



## Examining association between air pollution and emergency department visits and hospitalizations with acute exacerbations of people with COPD

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### ABSTRACT

**Background:** Air pollution is an important environmental risk factor affecting Chronic Obstructive Pulmonary Disease (COPD) and other respiratory system diseases.

**Objectives:** The aim of this study is to determine the relationship of air pollution in the northernmost part of Türkiye with acute exacerbation, admission to the emergency department and hospitalization of individuals with COPD.

**Methods:** Between January 01-December 31, 2016, outpatients and hospitalized patients admitted to the state hospital due to COPD exacerbation were retrospectively analyzed. The measured values of air pollutants from the measurement stations located in the city center were obtained from the web page of the Ministry of Environment and Urbanization.

**Results:** The mean age of the patients (n=2737) participating in the study was 67.5±13.3, and 69.8% of them were male. It has been determined that the patients with COPD apply to the hospital the most during the winter and autumn periods. Air pollutants measurement values were found to be significantly higher in the spring and winter seasons ( $p<0.05$ ). When the distribution of hospitalizations of the patients according to the seasons was examined, the rates of hospitalization (4.7%) in the spring and winter seasons were found to be significantly higher ( $p<0.05$ ). When examined in terms of risk, the probability of hospitalization increases 2.44 times compared to summer and autumn seasons in patients who apply to the hospital in the spring and winter seasons.

**Conclusion:** It has been determined that the emissions that cause air pollution are higher in the spring-winter seasons, which increases the probability of hospitalization of the patients who apply to the hospital in these seasons. According to the results obtained from our study, it has been suggested to combat air pollution, protect individuals with COPD from indoor and outdoor air pollution, and add it to the literature by making more studies on the subject.

**Key Words:** Air Pollution, COPD, Emergency Department Visit, Exacerbations, Hospitalization

### INTRODUCTION

Air pollution is the most important environmental factor that has negative effects on health. Ozone and particulate matter (PM<sub>2.5</sub>) are two important indicators used to measure the impact of air pollution on health. PM<sub>2.5</sub> is the most consistent and robust predictor of mortality in studies of long-term exposure to air pollution. Ozone is associated with respiratory disease independent of exposure to PM<sub>2.5</sub> (1). Worldwide, more than three million premature deaths occur annually due to respiratory diseases, cardiovascular diseases and cancer caused by

exposure to particulate matter with a diameter of 10 microns (PM<sub>10</sub>) or less due to air pollution (2). Air pollution is associated with 6.4 million deaths worldwide in 2015. It is estimated that indoor and outdoor air pollution will cause 6-9 million deaths per year until 2060 as a result of not taking serious measures in this regard (2).

Indoor and Outdoor Air Pollution are among the risk factors of COPD. The most important cause of indoor air pollution is the use of fuels such as plant roots, wood, dung or coal, which are called biomass, for heating or cooking, especially in environments with

poor ventilation. Especially the handling of the cooking process by women contributes to the development of COPD in women due to indoor air pollution. Around 3 billion people all over the world use biomass fuel and coal for heating and cooking purposes in their homes, which shows how large the population at risk is and the importance of this risk factor today. Regional, socio-economic and cultural characteristics are an important factor affecting the exposure to indoor air pollution (2,3).

Urbanization, increase in the number of vehicles in traffic, increase in the number of factories, failure to take the necessary precautions and maintenance of the chimneys are among the important factors that cause outdoor air pollution. Although there is not enough evidence in the literature about the effect of outdoor pollution on the development and progression of COPD as clearly as smoking, it is stated that it increases the severity and frequency of acute exacerbations, especially in individuals with COPD (2,3).

Although the use of tobacco and tobacco products is the most important risk factor for COPD, another important risk factor that causes the emergence of the disease and the development of acute exacerbations due to the increase of symptoms such as dyspnea, cough and sputum production is air pollution (3). Although the duration of exposure to outdoor air pollution brought about by urbanization varies according to the level of air pollution and individual characteristics, frequent emergency department admissions and hospitalizations due to acute exacerbation of individuals with COPD cause mortality and morbidity and create an economic burden (4). In many studies in the literature, it is stated that air pollution causes an increase in emergency visits, hospital admissions and hospitalizations due to acute exacerbation of individuals with respiratory system diseases such as COPD and asthma (5-10). However, it has been determined that studies on the subject are limited in Türkiye (11,12). This study is a descriptive study designed to determine the relationship between air pollution and acute

exacerbation, admissions to the emergency department and hospitalizations of individuals with COPD in a city located in the northernmost part of Türkiye, which has the oldest population in the country.

## **2. MATERIALS AND METHODS**

### **2.1. Sample and participants**

Between January 1-December 31, 2016, outpatients and inpatients who applied to the state hospital due to COPD exacerbation constitute the research population. Since the research was based on the retrospective file scanning method, a sample was formed of the cases that were registered at the hospital within the specified date range and met the inclusion criteria of the study. Among the criteria for inclusion in the study are getting the COPD diagnosis code (J41-J44) according to the International Classification of Diseases (ICD-10) and living in the city center. Individuals with respiratory system diseases other than COPD, hospital admissions outside of the specified dates and COPD individuals whose place of residence is outside the city center of Sinop were excluded from the scope of the study.

### **2.2. Measures**

**Patient Information Form:** In the patient identification form, there are introductory information about the patients (age, gender, place of residence), the date of application to the hospital, and the unit to which they applied.

**National Air Quality Monitoring Network Data Collection Form:** The measurements of the National Air Quality Monitoring Station in all provinces are available on the website of the Ministry of Environment and Urbanization. Sulfur dioxide (SO<sub>2</sub>) and particulate matter (PM<sub>10</sub>) values in the air are measured at the station in Sinop. This form is the form in which the monthly average values of SO<sub>2</sub> and PM<sub>10</sub> of Sinop Province are recorded.

### **2.3. Data collection**

Between January 1-December 31, 2016, outpatients

and inpatients admitted to the state hospital due to COPD exacerbation were retrospectively analyzed. These data were obtained from hospital records by electronic archive scanning method. Data of patients with ICD-10 code J41-J44 were accessed in electronic archive scanning. In this scan, data such as age, gender, residence, hospital registration number, date of application to the hospital, which unit he applied to, whether hospitalization was made or not, and the reason for hospitalization were obtained.

The monthly average SO<sub>2</sub> and PM<sub>10</sub> values for the province of Sinop were obtained from the "Ministry of Environment and Urbanization" air quality monitoring stations website. From this website, monitoring parameters related to hourly, daily and weekly air quality can be reported from the established stations of the provinces. SO<sub>2</sub> and particulate matter PM<sub>10</sub> parameters are reported from the station in Sinop province. The monthly average values of these data belonging to the city center were reached during the time period when the study was planned.

#### 2.4. Data collection

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province. The monthly average values of these data belonging to the city center were reached during the time period when the study was planned.

#### 2.5. Statistical analysis

The data obtained from the study were evaluated by entering the SPSS 22.0 (Statistical Package for Social Sciences for Windows) program. Kolmogorov Smirnov was used because of the number of units while investigating the normal distribution of the variables. Chi-square test was used to compare categorical data. While examining the differences between the groups, Mann-Whitney U test was used because the variables did not come from a normal distribution. When interpreting the results, it was stated that there was a significant difference in case of  $p < 0.05$ .

### 3. RESULTS

Between the dates of the study, it was determined that there were 2737 patients who applied to the hospital with COPD exacerbation with repeated admissions. 69.8% of the patients were male, 58.9% were 65 years and older, and the mean age was 67.5±13.3. Other demographic characteristics of the patients are given in Table 1.

**Table 1.** Characteristics of the patients

		n	%
Age (year)	45-64	1123	41.1
	≥65	1614	58.9
Gender	Female	826	30.2
	Male	1911	69.8
Applied Department	Emergency department	322	11.8
	Outpatient department*	2415	88.2
Hospitalization	Yes	93	3.4
	No	2644	96.6
<b>Total</b>		<b>2737</b>	<b>100</b>

\* Chest Diseases, Internal Medicine

According to Table 2, it is seen that the number of patients who apply to the outpatient clinics is higher than the emergency department, that the majority of the patients who are admitted to the emergency department (53%), and that the majority of the admitted patients (76.3%) are male.

In our study, when we look at the distribution of hospital admissions by months, it was determined that the most hospital admissions were in the winter (January-February) and autumn (October) periods. In terms of hospitalization rates, it was determined that hospitalization rates were significantly higher in January (16.1%), February (16.1%) and April (14.9%) ( $p < 0.05$ ). In addition, it was determined that the mean age of the hospitalized

patients was statistically significantly higher ( $p < 0.05$ ).

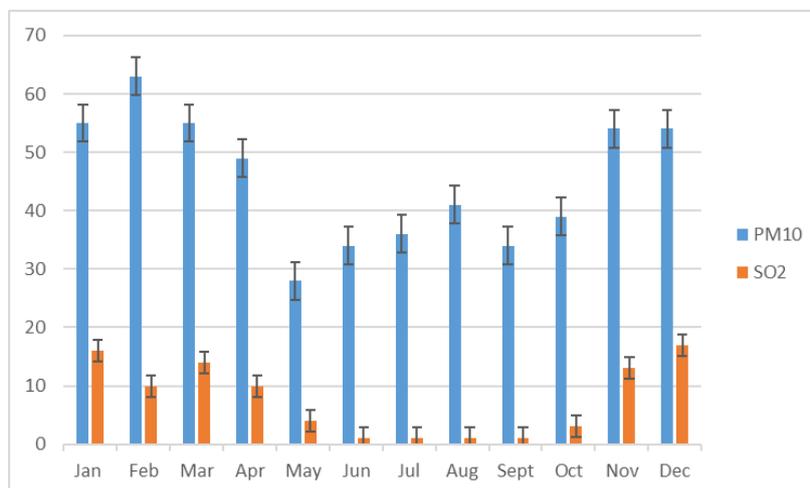
The distribution of the averages of provincial air quality monitoring parameters by months ( $\mu\text{g}/\text{m}^3$ ) is given in Figure 1. Accordingly, the highest  $\text{PM}_{10}$  average belongs to February ( $55 \mu\text{g}/\text{m}^3$ ) and the highest  $\text{SO}_2$  average belongs to December ( $17 \mu\text{g}/\text{m}^3$ ).

The comparison of the averages of air quality monitoring parameters according to the seasons is given in Table 3. According to Table 3, all air quality measurement values in the spring-winter season group were statistically significantly higher ( $p < 0.05$ ).

**Table 2.** Hospitalization status according to some variables related to patients

		Hospitalization State						Chi-Square	p
		No		Yes		Total			
		n	%	n	%	n	%		
<b>Gender</b>	Male	1840	69.59	71	76.34	1911	69.82	1.9	0.163
	Female	804	30.41	22	23.66	826	30.18		
	<b>Total</b>	2644	100.00	93	100.00	2737	100.00		
<b>Applied Department</b>	Emergency department	269	83.5	53	16.5	322	100.0	185.2	<b>0.001</b>
	Outpatient department*	2375	98.3	40	1.7	2415	100.0		
	<b>Total</b>	2644	96.6	93	3.4	2737	100.0		

\*Chest Diseases, Internal Medicine



**Figure 1.** Distribution of the averages of Sinop air quality monitoring parameters by months ( $\mu\text{g}/\text{m}^3$ )

**Table 3.** Comparison of the averages of air quality monitoring parameters according to the seasons

		Seasons					MannWhitney U test			
		n	Mean	Median	Min	Max	SS	Sıra ort.	z	p
<b>PM<sub>10</sub></b>	Spring-Winter	1425	53	55	28	131	15	1750,06	-26,5	<b>0,0001</b>
	Summer-Autumn	1312	41	39	34	123	10	955,12		
	<b>Total</b>	2737	48	49	28	131	14			
<b>SO<sub>2</sub></b>	Spring-Winter	1425	13	14	4	56	7	1864,57	-34,7	<b>0,0001</b>
	Summer-Autumn	1312	5	1	1	57	7	830,75		
	<b>Total</b>	2737	9	10	1	57	8			

**Table 4.** Distribution of hospitalizations by seasons

		Hospitalization						Chi-Square Test		
		Yes		No		Total		Chi-Square	p	OR
		n	%	n	%	n	%			
Seasons	Spring-Winter	67	4,7	1358	95,3	1425	100,0	15,3	<b>0,0001</b>	2,44
	Summer-Autumn	26	2,0	1286	98,0	1312	100,0			
	<b>Total</b>	93	3,4	2644	96,6	2737	100,0			

The relationship between hospitalizations and hospitalization seasons of the patients is given in Table 4. According to Table 4, hospitalization rates (4.7%) in the spring-winter season were significantly higher than in the autumn-summer seasons (2%) ( $p < 0.05$ ). When examined in terms of risk, the probability of being admitted to the hospital in the spring-winter seasons increases 2.44 times compared to the summer-autumn seasons.

#### 4. DISCUSSION

It was determined that the mean age of the patients participating in our study was  $67,5 \pm 13,3$  and the majority of them were men (69.8%). In the literature, it is stated that COPD is commonly seen in men over 40 years of age (3). Our research result showed parallelism with this information.

In our study, it was determined that the majority of patients who were admitted to the hospital as a

result of hospital admission were admitted to the emergency department. In addition, in our study, it was determined that the average age of the patients who were hospitalized was high and the majority of them were male. The reasons for patients with COPD to apply to the emergency department are usually acute exacerbations characterized by other respiratory system symptoms, especially dyspnea, which is exacerbated by factors such as infections, advanced age, malnutrition, other concomitant diseases, and air pollution. Acute exacerbations are generally a condition that should be treated with hospitalization (4,13). Similarly, Çapraz et al. (2017) demonstrated that short-term exposure to PM<sub>10</sub>, PM<sub>2.5</sub> and NO<sub>2</sub> outdoor air pollutants was positively associated with respiratory hospital admissions in İstanbul, Turkey (14).

In a study by Kılınç et al. (2012) in which the reasons for elderly individuals to apply to the emergency

department, it was stated that 17% of the applications were due to respiratory system diseases and the majority of the applicants were male (15). In another study conducted by Ünsal et al. (2003), in which the reasons for admission to the emergency department were examined, it was determined that pulmonary diseases were among the first five diseases among the reasons for admission to the emergency department (16). The results of our study confirm the literature knowledge that elderly patients with COPD have more emergency department admissions and hospitalizations. The increase in symptoms such as dyspnea, cough, sputum production, which is expressed as COPD exacerbation, due to the tendency of infection due to old age, increases the emergency admission rates of individuals with COPD in particular (17). As stated in the study of Kıraklı et al. (2003), individuals with COPD apply to the emergency department once or four times a year due to acute exacerbation, depending on the stage and age of COPD (18). Advanced age is an important risk factor for COPD exacerbation. Nasal complaints of elderly individuals are more prominent, especially in the seasons when the air temperature decreases. The fact that the function of the nose to warm the air is less in elderly individuals causes complaints about COPD to become more pronounced in cold weather. In addition, elderly people with weaker immune systems often have respiratory tract infections, which causes more elderly individuals to attend hospital admissions and hospitalizations (19,20). In the literature, it is stated that the emergency department admissions of individuals with COPD are usually due to infections that cause acute exacerbation and that there are repeated admissions and usually result in hospitalization (21,22). The fact that COPD is more common in males is an important factor in the conclusion that the majority of hospitalized patients are male. In addition, risk factors such as smoking and occupational exposure are thought to be a factor

that increases the rate of hospital admissions and hospitalization by causing symptoms to worsen.

In our study, it is seen that patients with COPD mostly apply to hospitals in the winter period (January-February) and autumn (October). In addition, in our study, it was found that the rates of hospital admissions and hospitalization were significantly higher in winter and spring months ( $p=0.001$ ). It has been reported in the literature that COPD patients experience more frequent exacerbations in winter and have higher hospitalization and morbidity rates. In addition, respiratory viral infections have seasonal variations and are more common in winter. Meteorological factors such as temperature, humidity, wind speed, sunlight and precipitation vary according to the seasons. Although COPD exacerbations are more frequent in winter, it is unclear whether the season itself or the meteorological factors listed above have an impact on exacerbations (23). In the study of Tseng et al. (2013), in which the effect of average air temperature on COPD exacerbation was evaluated, it was determined that a  $1^{\circ}\text{C}$  decrease in air temperature caused an increase in the exacerbation rate by 0.8%. It has been stated that long-term (28-day average) cold temperatures increase the risk of COPD exacerbation, and elderly patients and patients who do not take inhalers experience exacerbations when the average temperature drops by  $5^{\circ}\text{C}$  (23). A decrease in air temperature appears to be a potential risk factor for exacerbation. The increase in hospital admissions and hospitalizations of individuals with COPD in cold weather may be due to acute exacerbations caused by infections due to exposure to increased viral infections, the time spent outside due to the cold weather and the decrease in daily physical activity, and the direct bronchoconstriction effect of cold (24,25).

In our study, according to the distribution ( $\mu\text{g}/\text{m}^3$ ) results of the averages of air quality monitoring parameters by months, the highest  $\text{PM}_{10}$  average was found in February ( $55 \mu\text{g}/\text{m}^3$ ) and the highest

SO<sub>2</sub> average was in December (17 µg/m<sup>3</sup>). In addition, when looking at the seasons, the air quality measurement values in the spring-winter season group are statistically significantly higher. When the European Union air pollutants limit values are examined, the annual average value is determined as SO<sub>2</sub>= 20µg/m<sup>3</sup>, PM<sub>10</sub>= 40µg/m<sup>3</sup>. The limit values determined for our country are SO<sub>2</sub>= 150µg/m<sup>3</sup> and PM<sub>10</sub>= 60µg/m<sup>3</sup> as a warm average. In a study conducted to evaluate the effect of air pollution on hospitalizations in Sivas province, the average SO<sub>2</sub> was determined as 63.3 µg/m<sup>3</sup> (11). In a study conducted by Tecer (2013) to determine the effects of air pollution on respiratory diseases in children and adults in Balıkesir, the average of SO<sub>2</sub> concentrations measured between 1996 and 2006 was 78 µg/m<sup>3</sup>, and the average of total particulate matter was 53 µg/m<sup>3</sup>. In the same study, particulate matter concentrations were high in winter and low in summer (12). The different values obtained in the studies have revealed different results in relation to the characteristics of the cities and the meteorological situation. Since there is no heating service with natural gas with the decrease in air temperature in Sinop in the winter months, the start of the fuel burning process for heating with stoves and central heating and the continuation of the fuel burning process due to the cool climate in the spring may be a factor causing the PM<sub>10</sub> increase. Singkam et al. (2022) found that the average increase of PM<sub>2.5</sub> by 1%, would add an increased risk of COPD cases by 0.25% at a significance level of 0.10 (26).

In our study, when examined in terms of risk, the probability of being hospitalized in patients admitted to the hospital in the spring-winter seasons increases 2.44 times compared to the summer-autumn seasons. Therefore, it can be said that the spring-winter season is an important risk factor for individuals with COPD. It can be said that the fact that the emissions that cause air pollution are higher in the spring-winter seasons increase the probability of hospitalization of the patients

who apply to the hospital in these seasons, 2.44 times. An increase of 7 µg/m<sup>3</sup> in five years in the amount of PM<sub>10</sub> in the environment causes a 5.1% faster decrease in FEV<sub>1</sub> and poses a 1.33 risk for the development of COPD (27). In a study conducted by Ding et al. (2017) to evaluate the effect of air pollutants on emergency room admissions of individuals with COPD in Taiwan, NO<sub>2</sub>, CO and O<sub>3</sub> levels were associated with hospital admissions of individuals with COPD, especially on hot days. It is stated that meteorological factors such as humidity and barometric pressure play an important role in increasing the concentrations of air pollutants and affect COPD-related emergency department visits (28). In the study conducted by Qui et al to determine the effects of air pollution on seasonal and humidity dependence in Hong Kong on hospitalizations of individuals with COPD, an increase in the harmful effects of air pollution in cool seasons and low humidity periods was observed. It was determined that there was an increase in the rates of emergency applications and hospitalization of individuals (29). Similarly, in the study conducted by Hoffman et al. (2022) in Berlin, it was determined that outdoor air pollution increases the exacerbations of COPD (30).

## 5. CONCLUSION

The most important results obtained from our study; when the hospital admissions of individuals with COPD are examined over a one-year period, it is seen that the average age is high, the hospitalization rates of those who apply to the emergency service, the elderly and male patients are higher, the annual average of air pollution measurement values is lower than the air pollutants limit values determined for Turkey. It can be listed as the fact that it is higher especially in winter and spring seasons and that hospital admissions and hospitalizations are high in these months. According to the results obtained from our study, it has been suggested to combat air pollution, to protect individuals with COPD from

indoor and outdoor air pollution, and to add to the literature by making more studies on the subject.

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**Ethical Statement:** This study was approved by the Institutional Review Board of the University (IRB approval number: 2017/01). Also written permission was also obtained from the hospital where the study was conducted.

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