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Correlation between Criteria Air Pollutants and Daily Case of COVID-19 Pandemic in Padang City

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Abstract: From the concept of the epidemiological triangle, air pollution is a risk factor that becomes a carrier of disease agents and affects the vulnerability of the human body, including COVID-19. This study aims to see the correlation between PM_{10}, CO, O_3, SO_2, and NO_2 with daily cases of COVID-19 in Padang City. This study uses an ecological study using one-year data (March 26, 2020 - March 26, 2021). Data for specific pollutants were obtained from reanalysis datasets of the European Center for Medium-Range Weather Forecast (ECMWF). Meanwhile, data on the COVID-19 pandemic was obtained from the daily report of Padang City. Spearman and Pearson correlation tests were used to assess the correlation of specific pollutants with COVID-19 daily cases. The results found that CO, O_3, SO_2, and NO_2 correlated negatively with COVID-19 daily cases at lag 0, lag –7, lag –14, and lag –21. In contrast, PM_{10} positively correlates at lag 0 and lag -7. Social distancing also had a significant relationship with the concentrations of O_3 and PM_{10}. Understanding the contribution of air pollutants to the increase of COVID-19 daily cases is essential for preventing more serious health impacts and requiring policy to control the emissions.
Keywords: particulate matter, carbon monoxide, tropospheric ozone, sulfur dioxide, nitrogen dioxide, COVID-19

1. Introduction

At the end of 2019, all countries began to face an outbreak of pneumonia in Wuhan, China. Two months later, WHO inaugurated COVID-19 as the disease's official name [1]. Indonesia is one of the countries that experienced the highest increase in COVID-19 cases. The government has issued several policies to prevent the pandemic, such as improving health protocols, isolating positive patients, physical distancing, social distancing, and restricting human movement between regions [2].

Similar conditions also occur in the city of Padang, West Sumatra. Since March 26, 2020, there has been a significant increase in COVID-19 cases, followed by a rise in COVID-19 deaths [3]. This condition needs to be studied from the concept of the epidemiological triangle, where the infectivity of a virus is influenced by the susceptibility of the disease host and environmental conditions [4]. Air pollution, which is included in environmental factors, can affect host immunity and carriers of viruses as disease agents [5]–[7]. With the interaction between air pollution and viruses and hosts, several studies have shown that indicators of pollutants in the air also influence the spread of the COVID-19 viruses.

In early 2020 in China, it was found that short-term exposure to PM_{10}, CO, NO_2, and O_3 has a significant relationship with the risk of COVID-19 infection [8]. Research in Korea found a significant relationship between concentrations of NO_2, CO, and SO_2 with COVID-19 daily cases [9]. Previous studies found that the virus's incubation period ranges from 7 to 21 days [10]–[12]. Therefore, this study will look at the correlation between PM_{10}, CO, O_3, SO_2, and NO_2 with COVID-19 daily cases in Padang City. In addition, the social restrictions imposed by the Padang City government from April 22, 2020, to June 7, 2020, resulted in changes in mobility, so it is necessary to know the impact of criteria air pollutants and their correlation with COVID-19 daily cases in the city of Padang.

2. Material and Methods

2.1. *Sample collection and preparation*

This research used an ecological study approach to see the strength of the relationship of specific air pollutant variables with COVID-19 daily cases. One year of data on COVID-19 daily cases, from March 26, 2020 (confirmation of the first case) to March 25, 2021, was collected from the Padang City Health Office. Daily data on specific air pollutants (PM_{10}, CO, O_3, SO_2, and NO_2) concentrations were obtained from reanalysis datasets of the European Center for Medium-Range Weather Forecast (ECMWF) provided by the Global Atmosphere Watch Koto Tabang. Data was collected from March 5, 2020, to March 25, 2021. The reason for using specific pollutant data from ECMWF is because satellite data from ECMWF can produce a higher resolution. It also produces detailed pollutant measurement data obtained from the entire Padang City area, compared to other measurements of air pollutants data that are only carried out at one point.

2.2. Data Analysis

The data were processed according to a period of virus incubation in the human body: day 0 (lag 0), day 0-7 (lag -7), day 0-14 (lag -14), and day 0-21 (lag -21). Based on the normality test using the One-Sample Kolmogorov-Smirnov test, the correlation between PM_{10}, O_3, SO_2, and NO_2 with daily cases of COVID-19 was tested using the Spearman correlation test. Meanwhile, the correlation between CO and daily COVID-19 cases will be tested using the Pearson correlation test. The level of linear dependency between the two variables was defined as very strong ($r > 0.7$), strong ($0.7 \leq r < 0.5$), moderate ($0.5 \leq r \leq 0.3$), and weak ($r < 0.3$). The strength of the correlation value + indicates a unidirectional relationship, while the value - indicates an inverse relationship The Two-Sample t-test that assumed unequal variances was conducted to determine differences in pollutant levels during social restriction and non-social restriction periods.

3. Results and Discussion

3.1. Correlation between Specific Pollutants and COVID-19 Daily Cases

From 26 March 2020 to 25 March 2021, the peak of COVID-19 daily cases occurred on 16 October 2020 as many as 347 cases. The highest pollutant levels for PM_{10}, CO, O_3, SO_2, and NO_2 were 975 ppb, 14 ppb, 64 ppb, 69 µg/m^3, and 46 ppb, respectively (Figure 1). Table 1 shows the correlation between specific pollutants (PM_{10}, CO, O_3, SO_2, and NO_2) and the daily cases of COVID-19 in Padang City.

Table 1. Correlation between Specific Pollutants and Daily Cases of COVID-19

Time	CO		NO_2		O_3		PM_{10}		SO_2	
Lag	Pv	r	Pv	r	Pv	r	Pv	r	Pv	r
Lag 0	<0.001	-0.376*	<0.001	-0.338*	<0.001	-0.209*	0.02	0.160*	0.004	-0.150*
Lag -7	<0.001	-0.353*	<0.001	-0.343*	<0.001	-0.195*	0.02	0.120*	<0.001	-0.185*
Lag -14	<0.001	-0.237*	<0.001	-0.315*	<0.001	-0.173*	0.06	0.098	0.029	-0.114*
Lag -21	<0.001	-0.211*	<0.001	-0.285*	0.009	-0.138*	0.21	0.066	0.04	-0.107*

**Significant correlation*

PM_{10}, O_3, SO_2, and NO_2, had a significant negative correlation with daily cases of COVID-19 at all-time lags. However, PM_{10} has a significant positive correlation at lag 0 and lag -7. As a respiratory disease, COVID-19 is associated with high levels of CO exposure. However, this study found CO has a significant negative correlation with COVID-19 daily cases in all-time lags. The negative correlation can be explained because CO levels are far below the quality standard. They have not affected problems in the respiratory system that can increase the risk of emergencies due to the Sars-Cov-2 virus. CO exposure is associated with increased endogenous CO concentrations, resulting in carboxyhemoglobin (COHb) and airway inflammatory disease [13]. An increase of 0.1 ppm CO (lag -21) is associated with confirmed COVID-19 daily cases [9]. Another study also found that an increase of 1 unit of CO level will increase daily cases and deaths of COVID-19 significantly by 21.3% and 21.8%, respectively [14].

At all-time lags, NO_2 correlates significantly with COVID-19 daily cases. This is similar to previous research in California and Bangkok found that NO_2 and COVID-19 are associated negatively [15], [16]. In contrast, research in the UK found that nitrous oxide was a major contributor to the increase in morbidity and mortality in the early phase of the pandemic of COVID-19. Other research also stated that NO_2 levels are also significantly associated with increased COVID-19 infectivity (OR: 1,020 95% CI: 1,027-1,013) and death (OR: 1,025 95% CI: 1,032-1,019) [17]. A study found a positive relationship between NO_2 concentration and new daily confirmed cases of COVID-19 in Korea. The findings showed that the increase of 0.01 ppm NO_2 (lag -7, lag -14, and lag -21) is associated with the rise od in confirmed COVID-19 cases significantly, with an OR (95% CI) of 1.13 (1.02-1.25), 1.19 (1.09-1.30), and 1.30 (1.19-1.41) [9]. In addition, the rise of NO_2 (lag -14) was associated with 6.94% of COVID-19 daily cases (95% CI = 2.38 - 11.51) (95% CI = 2.38 - 11.51) [8]. This is also similar to SO_2 in that there was a significant correlation for all-time lags regarding the correlation of SO_2 and COVID-19 daily cases. However, the results of several studies show that increasing SO_2 concentrations raises the risk of all-cause and respiratory death in humans [18].

In Padang City, PM_{10} found a significant positive correlation with COVID-19 daily cases in time lag 0 and time lag -7. Since cardio-respiratory diseases become risk factors for COVID-19-related mortality, the presence of PM10 as a substance may increase the risk of these diseases [19]. PM_{10} was a significant predictor of increased infectivity of SARS-CoV-2 with an odds ratio of 1.078 (CI: 1.109-1.048). An increase of one PM_{10} unit is associated with approximately 8% more cases of COVID-19 [17].

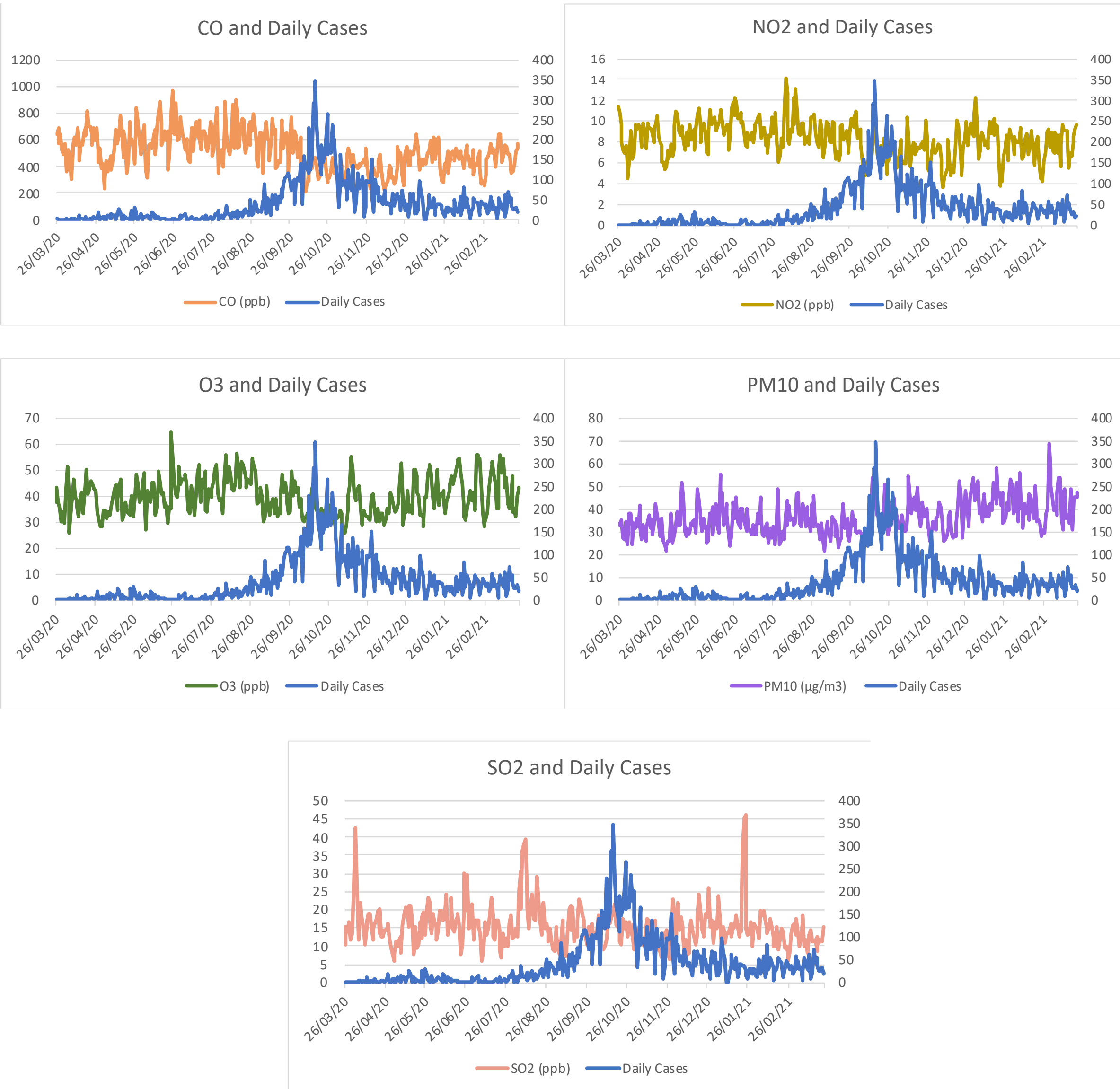

Figure 1. Concentration of Specific Pollutants and COVID-19 Daily Cases

This study found that O_3 had a significant negative correlation with COVID-19 daily cases in all-time lag. The negative relationship between O_3 and morbidity and mortality can be explained by the conversion of NO_2 to O_3. This mostly happens in urban areas with heavy traffic, where NO_2 is known to significantly affect the infection [20]. A rise in O_3 (lag -14) has an association with a 4.76% increase in daily confirmed cases (95% CI = 1.99 - 7.52) [8]. However, another study found that the case-to-death rate ratio for O_3 levels was less than 1 (higher ozone levels contribute to a lower number of morbidity and mortality) [17].

3.2. Effect of Social Restriction on Pollutants in Padang City

To prevent the COVID-19 pandemic, the Padang City government implemented a social restriction starting from April 22, 2020, to June 7, 2020. During this time, work and school were carried out from home, with restrictions on public places and modes of transportation. The difference between pollutants during the social restriction and non-social restriction period can be seen in Table 2.

This study found that the mean concentration of O_3 and PM_{10} decreased significantly during the social restriction period, and the concentration of SO_2 was also lower than during non-social restriction. Reducing SO_2 emissions will also indirectly reduce the formation of secondary PM and O_3. This decrease in these pollutants could be caused by the suspension of inter-city transportation policies and reduced community mobility. This condition is by other studies that found an increase in air quality during the social restriction period [21].

Table 2. Effect of Social Restriction on Air Quality

Pollutant	Mean Concentration		Pv
	Non-Social restriction	Social Restriction	
CO (pbb)	514.3	545.6	0.08
NO_2 (pbb)	8.24	8.51	0.13
O_3 (pbb)	40.18	37.81	0.0005*
PM_{10} (µg/m^3)	36.53	32.98	0.0006*
SO_2 (pbb)	15.23	14.79	0.267

**Significant correlation*

Meanwhile, CO and NO_2 mean concentrations were higher in the social restriction period. Although there are restrictions on human movement during the social restriction period, CO and NO_2 are still high due to activities carried out as usual. Such as industry, markets, public transportation, and several other vital activities still have to operate to serve the community's needs. Another cause is the habit of people burning waste and biomass, which has not changed as in the non-social restriction period. This condition is similar to Zhang et al. (2021) because the government does not close certain important facilities so that there is no decrease in pollutant concentrations. This is different from previous studies where CO and NO_2 experienced a significant decrease in 20 major cities in the world due to the lockdown during the COVID-19 period [23]. Reduction in the O_3 concentration could be influenced by higher CO and NO_2 emissions due to the relationship can be inverted [24], [25].

Air pollution can influence the incidence of COVID-19 by various mechanisms. Worsening lung function can occur due to substances in air pollution, thereby increasing the fatality of this viral infection [26]. Cellularly, pollutants activate the immune response against bacteria, thereby reducing defenses against viruses. In addition, cell damage occurs, and inflammation increases due to the substances contained in pollutants. This can indirectly encourage more replication of the SARS-COV-2 virus [27].

The insignificant change in air quality needs to be explained by a deeper study of the sources of emissions in the city of Padang. Since CO and NO_2 are emitted from transportation and combustion, it needs to explore further industry operations and the amount of transportation that continues to pass through despite social restrictions. In addition, further analysis is needed regarding the involvement of meteorological conditions as a factor that affects the presence of pollutants in the air. Although there is a decrease in pollutant concentrations during the social restriction period, it is necessary to consider changes in the long-term quality of air related to COVID-19 severity. In addition, there are changes in local and regional regulations about air pollution.

4. Conclusion

This study found that criteria air pollutants have a significant negative correlation with daily cases of COVID-19 with a weak to moderate correlation ranging from -0.107 to -0.376. However, only PM_{10} showed a positive correlation with daily COVID-19 cases with a weak correlation. Restrictions on human movement can significantly affect air quality, particularly for O_3 and PM_{10}. In addition, social restriction policies can also control the spread of the epidemic. Other factors affecting the distribution of pollutants in ambient air must be explored further using more in-depth methods.

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