers are the busiest professionals in dealing with the Covid19 pandemic worldwide. Providing unconditional service and prioritizing patient safety regardless of status is a guiding principle of healthcare workers worldwide. The number of patients increasing so fast must, of course, be accompanied by the health system's readiness in an area with the help of health workers (37-38). The results showed that the availability of the number of health workers correlated with the incidence of new cases of Covid19 in addition to the population density variable. This research is in line with research conducted in Indonesia in 2020, which has found that health workers are the main element in solving the Covid19 health disaster problem in Indonesia because the readiness of the health system is influenced by the number of health workers, operational standards, and available health facilities (39).

The large number of medical personnel in Indonesia who have contracted Covid19 adds to the problem of the lack of health workers in areas with a high increase in cases (39). Not to mention, the mental and psychological problems of health workers in dealing with the Covid19 pandemic add to the burden on them, and when they contract the Covid19 virus while carrying out their duties, it will certainly reduce the ability of the health system in the region (6). Research in Iran in 2022 has found that the resilience of the health system will be influenced by health workers, not on the number but on the psychological abilities of these health workers, given their concern and anxiety about the potential for infection is a different problem in handling Covid19 patients (40). The psychological condition of health workers will affect their performance in handling the Covid19 pandemic, especially related to high fatigue during health emergencies (41). A study also explains the importance of managing health workers to improve the performance of health services to optimally support the health service system to maintain the quality of public health and can be considered as a monitoring system and rotation of the duties of health workers as part of an effort to establish a sense of shared responsibility in a team (42). An adequate health system with health workers is needed to maintain the stability of health services during a health emergency. Several factors that can be used as essential

lessons during a pandemic are the tiered management of health services, robust and flexible financing capacity, and good partnerships between stakeholders (43).

These conditions can make special considerations for the government in increasing the resilience of mental and psychological health personnel to deal with future outbreaks. A comprehensive approach to health workers by optimizing good risk communication patterns accompanied by occupational safety, health training, and psychological support programs can help strengthen health workers' abilities, especially in areas with high population density (44).

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CONCLUSION

New Covid19 cases in Central Java Province during 2020 formed a clustered pattern. The close relationship between regions could affect the increase in cases in other regions. After going through several tests, it was found that the factors that had significant spatial autocorrelation were population density and the number of health workers. The rest of the factors in this study had spatial autocorrelation with new Covid19 cases but not significantly.

Collaboration and synergy between stakeholders will help handle and prevent disease outbreaks more quickly in the future. The population density and the number of health workers significantly influence the incidence of Covid19 in Central Java Province. However, further research is still needed on factors that can help accelerate the handling of Covid19, such as the effectiveness of implementing policies to limit the movement of people in areas of high density and the ability of health workers in terms of hard and soft competence. The availability of health workers and adaptation to an area's population density can be strategic choices in the future in efforts to prevent the transmission of infectious diseases in an area.

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