Original Article

The Correlation between Air Pollution Levels in East Jakarta and COPD Exacerbation at Persahabatan Hospital in 2019

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Abstract

Background: Air pollution has become a global environmental issue that has an impact on public health. Chronic obstructive pulmonary disease (COPD) is a chronic lung disease that can be caused by exposure to noxious gases and environmental factors. Cigarette smoke is a major risk factor for the development of COPD. However, several studies have shown that environmental exposures such as air pollution can contribute to the worsening of COPD. This study aimed to evaluate the correlation between the level of air pollution and exacerbation of COPD in East Jakarta in 2019.

Method: This was a retrospective cohort study on COPD patients who experienced exacerbation in 2019 and came to the emergency room of Persahabatan National Respiratory Referral Hospital (PNRRH). Data was taken from the medical records by consecutive sampling. Data on the Index of Air Pollution Standards were obtained from the DKI Jakarta Provincial Environmental Service.

Results: A total of 198 subjects met the inclusion criteria. Most of the subjects were male (92.4%), and the mean age was 63.39 years. Three pollutants had a positive correlation with COPD exacerbation rates, including PM_{10} (r=0.245), SO_2 (r=0.497), and O_3 (r=0.344). While the negative correlation were the levels of CO (r=-0.187) and NO_2 (r=-0.366). However, the correlations were not statistically significant.

Conclusion: PM_{10}, SO_2, and O_3 are correlated with COPD exacerbations, whose visits to the emergency department of Persahabatan hospital. However, this correlation does not establish a cause-and-effect correlation because there are still other factors that trigger COPD exacerbations.

Keywords: air pollution, COPD exacerbations, East Jakarta

INTRODUCTION

Air pollution has become a global environmental issue with significant impacts on public health, especially on the respiratory system. Air pollution is one of the risk factors for the occurrence of Chronic Obstructive Pulmonary Disease (COPD).[1,2] Several studies have shown that exposure to environmental air pollution is a key determinant in the development of

COPD.[2,3] However, there are other significant factors involved in the development of COPD, such as genetic factors and abnormalities in lung development.[4]

Recent studies have indicated a correlation between exposure to air pollutants, such as particulate matter (PM), and the occurrence of COPD exacerbations.[3] Studies conducted in the United States and Europe have concluded that for every 10 µg/m³ increase in PM_{10} levels, there is a 2.5% increase in the number of hospital visits due to COPD. Similarly, for every 10 µg/m³ increase in $PM_{2.5}$ levels, there is a 0.9% increased risk of hospitalization due to COPD. Additionally, a 5 ppb (parts per billion) increase in ozone (O_3) levels leads to a 0.27% increase in hospital admissions due to COPD exacerbations.[5]

Every 1 mg/m³ increase in CO gas levels is associated with an increased need for hospitalization due to COPD.[6] Currently, no research directly links air pollutant exposure to COPD exacerbations in Indonesia. This study aimed to investigate the correlation between air pollutant levels in East Jakarta and the incidence of acute COPD exacerbations among patients who presented at the Emergency Department of Persahabatan National Respiratory Referral Hospital (PNRRH) in 2019.

METHOD

This research employed a retrospective cohort design. Sample collection was conducted through consecutive sampling, and data from subjects meeting the inclusion criteria were extracted from medical records. The subjects in this study were patients diagnosed with COPD exacerbation who were above 40 years old and resided in East Jakarta, who visited the Emergency Department of PNRRH during the period from January 1, 2019, to December 31, 2019.

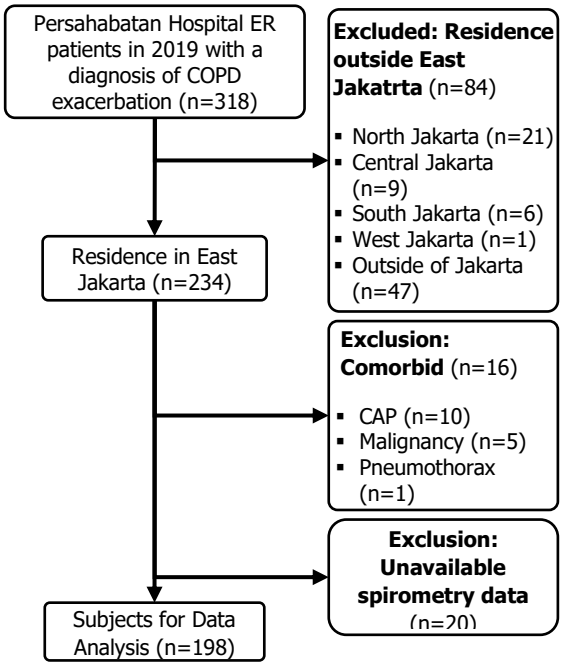

Figure 1. Flow of subject recruitment

Patients with COPD who had comorbidities such as cancer, pneumonia, asthma, and pneumothorax were excluded from this study. Data on the standard air pollution index (ISPU) in East Jakarta for the year 2019 was obtained from the Environmental Agency of DKI Jakarta Province, which includes particulate matter (PM_{10}), sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and nitrogen dioxide (NO_2).

The research data in this study were processed using the statistical program

SPSS for Windows version 22.0. The correlation between air pollutant levels and the incidence of COPD exacerbation was analyzed using the Pearson correlation coefficient when data distribution was normal or the Spearman correlation if the data distribution was not normal.

RESULT

In this study, 198 COPD exacerbation patients met the inclusion criteria. The mean age was 63.39±9.11 years, with the majority of subjects being male (92.4%).

Table 1. Demographic characteristics

Characteristic	n (%)
Age (mean±SD)	63.39±9.11
41-65 Years	118 (59.6%)
≥66 Years	80 (40.4%)
Sex	
Male	183 (92.4%)
Female	15 (7.6%)
ER visitation period	
January	17 (8.6%)
February	15 (7.6%)
March	12 (6.1%)
April	16 (8.1%)
May	15 (7.6%)
June	17 (8.6%)
July	15 (7.6%)
August	16 (8.1%)
September	16 (8.1%)
October	21 (10.6%)
November	13 (6.6%)
December	25 (12.6%)
Body Mass Index (mean±SD)	21.52±3.7
Normal	119 (60.1%)
Underweight	28 (14.1%)
Risk	18 (9.1%)
Type 1 Obesity	28 (14.1%)
Type 2 Obesity	5 (2.5%)
Brinkman Index	
Non-Smoker	15 (7.6%)
Mild BI	5 (2.5%)
Moderate BI	29 (14.6%)
Severe BI	149 (75.3%)
Distance to SPKU (mean±SD)	9.7±1.5
0.0-10.0 km	137 (69.2%)
10.1-15.0 km	61 (30.8%)

Most of the subjects were smokers, with 75.3% of them having a heavy smoking history. The mean distance from the subjects' residence to the Air Quality Monitoring Station, or *Stasiun Pemantau Kualitas Udara* (SPKU), was 9.7 km. A total of 119 subjects had a normal BMI. The highest number of emergency department visits due to COPD exacerbation was in December, with a total of 25 (12.6%) visits (Table 1). The majority of patients belonged to the COPD group E (94.4%) and the exacerbation group without respiratory failure (77.3%) (Table 2).

Table 2. Clinical characteristics of study subject (n=198)

Characteristic	n (%)
Treatment category	
Outpatient	105 (53.0%)
Inpatient	93 (47.0%)
Length of inpatient stay (Days) [Median (Min-Max)]	4 (1-24)
COPD Group	
Group A	1 (0.5%)
Group B	10 (5.1%)
Group E	187 (94.4%)
GOLD Criteria	
GOLD 1	12 (6.1%)
GOLD 2	43 (21.7%)
GOLD 3	84 (42.4%)
GOLD 4	59 (29.8%)
COPD Exacerbation Category	
Without respiratory failure	153 (77.3%)
Respiratory failure without a life-threatening condition	29 (14.6%)
Respiratory failure with a life-threatening condition	16 (8.1%)

The Standard Air Pollution Index or *Indeks Standard Pencemar Udara* (ISPU) is divided into five categories: good (0-50), moderate (51-100), unhealthy (101-199), very unhealthy (200-299), and hazardous (≥300).

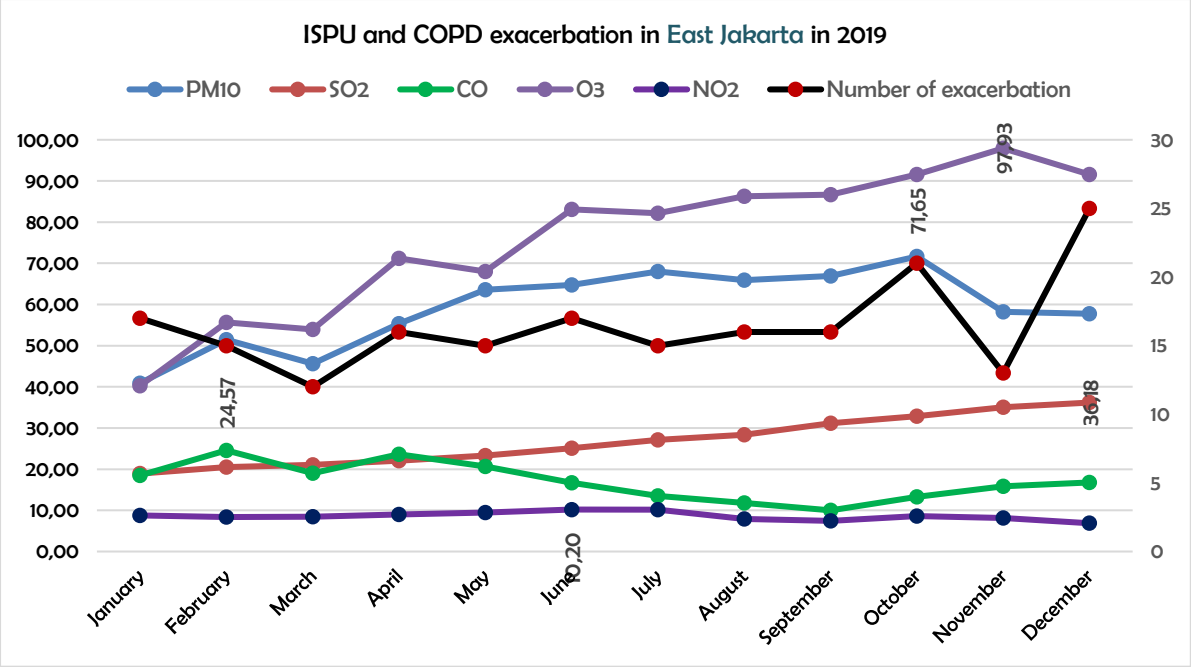

Figure 2. Air pollutant levels and number of COPD exacerbations in East Jakarta in 2019

For the East Jakarta region, PM_{10} and O_3 levels reached moderate levels, while SO_2, CO, and NO_2 were still within good air pollution index standards. The highest PM_{10} levels were recorded in October, while the highest levels of SO_2, CO, O_3, and NO_2 were observed in December, February, November, and June, respectively (Figure 2).

Among the five air pollutants, O_3 and PM_{10} had the highest ISPU levels and fell into the 'moderate' category. Meanwhile, the ISPU levels for SO_2, CO, and NO_2 remained in the 'good' category. The lowest ISPU level was attributed to NO_2. The ISPU levels, such as PM_{10}, SO_2, and O_3, showed a positive correlation with the number of COPD exacerbations, but the correlation was weak. Meanwhile, the correlation between CO and NO_2 levels and COPD exacerbations demonstrated a negative correlation with a very weak strength.

Table 3. Mean air pollution levels at the time of COPD exacerbation

Air Pollution exposure	Mean±SD) or Median (Min-Max)
PM_{10}	
PM_{10} D-day	60.50 (17-90)
PM_{10} D-3	59.81±11.70
PM_{10} D-7	59.48±10.46
PM_{10} Monthly	59.52±9.00
SO_2	
SO_2 D-day	28.00 (7-37)
SO_2 D-3	27.33 (7-43)
SO_2 D-7	27.29 (9.43-37.29)
SO_2 Monthly	27.13 (18.93-36.18)
CO	
CO D-day	16.00 (5-46)
CO D-3	16.50 (5.33-39.67)
CO D-7	16.65 (6.29-78.79)
CO Monthly	16.76 (10-24.57)
O_3	
O_3 D-Day	75.00 (13-185)
O_3 D-3	79.84 (17.67-143.0)
O_3 D-7	78.65 (26.86-130.64)
O_3 Monthly	83.10 (40.27-97.93)
NO_2	
NO_2 D-Day	8.00 (3-19)
NO_2 D-3	8.67 (3.67-16)
NO_2 D-7	8.71±1.71
NO_2 Monthly	8.55±1.01

Table 4. Correlation of particulate matter with COPD exacerbation

Particulate Matter	COPD Exacerbation	
	r	*P*
PM_{10}	0.26	0.44
SO_2	0.50	0.10
CO	- 0.19	0.56
O_3	0.34	0.27
NO_2	- 0.37	0.24

DISCUSSION

PM_{10} has a significant correlation with COPD exacerbations.[7–9] In this study, a positive correlation is observed between PM_{10} levels and the incidence of COPD exacerbations. Patients experiencing COPD exacerbations are exposed to an average PM_{10} ISPU value of 59.52±9.00, which is equivalent to a PM_{10} concentration of 150 µg/m^3. The COPD exacerbations correlate with PM_{10} on the day of exacerbation (ISPU 60.5), in the last 3 days (59.81), the last 7 days (59.48), and the monthly PM_{10} level (59.52).

Morantes-Caballero and colleagues found an increase in PM_{10} levels two days before the onset of COPD exacerbation symptoms.[7] The study by Krachunov et al also found a significant correlation between the average PM_{10} levels in the six days preceding COPD exacerbation.[8] Research in New Zealand yielded results indicating that each 14.8-unit increase in PM_{10} leads to a 3.37% increase in the incidence of COPD exacerbations.[9]

A systematic review and meta-analysis concluded that there is a correlation between short-term exposure to PM_{10} and the risk of COPD exacerbations.[9] The most significant correlation between COPD exacerbations and PM_{10} levels is observed in the three days leading up to the exacerbation.[10]

Several previous studies have demonstrated a positive correlation between SO_2 levels and the incidence of COPD exacerbations.[9,11–13] In this study, a positive correlation is found between SO_2 levels and the incidence of COPD exacerbations. Patients experiencing COPD exacerbations are exposed to an ISPU SO_2 value of 27.13 (18.93-36.18), which is equivalent to 52 µg/m^3. This value exceeds the threshold recommended by the World Health Organization (WHO), which is 20 µg/m^3.

A systematic review conducted by Moore and colleagues stated differing results between geographical regions. In the Asian region, there is a stronger positive correlation compared to Europe and North America. The average SO_2 levels in Asia are also higher than in Europe and North America, with levels of 25.1±11.3, 18±3.2, and 18.1±4.7 µg/m^3, respectively. Additionally, research in Taiwan found that the correlation between SO_2 levels and COPD exacerbations only occurred during the winter season.[14]

The study of the correlation between CO and COPD exacerbation were inconsistent. In this study, we obtained a negative correlation between CO levels and the incidence of COPD exacerbations with a correlation coefficient of r=-0.187 (P=0.561). Patients experiencing COPD exacerbations are exposed to an ISPU CO value of 16.76 (10-24.57), equivalent to 4000 µg/m^3. The results of this study are in line with findings from research in

Shanghai and Hong Kong, where they also observed a negative correlation between short-term CO exposure and the incidence of COPD exacerbations and hospitalizations. This negative correlation is more pronounced during the winter season.[15,16]

One hypothesis proposed is that COPD is an inflammatory disease, and the anti-inflammatory effects of exogenous CO have been suggested in some experimental and clinical trials. The first human pilot study on the impact of CO on COPD indicated that inhalation of CO at concentrations of 100-125 ppm by COPD patients resulted in a reduction in eosinophil counts in sputum and an increase in response to methacholine. Additionally, several reviews in the literature suggest that exogenously administered CO through CO-releasing molecules can have antimicrobial effects.[15,16]

There is a positive correlation between O_3 levels and COPD exacerbations. Patients with COPD exacerbations are exposed to an ISPU O_3 value of 83.1 (40.27-97.93), which is equivalent to 235 µg/m^3. Studies by Gao et al and Sun et al show a stronger correlation between O_3 exposure and COPD exacerbations during the summer and winter. This can be attributed to higher O_3 concentrations during the summer and increased outdoor activities, leading to greater exposure to air pollution, including O_3.[17] Conversely, Lin et al found that during the summer, with higher O_3 levels, lower exacerbation rates were observed. During the winter, with lower O_3 levels resulting in higher exacerbation rates.[18]

In this study, a negative correlation is observed between NO_2 levels and the incidence of COPD exacerbations. Patients experiencing COPD exacerbations are exposed to an average ISPU NO_2 value of 8.55±1.01, equivalent to 80 µg/m^3. This finding differs from the positive correlation observed in the study by Lin et al, with a correlation coefficient of r=0.763 (P<0.05). Research in Taiwan found a correlation between increased NO_2 levels and the incidence of COPD exacerbations during both the summer and winter seasons. Every one ppb increase in NO_2 was associated with a 1.00-1.30 odds ratio for COPD exacerbations.[18]

Other studies have reported an increase in visits to the emergency department and hospitalizations due to COPD exacerbations associated with higher NO_2 concentrations.[13,19] It has also been stated that each 10 µg/m^3 increase in NO_2 levels increases the incidence of COPD exacerbations by 2%.[13] Meta-analysis studies have found an increase in the number of COPD exacerbations with rising environmental NO_2 levels. This is more pronounced in low- and middle-income countries.[9] Similar results were obtained in the study by Du et al, which concluded that a 10 µg/m^3 increase in NO_2 levels is related to the incidence of COPD exacerbations.[20]

There are several limitations in this study. Firstly, this study was conducted retrospectively, so data quality depends on the completeness of medical records. Second, the subjects of the study were only

obtained from one hospital in East Jakarta and air pollution data were gathered only from one SPKU point. Third, there were variations in the distance of the subject's house/residence from SPKU, which could potentially cause variation in the amount of air pollution exposure among subjects.

Apart from that, several factors can affect air pollution levels in the environment, such as air temperature and wind direction/speed. Fourth, the level of air pollution used is ISPU, which is different from the literature abroad, who generally use units of $\mu g/m^3$. Lastly, there is no data comparison with the stable COPD group or healthy subjects.

CONCLUSION

Air pollution levels in East Jakarta have exceeded the established thresholds, resulting in an influence on COPD exacerbations. PM_{10}, SO_2, and ozone are particles from air pollution that are correlated with COPD exacerbations and visits to the emergency department of Persahabatan Hospital. The association between pollutant exposure and the occurrence of COPD exacerbations varies from findings in other studies. These disparities may be due to differences in research designs, variations in demographic profiles between countries/regions, fluctuations in local air temperatures and climates, disparities in other air pollutant concentrations, and other factors. Moreover, it is essential to note that this study was conducted solely at a single hospital in East Jakarta, utilizing air quality data from a solitary air quality monitoring station.

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