Characteristics, Effective Reproduction Number (Rt), and Spatial Modelling of Covid-19 Spread at Magetan District, East Java, Indonesia

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Abstract: Covid-19 has been rapidly spreading to various regions in Indonesia including to Magetan District which has the 3rd highest cases (0.91%) in East Java Province. This study was aimed to determine the characteristics, effective reproduction number (Rt) and spatial modelling of Covid-19 spread in the Magetan District. This was a cross-sectional study which included 43 patients with confirmed Covid-19. Univariate analysis was used to describe the characteristics of Covid-19. Epiestim was used to calculate Rt while the spread of Covid-19 cases was spatially modelled using Crimestat. On June 28, 2020, Magetan had 96 suspected cases, 104 confirmed cases with 75 cases were recovered and 4 people died. Most of the confirmed cases were at the age group of 40-49 years (22.6%), male (54%), and symptomatic (91.5%). Fever was the most commonly found symptom (81.7%). The Rt for the period March 10, 2020-June 28, 2020 was 1.27 (0.85-1.82; 95% CrI). Spatial analysis showed that the distribution of confirmed cases was widespread in 15 sub-districts. The Covid-19 outbreak was still out of control and still ongoing in Magetan. Therefore, a strong implementation of health protocol is recommended.

1 INTRODUCTION

Corona virus disease-19 (Covid-19) is an infectious disease caused by Severe Acute Respiratory Syndrome-Corona Virus-2 (SARS-CoV-2) formerly known as 2019-nCov. This disease was firstly identified from 41 cases of pneumonia with unknown cause in Wuhan, Hubei Province, China on December 30, 2019. It was reported that the disease related to the contact with the seafood market (Isaac I. Bogoch, Alexander Watts, Andrea Thomas-Bachli, Carmen Huber, 2020; Lu, Stratton and Tang, 2020; WHO, 2020a, 2020c).

On March 11, 2020, World Health Organisation (WHO) declared a global Covid-19 pandemic due the rapid increase in the number of cases (13 times) and affected countries (three times) within two weeks (Cucinotta and Vanelli, 2020; Sohrabi et al., 2020). As of May 5, 2020, the Covid-19 pandemic has spread to 215 countries and territories. Globally there were 3,525,116 confirmed Covid-19 cases and 243,540 deaths (WHO, 2020b).

While in Indonesia as of May 6, 2020, there were 12,071 confirmed Covid-19 and 872 deaths. East Java Province is the second epicenter of Covid-19 cases in Indonesia after DKI Jakarta (Kemenkes R, 2020). Magetan District had 69 positive people with 4 people

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died which make this district had the third highest confirmed cases in East Java Province. Furthermore, Magetan District has relatively high population mobility due to tourism attractions which increase the risk of Covid-19 spread in this area.

At present, most countries, including Indonesia, are preparing for a new normal life, as well as the Magetan District. WHO has issued public health criteria to adjust public and social health measures in the context of Covid-19. According to WHO, the covid-19 outbreak can be considered as "in controlled" if the Rt <1 for at least 2 weeks.(World Health Organisation, 2020) This study aims to determine the characteristics, effective reproduction number and spatial modeling of Covid-19 spread in Magetan District, East Java Province, Indonesia.

2 MATERIALS AND METHODS

2.1 Research Design and Population

This study was an observational study using a cross-sectional design. This study used secondary data from the Magetan District Health Office. Suspect and confirmed cases of Covid-19 between the period of period March 10 to June 28, 2020 were included in this study. Suspect and confirmed cases were define according to WHO definition (WHO. World Health Organization, 2020).

The sample size was calculated using the assumptions of (i) level of significant = 0.05, (ii) the power of the study = 80%, (iii) the case proportion p = q = 0.5, which yielded a minimum sample size of 43 people. The total sample size included in this study was 71 confirmed cases and 392 suspected cases. The data were collected by the Magetan District Health Office through a survey which include demographic characteristics, geographical location, date of onset, symptoms and signs, as well as travel history from / to outside city.

This study has undergone ethics review and received ethics approval from Health Research Ethics Committee, Faculty of Medicine, Jenderal Soedirman University (Reference number 137/KEPK/VI/2020).

2.2 Data Analysis

The basic characteristics of the confirmed cases were described according to age group, sex, travel history to / from out of town, symptoms and signs.

The effective reproduction number (Rt) is an important parameter to find out whether outbreak control is effective or additional interventions are needed (Nishiura and Chowell, 2009). Rt values represent the number of new secondary cases that are infected from one infective case at time t. If Rt> 1, the possibility of disease will become epidemic, if Rt = 1, the disease becomes endemic and if Rt <1, the possibility of disease will disappear from circulation (Camacho et al., 2015). In this study, Rt was calculated using EpiEstim software based on Excel developed by Cori et al in 2013(Cori et al., 2013), and corrected by Thomson et al in 2019 (Thompson et al., 2019). The mean serial interval (SI) and standard deviation (SD) from of Tindale et al were used in this study with the average SI = 4.56 and SD = 0.95 (Tindale et al., 2020).

The standard deviational ellipse (SDE) was used to analyze trends and patterns of dispersion of confirmed Covid-19 cases. Standard deviation ellipse is a summary of central tendency and dispersion in two dimensions, as well as a directional trend. Two points were used as the basis for the distribution of point locations on SDE which were central tendency and dispersion. Central tendency uses the center of the mean while dispersion refers to the spread of the center mean bounded by the ellipse. Standard deviational ellipse models can be used to gain a better understanding of the geographical aspects of the phenomenon and identify the cause of an event, based on specific geographic patterns (Lai, So and Chan, 2008). The spatial analysis was conducted using Crimestat software.

3 RESULTS

Magetan District is one of the districts in East Java, Indonesia. Magetan District consists of 18 sub-districts and 235 villages with land area of 688.8 km2 and total population of 628,924. During the period from March 10 to June 28, 2020, there were 104 confirmed cases, and 4 cases died due to covid-19.

The characteristics of 104 confirmed cases when first treated are presented in Table 1. The confirmed cases were predominantly at the age group of 15-24 years (30.8%) and male (69.2%). Only 20.2% of confirmed cases were symptomatic with main symptoms were cough (12.5%) and fatigue (6.7%). The proportion of confirmed cases with comorbidities were 17.3% with pneumonia (8.7%) and hypertension (5.8%) were the most frequent comorbidities. The number of deaths among confirmed cases was four people which resulted in mortality rate of 4.8%. Most of deaths were occurred at the age of 35-64 years and 3 out of 4 cases had comorbid diseases.

Table 1: The characteristics of confirmed Covid-19 cases.

Characteristics	Recovered		Died		Total	
	n	%	n	%	n	%
Gender						
Male	4	100	68	68	72	69.2
Female	0	0	32	32	32	30.8
Age Group						
0-<5	0	0	2	2	2	1.9
5-14	0	0	2	2	2	1.9
15-24	0	0	32	32	32	30.8
25-34	0	0	17	17	17	16.3
35-44	2	50	11	11	13	12.5
45-54	1	25	20	20	21	20.2
55-64	1	25	11	11	12	11.5
65-74	0	0	4	4	4	3.8
75-84	0	0	1	1	1	1
Citizenship						
Indonesian	4	100	78	78	82	78.8
Foreigner	0	0	22	22	22	21.2
Symptoms						
Yes	4	100	17	17	21	20.2
No	0	0	83	83	83	79.8
Type of symptoms						
Fever	2	50	2	2	4	3.8
History of fever	3	75	3	3	6	5.8
Cough	2	50	11	11	13	12.5
Flue	0	0	3	3	3	2.9
Sore throat	0	0	2	2	2	1.9
Dyspnoea	3	75	2	2	5	4.8
Shivering	0	0	1	1	1	1
Headache	0	0	1	1	1	1
Fatigue	2	50	5	5	7	6.7
Myalgia	0	0	2	2	2	1.9
Nauseous vomit	1	25	2	2	3	2.9
Abdominal pain	1	25	2	2	3	2.9
Comorbidities						
Yes	3	75	15	15	18	17.3
No	1	25	85	85	86	82.7
Type of comorbidities						
Diabetes Mellitus	0	0	3	3	3	2.9
Hypertension	1	25	5	5	6	5.8
Cancer	0	0	1	1	1	1
Liver diseases	0	0	1	1	1	1
COPD	0	0	2	2	2	1.9
Tuberculosis	0	0	1	1	1	1
Pneumonia	2	50	7	7	9	8.7

The trends of effective reproduction number (Rt) for the period March 10 to June 28, 2020, is shown in figure 1. From the calculation, the average Rt during this period was 1.27 (95% CrI: 0.85-1.82). The trends of Rt are further detailed in the table 3. In the last 14 days of the the observation period from 15-28 June 2020, the Rt for several days are below 1. However, the upper bond of the Rt is still above 1 in all of the observation days.

The results of the spatial modelling of the spread of covid-19 for the period March-July 2020 in Magetan district are presented in Table 3 and Figure 2. According to Table 3, it is found that the counter clockwise shifted from 43.81° to 60.10°, SD x from 0.02 km to 0.05 km and SD y from 0.08 km to 0.11 km. Based on Figure 2, the trend of the spread is predicted to be towards the southwest and the northeast and counter clockwise.

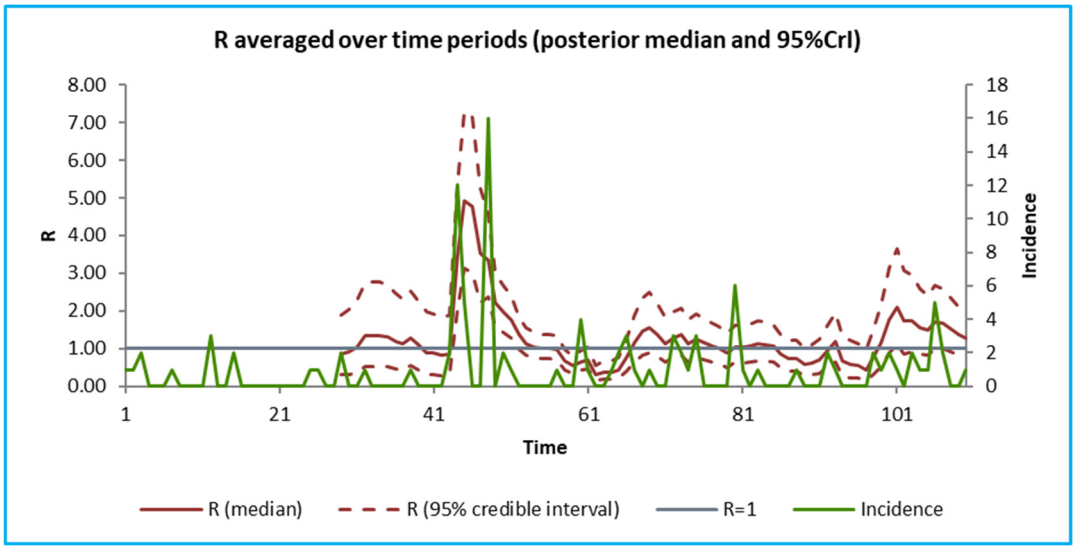

Figure 1: Trends of Effective Reproductive Number (Rt) of Covid-19 in Magetan District, Period March 10 to June 28, 2020.

4 DISCUSSION

Our research aims to determine the characteristics, effective reproduction number (Rt), and spatial modeling of Covid-19 spread in Magetan district. The confirmed cases in Magetan District were predominantly occurred in the age group of 15-24. Covid-19 affects individuals in all age groups (Centers for Disease Control and Prevention, 2020). The high number of confirmed cases in this age of group related to outbreak which were happened in the Islamic boarding school located in Magetan District. At the beginning of the outbreak, no action has yet been taken to close the learning activity in school and resulted to rapid transmission of Covid-19 among the students. One of the Islamic boarding schools had students from Malaysia which explain a significant proportion of the confirmed cases were foreign citizens. The existence of foreign students with travel history inside and outside of the city increase the risk of Covid-19 transmission. Previous study shows that travelling and people mobility increase the risk of Covid-19 transmission (Bi et al., 2020).

The confirmed Covid-19 cases in this study were mostly men which are consistent to the findings in many studies. Men have higher susceptibility to Covid-19 likely due to exposure of major risk factor such as smoking. Furthermore, compare to women, men have less protection the X chromosome and sex hormones which play an important role in innate immunity and adaptation (Jaillon, Berthenet and Garlanda, 2019; Cai, 2020; Chen et al., 2020).

Table 2: Trends of effective reproductive numbers (Rt) of covid-19 for the last 14 days.

Onset	Rt		
	Q 5%	Median	Q 95%
15/06/2020	0.19	0.44	0.87
16/06/2020	0.37	0.76	1.35
17/06/2020	0.60	1.15	1.98
18/06/2020	0.99	1.77	2.88
19/06/2020	1.22	2.12	3.36
20/06/2020	0.98	1.74	2.83
21/06/2020	1.04	1.74	2.72
22/06/2020	0.95	1.56	2.40
23/06/2020	0.92	1.49	2.25
24/06/2020	1.11	1.71	2.50
25/06/2020	1.11	1.69	2.43
26/06/2020	1.01	1.53	2.21
27/06/2020	0.90	1.37	1.98
28/06/2020	0.85	1.27	1.82

In this study, the mortality rate of Covid-19 confirmed cases is 4.7% which is relatively high compare to global mortality rate. The death cases were occurred in the age group of 35-64 years and most of them had comorbidities. Older individual and individuals with comorbidities such as chronic disease have been known to have the higher fatality risk of Covid-19. However, when individuals are 80 years old or older, the risk of fatality are more and less the same disregard to the presence of comorbidities (Chen et al., 2020; Onder, Rezza and Brusaferro, 2020). According to the Centers for Disease Control and Prevention (CDC), the risk of fatality is significantly higher for the age group of ≥65 years and for all age groups with comorbidities such

as chronic lung disease, moderate-severe asthma, heart disease, and immunocompromised patient (cancer treatment, smoking, organ transplantation) or bone marrow, immune deficiency, uncontrolled HIV / AIDS, prolonged use of corticosteroids, and other treatments that weaken the immune system), severe obesity, diabetes mellitus, chronic kidney disease, and liver disease, increase the risk of suffering from severe covid-19.(Centers for Disease Control and Prevention, 2020)

Table 3: Results of Spatial Modeling of Spread of Covid-19 in Magetan District, Period March-July, 2020.

	March	April	May	June	July
Sample size	9	46	56	60	122
Clockwise angle of Y-axis rotation (°)	43.81	33.90	44.95	43.11	60.10
Ratio of the long to the short axis after rotation	4.46	1.87	1.99	1.50	2.17
Standard deviation along the new X axes (km)	0.02	0.03	0.03	0.04	0.05
Standard deviation along the new Y axes (km)	0.08	0.05	0.06	0.06	0.11
X-axes length	0.04	0.06	0.06	0.09	0.10
Y-axes length	0.16	0.11	0.12	0.13	0.22
Area of the ellipse defined by these axes (km^2)	0.00	0.00	0.01	0.01	0.02
Standard deviation along the X axes (km)	0.04	0.06	0.06	0.09	0.10
Standard deviation along the Y axes (km)	0.16	0.11	0.12	0.13	0.22
X-axes length for a 2× SDE	0.07	0.11	0.13	0.17	0.20
Y-axes length for a 2× SDE	0.32	0.21	0.25	0.26	0.43
Area of the 2× ellipse defined by these axes (km^2)	0.02	0.02	0.02	0.03	0.07

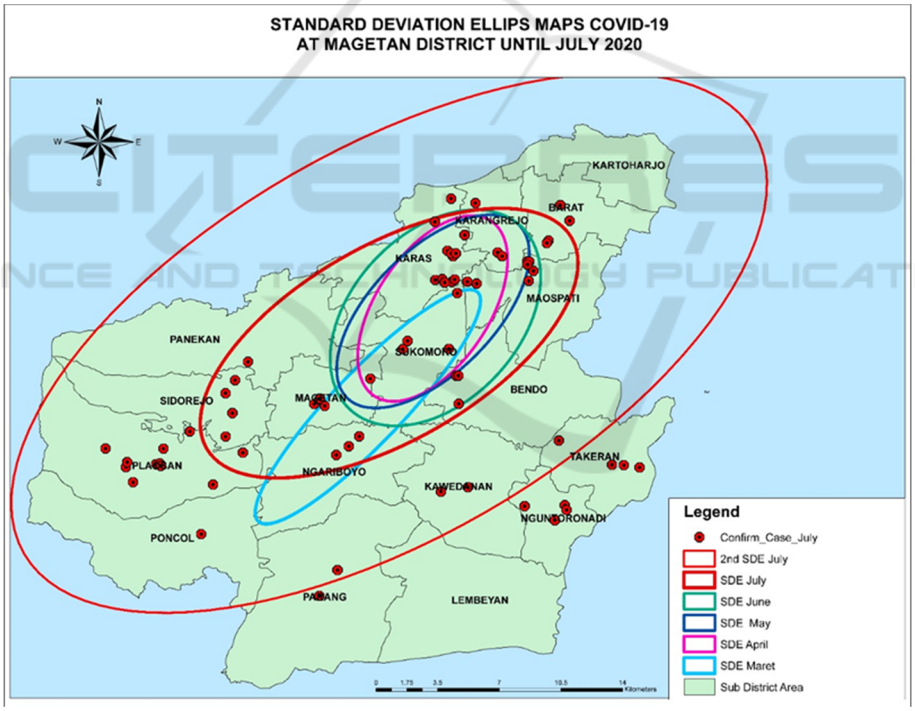

Figure 2: Results of SDEs Map of Covid-19 in Magetan District, Period March-July, 2020.

The effective reproduction number (Rt) in the last 14 observation days (June 15, 2020 to June 28, 2020) was still above one. This indicates that the Covid-19 outbreak in Magetan Districs are still not under controlled (World Health Organisation, 2020).

Spatial modeling of spread covid-19 found that the prediction of the spread of covid-19 to the southwest and northeast in a counter clockwise direction. This can be seen from the results of the analysis of the standard deviation ellipse (SDE). SDE and mean center visually form spatial and temporal movement of disease explicitly. The spatiotemporal analysis of this disease estimates future disease patterns based on previous disease trends. This has

implications for policy development and resource planning according to the groups most at risk (Lai, So and Chan, 2008). Therefore, efforts to increase discipline on health protocols such as wearing face masks properly, maintaining distance from others at least 1-2 meters, and handwashing regularly. In addition of that, contact tracing, testing and treatment need to be continued and improved, as well as protection for the vulnerable groups.

5 CONCLUSIONS

The covid-19 outbreak in Magetan Districs is still not under controlled. Therefore, it is still necessary to strictly implement health protocols and other prevention efforts. Tracing contacts, testing and treatment need to be strengthened as well as effort to protect the vulnerable groups.

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