



Spatio Temporal Analysis of Covid-19 Cases Distribution Pattern in Batang Regency

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Abstract— *The Covid-19 cases increase significantly in Batang Regency since it was first identified on April 4, 2020 until nowadays. The efforts and strategies have taken by the government to reduce the rate of Covid-19, but have not shown significant results. There has increased 1.125 cases in Batang Regency on December 2020. This study aimed was analyzed by spatio temporal approach of the Covid-19 case and determine the distribution pattern of the Covid-19 in Batang Regency. Methods: This type of research was an observational research with a spatiotemporal explanatory research design. Data analysis for spatial autocorrelation were performed using Moran's index and location quotient (LQ) index. The research data were obtained from the Batang Regency Health Office. The sample in this study were 248 villages in Batang Regency. Result and discussion: The results showed that as many as 209 villages (84.3%) were identified cases, and 39 villages (15.7%) had no identified cases of the Covid-19. The results of the moran's index showed that the pattern of the Covid-19 incidence which has a significant spatial correlation in 248 villages with p value <0.01 and Z -score > 2.58 . The results of the Location Quotient (LQ) index shows that 78 villages (31.4%) in Batang Regency having high level of the Covid-19 concentration ($LQ > 1$). Conclusion: The distribution pattern of Covid-19 shows a change in pattern from random to clustered. Spatio-temporal analysis of Covid-19 cases shows an increase in the number and areas of cases.*

Keywords— *Covid-19 distribution pattern, LQ value, Moran Index value, spatial autocorrelation*

I. INTRODUCTION

Corona virus or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a virus that attacks the respiratory system. The disease caused by this virus is known as Coronavirus Disease 19 (Covid-19). Since on 31 December 2019 until 23 September 2020, the trend of Covid-19 cases still shows an increase worldwide, with total cases of 31,771,402 cases, consists of 7,120,370 active cases (patients infected), and 24,651,032 (23,675,722 were declared cured, and 975,310 died) closed cases with 315,717 new cases worldwide [1].

The Covid-19 case was first identified in the city of Wuhan, China, at the end of December 2019 with a very fast rate of transmission and spread. Based on September 2020, this disease has spread in 215 countries in the world, included Indonesia. The first identified Covid-19 cases in

Indonesia on March 2, 2020 were imported cases. Increasingly significant cases occurred on 6 months since the first case identified. On September 23, there were 4,465 new cases with a total of 252,923 cases, consist of 9,837 died, 58,788 under treatment patients and 184,298 patients was cured [2].

Central Java Province is one of the provinces with the highest positive case numbers and Dead of Covid-19 have reached 19,982 cases, with 1,314 patients was die, 14,083 patients recovered and 4,585 patients treated in September 2020 [3]. Batang Regency is a part of Central Java Province with the number of Covid-19 cases increasingly fast. Since the first case was identified on April 4, 2020, the number of positive cases was 331 cases have spread at 99 villages in Batang Regency [4]. The distribution of Covid-19 in Batang for monthly period shows a significant

increase in the number of cases and the distribution of virus-infected areas. At the end of September 2020, there were 105 (42.34%) infected villages in Batang.

Research about pattern of disease distribution is important carry on as an effort to prevent and control Covid-19 transmission. Many of spatial research designed by Geographical Information Systems (GIS) have been in line with WHO efforts to prevent the increasing cases and expansion of infected areas. Spatial analysis use to describe various natural phenomena occurred, including mapping disease transmission area, especially in the current Covid-19 pandemic conditions [5].

Murugesan have been tracing disease triggers and how they have been transmitted through distribution and analysis of COVID-19 trends in India with a spatial approach [6]. Shariati conducted a temporal ratio analysis by calculating the cumulative incidence rate (CIR) and cumulative mortality rate (CMR) in several European countries affected by Covid-19 in the period March to April 2020 [7].

Spatio temporal analysis is one of analysis data methods which connecting the dimensions of space and time to explain a phenomenon at a certain location and time. The current distribution of Covid-19 cases required data with connected scope of time and space to find out the journey and development of cases in an area. This data can be in the form of statistical data or distribution maps that provide information about the travel and development of cases in an area, thereby facilitating efforts to prevent and suppress current cases.

Florence (1939) introduced the use of the location quotient as a measure of geographic concentration within an area. Location Quotient (LQ) is a special way of expressing the uniqueness of an area compared to the national average. The point is to measure how much concentration of phenomena, characteristics, occupations, or certain groups in an area is compared to a wider scope [8]. This study aims to analyze the development of the Covid-19 case in a temporal ratio to determine the distribution pattern of Covid-19 in Batang Regency with the spatial correlation and LQ approach.

II. METHODS

This observational study included of 248 villages which were identified the number of Covid-19 cases in Batang Regency from April to December 2020. The number of Covid-19 cases was obtained from the Health Service of Batang Regency and the demographic data was obtained from the Central Statistics Agency of Batang Regency.

Table 1. Distribution of Cases Number and Villages Infected with Covid-19 per April until December 2020

The research was carried out in Batang Regency from April to December 2020.

The study was approved by Health Research Ethics Committee of Universitas Diponegoro No : 287/EA/KEPK-FKM/2020. The research began by collecting data of Covid-19 cases periodically, and demographic data (the number of population, population density and large area), followed by inputting data in tabulation form, correcting data, classifying data and modelling data. Statistic analysis was pointed the distribution frequency, proportion, spatial autocorrelation of Covid-19 cases which conducted on Moran's index and LQ value on p value < 0.01 and Z-score > 2.58 were considered significant.

Spatio temporal analysis was described the temporal distribution pattern of Covid-19 cases, the autocorrelation distribution pattern of Covid-19 cases and location quotient of Covid-19 cases in research period. The autocorrelation distribution pattern of Covid-19 cases was analyzed using Moran's index with ArcMap 10.3 software. The interpretation of the research results refers to the Moran's index value and the LQ value which are narrated according to literacy.

III. RESULT AND DISCUSSION

A total of 209 villages were identified Covid-19 in this study. The number of Covid-19 cases is the accumulation positive cases number confirmed through the PCR test conducted by the Covid-19 task force in Batang Regency. The highest number and distribution of cases occurred in December (1.125 cases or 49.3% of the total cases and 177 villages or 71.37% of Batang Regency). Increasing cases of Covid-19 occurred every month, was begin 12 cases (11 villages) in April, up to 2.282 cases (177 villages) at the end of December 2020. The distribution of Cases Number and Villages Infected was shown in Table 1.

The accumulation number of cases per village have varied from 1 to 153 cases in the period April to December 2020. There were 29 villages (11.7%) with an accumulated number of cases 1, and 1 village (0.4%) with the number of accumulated cases 153. The villages with the highest accumulated number of cases were Kauman (153 cases), followed by Sambong (99 cases), Proyonanggan Tengah (80 cases), and Proyonanggan Selatan (75 cases) which were located close each other on Batang sub-district. It was shown in Table 2.

Month	Number of cases	Percentage (%)	Number of villages	Percentage (%)
April	12	0.53	11	4.44
May	28	1.23	17	6.85
June	28	1.23	16	6.45
July	30	1.31	20	8.06
August	127	5.57	53	21.37
September	165	7.23	63	25.4
October	291	12.75	83	33.47
November	476	20.86	120	48.39
December	1125	49.3	177	71.37
Total	2282	100	-	-

Table 2. The Accumulation Number of Cases and Villages Infected with Covid-19 per April until December 2020

amount case	amount village	(%)	Cumulative percentage	Accumulated cases	Number of villages	(%)	Cumulative percentage
0	39	15.7	15.7	22	2	.8	89.9
1	29	11.7	27.4	23	2	.8	90.7
2	24	9.7	37.1	24	1	.4	91.1
3	13	5.2	42.3	25	1	.4	91.5
4	25	10.1	52.4	27	2	.8	92.3
5	8	3.2	55.6	28	2	.8	93.1
6	12	4.8	60.5	30	2	.8	94.0
7	15	6.0	66.5	31	1	.4	94.4
8	10	4.0	70.6	32	1	.4	94.8
9	15	6.0	76.6	34	1	.4	95.2
10	8	3.2	79.8	36	1	.4	95.6
11	4	1.6	81.5	37	1	.4	96.0
12	5	2.0	83.5	42	1	.4	96.4
13	3	1.2	84.7	54	1	.4	96.8
15	3	1.2	85.9	55	2	.8	97.6
16	2	.8	86.7	56	1	.4	98.0
17	2	.8	87.5	63	1	.4	98.4
18	1	.4	87.9	75	1	.4	98.8
19	1	.4	88.3	80	1	.4	99.2
20	1	.4	88.7	99	1	.4	99.6
21	1	.4	89.1	153	1	.4	100.0
				Total	248	100.0	

The trend of increasing Covid-19 did not only occur in Batang Regency, but all of the world. This showed that the transmission and distribution of Covid-19 is so fast in a

wide scope. These result was in line with Sahin's research stating that the Coronavirus (CoV) has included in the Coronavirus genus with high mutation level. As the most

of virus character which attack the respiratory system, transmission occurred through the person who had symptoms of the disease [9]. However, nowadays, the person infected by this virus does not show the symptoms, so the data about the way the disease is transmitted is still being studied until now.

The map of cases distribution in the monthly period can be seen in Fig. 1, with red color, which indicated that an infected area with Covid-19 has expanded over time. The distribution cases of Covid-19 is an accumulation of the village areas distribution cases Covid-19 which obtained by grouping the accumulated domicile data in monthly period. An area with the largest infected area were in December on 177 villages (71.37%).

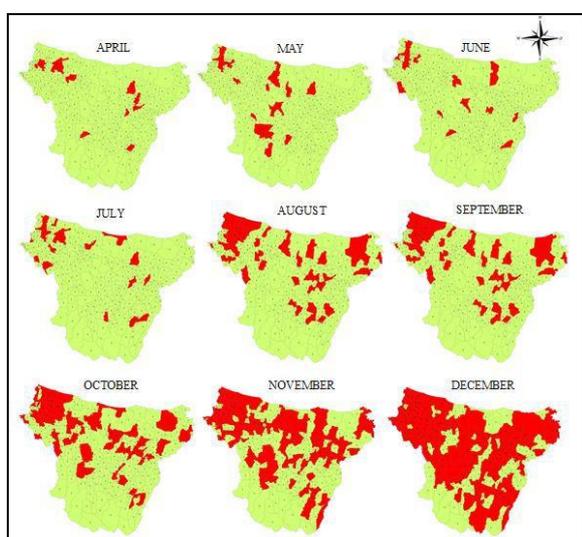


Fig.1: Map of distribution case per April until December 2020

Based on these results, it can be concluded that the highest cases and distribution of Covid-19 infected areas in Batang occurred in December and there were 4 villages

with the highest accumulated number of cases which closed each other. Distribution areas of cases increased alongside increasing the number of cases. The higher number of cases in a period, followed with the wider distribution area of cases. The research about distribution cases of Covid-19 conducted by Dayun Kang showed at the beginning stage of Covid-19 pandemic, this disease widespread fast from one area to another in China. The spatial distribution pattern of the disease become so important to be done as an effort to prevent further transmission to various types of environment in China [10]. Ren was mentioned the importance of early and quick identification of zones potentially risk of Covid-19 infection in big cities for infection prevention and control efforts. Ren et.al did various spatio-temporal evaluations with Ecological Niche Model / ENM approach method to identify potential risk zones for this infection [11].

The distribution pattern of Covid-19 cases can be determined by using spatial autocorrelation which showed that there was a distribution pattern change from random to clustered with significant spatial correlation value (p value < 0.01 and Z-score > 2.58) in August, September, October, November and December. The highest Z-score was in October (15.53). The distribution pattern of cases in April, June and July formed random pattern which showed no spatial autocorrelation. In August until December, the case distribution pattern formed clustered or systematic pattern on the spatial distribution of case number. The p value <0.01 and Z score> 2.58 indicated a significant spatial autocorrelation. The Moran index value of $0 < I \leq 1$ indicated that there is positive spatial autocorrelation, which was systematic pattern alongside the closer regional or neighborhood. Distribution pattern and density level Cases of Covid-19 was shown in Table 3.

Table 3. Moran's Index Value of Covid-19 Distribution Cases per April until December 2020

Month	Moran's Index	Spatial correlation		Information
		Z-score	p-value	
April	0.0215	1,0506	0.2934	Random
May	0.0436	1,941	0.0522	Clustered
June	0.0087	0.6105	0.5415	Random
July	0.0129	0.7656	0.4338	Random
August	0.2385	10,6496	0.0001	Clustered
September	0.2154	8,9161	0.0001	Clustered
October	0.3586	15,5277	0.0001	Clustered
November	0.2169	8,9613	0.0001	Clustered
December	0.4363	18,392	0.0001	Clustered

The distribution pattern cases of Covid-19 with the Moran index showed there was a distribution pattern change from random to clustered. This indicates there was spatial randomness which formed cluster patterns or a trend towards space [12]. Kosfeld had pointed about classification methods of the characteristics spatial autocorrelation, which was about 4 things. First, if there is systematical patterns on spatial distribution of observed variables, there is spatial autocorrelation. Second, if inter-regional nearest or neighborhood was closer, it can be said that there was positive spatial autocorrelation. Third, negative spatial autocorrelation describes unsystematical neighborhood patterns. Fourth, if random patterns of spatial data show no spatial autocorrelation [13]. The distribution pattern of Covid-19 cases in Batang Regency was inclined to become clustered with significant spatial autocorrelation values. This means that the distribution of cases between regions has significant nearest or neighborhood.

The spatial analysis about the risk distribution Covid-19 in Indonesia was conducted by Eryando to describes the distribution of Covid-19 cases in Indonesia’s areas on

March 3 until April 9, 2020. Jakarta, Yogyakarta, West Java, Gorontalo, and North Sulawesi were the areas with high risk of getting infected by Covid-19 in Indonesia [14]. The other research about spatial analysis was done by Franch-Pardo to review of the spatial analysis and Geographic Information System (GIS) to analyze of the Covid-19 level cases density by LQ method [15]. Table 4 was determined measurement and mapping of the distribution of cases based on the level of density cases in Batang Regency. This showed that the level of density cases was highly influenced by the increase of the cases number per village and distribution of infected areas. The density cases level of Covid-19 based on LQ showed the highest distribution value of $LQ > 1.2$ on November, which was on 58 villages. The LQ value ranges from 0 to ≥ 120 with 5 categories. Very light category ($0.00 \leq LQ < 0.80$), mild category ($0.80 \leq LQ < 0.95$), average category ($0.95 \leq LQ < 1.05$), high category ($1.05 \leq LQ < 1.20$) and the highest category ($LQ \geq 120$) [16].

Table 4. Location Quotient (LQ) Value of Covid-19 Cases per April until December 2020

Month	LQ value					amount
	≤ 0.8	≤ 0.95	≤ 1.05	≤ 1.20	> 1.20	
April	-	-	1	1	9	11
May	-	-	1	-	16	17
June	-	-	2	-	14	16
July	-	-	1	-	19	20
August	2	3	1	3	44	53
September	3	3	3	3	51	63
October	11	1	7	8	56	83
November	39	10	6	7	58	120
December	90	15	7	10	55	177

This result is in line with the research by Hazbavi, who conducting a spatio-temporal analysis of Covid-19 incidence at various locations in Iran, showed that there was a difference in the spatio-temporal pattern and the Location Quotient (LQ) index in most Iran’s provinces having $LQ > 1$ [17].

The map of the concentration level of Covid-19 cases can be seen in Figure 3 which has 5 color categories with a value range between 0 to > 1.2 . Regions with $LQ > 1,2$ were shown in red.

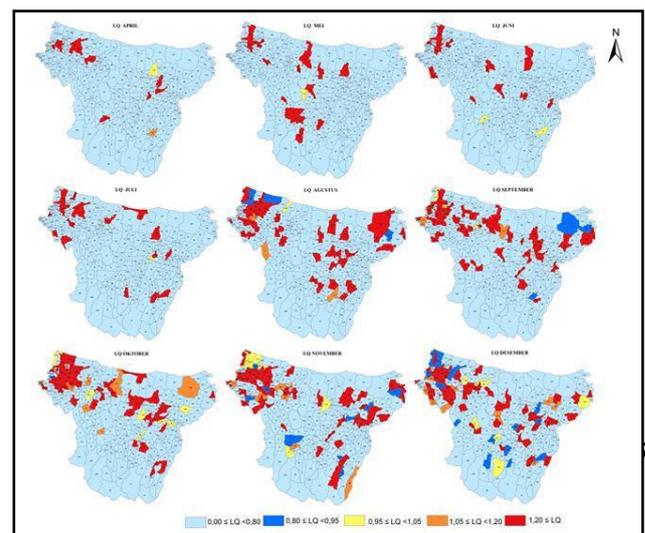


Fig.2: Map of Location Quotient (LQ) per April - December 2020

The highest percentage of area distribution with $LQ \geq 120$ occurred in July at 95% and the lowest percentage in December (31.07%). The LQ value ≤ 0.8 had the largest area distribution in December (50.85%) and the lowest in April, May, June and July (0%). Based on the distribution pattern and concentration level of Covid-19 cases, it can be concluded that October had the highest Z-score value, and November had the highest case density level distribution ($LQ > 1,2$) in Batang Regency.

IV. CONCLUSION

Spatio-temporal analysis in this study showed that there was a pattern change in the distribution of Covid-19 cases from random (April to July) to clustered (August to December) alongside increase of the cases number and the distribution of infected areas in a certain time and places. This shows that spatio-temporal analysis can be used as a method to describe the spatial trend of disease distribution and pattern of cases in an area within a certain time. The more red color on the map of Covid-19 cases shows the increasing number of cases and the density level of cases in an area in one period of time.

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