**KLİNİK ÇALIŞMA**
**RESEARCH ARTICLE**

# Do meteorological changes and air pollution increase the risk of pneumonia?

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**ABSTRACT**

**Do meteorological changes and air pollution increase the risk of pneumonia?**

**Introduction:** *Our study aimed to evaluate the relationship between pneumonia, air pollution (sulfur dioxide [$SO_2$] and particulate matter [$PM_{10}$]) and meteorological data (atmospheric pressure, amount of rainfall, temperature, rate of humidity, sunshine duration and wind velocity).*

**Materials and Methods:** *Our study included 822 of the 826 patients who were admitted to the emergency service of our hospital between August 2016 and July 2017 and who were diagnosed with pneumonia. Four patients whose information was not available were excluded from the study. The data for the patients were obtained retrospectively from the hospital information system and patient emergency files. The meteorological data were obtained from the website of the Ministry of the Environment and Urbanization and from the Directorate General of Meteorology of our city. Daily meteorological data ($SO_2$, $PM_{10}$, air pressure, temperature, humidity, wind speed and sunshine duration) were compared with the number of daily patients admitted to the emergency department and diagnosed with pneumonia. Statistical analysis was performed using Pearson correlation analysis.*

**Results:** *Three hundred and twenty-nine of the patients were female, and 493 were male. A total of 605 inpatients, of whom 106 were in the intensive care unit, were treated in the hospital, while 217 were outpatients. A statistically significant relationship was found between the number of patients with pneumonia and the intensity of $SO_2$ (r= 0.740; p< 0.001), atmospheric pressure (r= -0.691; p< 0.01), wind velocity (r= 0.777; p< 0.001), average humidity rate (r= -0.454; p< 005) and sunshine duration (r= 0.475; p< 0.05).*

**Conclusion:** *We determined that meteorological changes are important risk factors in the development of pneumonia and that reducing air pollution and taking protective measures may decrease the frequency of pneumonia and the mortality rates related to pneumonia.*

**Key words:** *Pneumonia; meteorological changes; mortality*

## ÖZ

### Meteorolojik değişiklikler ve hava kirliliği pnömoni riskini artırır mı?

**Giriş:** Çalışmamızda pnömoni ile meteorolojik veriler (sülfür dioksit [SO₂], partikül madde [PM₁₀] miktarları, hava basıncı, yağış miktarı, sıcaklık, nem oranı, güneşlenme süresi ve rüzgar hızı) arasındaki ilişkiyi değerlendirmeyi amaçladık.

**Materyal ve Metod:** Ağustos 2016-Temmuz 2017 tarihleri arasında hastanemiz acil servisine başvuran ve pnömoni tanısı alan 826 hastadan 822'si çalışmamıza dahil edildi. Bilgisine ulaşılamayan dört hasta çalışma dışı bırakıldı. Hastalara ait veriler hastane bilgi sistemi ve hasta acil dosyalarından retrospektif olarak elde edilmiştir. Meteorolojik veriler de Çevre ve Şehircilik Bakanlığı web sitesi ve ilimize ait Meteoroloji Müdürlüğü'nden alınmıştır. Çalışmamızda acil servise başvuran ve pnömoni tanısı alan günlük hasta sayısı ile günlük meteorolojik veriler (SO₂, PM₁₀, hava basıncı, sıcaklık, nem, rüzgar hızı, güneşlenme süresi) karşılaştırılmıştır. Pearson korelasyon analizi ile veriler değerlendirilmiştir.

**Bulgular:** Hastalardan 329'u kadın, 493'ü erkektir. Hastaların 106'sı yoğun bakımda olmak üzere 605 hasta yatarak, 217 hasta ise ayakta tedavi edilmiştir. Pnömoni hastalığı ile kükürt dioksit (SO₂) yoğunluğu (r= 0,740; p< 0,01), hava basıncı (r= -0,691; p< 0,01), rüzgar hızı (r= 0,777; p< 0,001), ortalama nem oranı (r= -0,454; p< 0,05) ve güneşlenme süresi r= 0,475; p< 0,05) arasında istatistiki olarak anlamlı ilişkiler bulunmuştur.

**Sonuç:** Meteorolojik değişikliklerin pnömoni gelişiminde önemli bir risk faktörü olduğunu saptadık. Hava kirliliğinin azaltılması ve koruyucu önlemlerin alınmasının pnömoni sıklığını ve pnömoniye bağlı mortaliteyi azaltabileceğini düşünmekteyiz.

**Anahtar kelimeler:** Pnömoni, meteorolojik değişiklikler, mortalite

## INTRODUCTION

Pneumonia is an inflammatory and infectious disease of the lung parenchyma tissue that develops with bacteria, viruses, parasites and fungi. In our country and around the world, pneumonia comprises a group of diseases with high mortality and morbidity in both children and adults (1). The frequency of pneumonia increases in direct proportion to increasing age and the occurrence of comorbid diseases. While pneumonia is in the first place among the causes of death due to infection in our country, it is in the fifth place among all causes of death (2). Pneumonia is one of the most common causes of emergency admissions.

The effects of the changes in meteorological parameters have been investigated on various diseases. It has been found to increase morbidity and mortality in patients with chronic lung diseases such as asthma and chronic obstructive pulmonary disease (COPD) significantly and the risk of cerebrovascular diseases and coronary artery disease. The incidence of pneumonia varies seasonally. Meteorological changes such as air temperature and humidity affect the frequency of pneumonia (3). It is known that morbidity and mortality usually increase in patients with chronic diseases, advanced age and the male gender; however, the number of studies searching for the effect of the environmental factors is limited (4).

We aimed to evaluate the relationship between the frequency of pneumonia and meteorological data [sulfur dioxide (SO₂), particulate matter (PM₁₀) amounts, atmospheric pressure, amount of rainfall, temperature, rate of humidity, sunshine duration and wind velocity] in our study.

## MATERIALS and METHODS

Our study included 822 of 826 adult patients over the age of 18 who were admitted to the emergency service of our hospital between August 2016 and July 2017 and were treated following a diagnosis of community-acquired pneumonia. Four patients with missing data were excluded from the study. Medical history, comorbidities, laboratory findings, chest radiographies and lung computed tomography (CT) of the patients were obtained retrospectively from the hospital information system and patient emergency files. Patients with obstructive pneumonia and hospital-acquired pneumonia were excluded from the study. Meteorological data were obtained from the website of the Ministry of the Environment and Urbanization and from the Kastamonu Directorate General of Meteorology. Approval for the study was obtained from the General Secretariat of the Public Hospitals Union of Kastamonu (3 August, 2017; no. 91379769/604.02).

### Statistical Analysis

Statistical analyses were performed using SPSS v. 24. The relationship between pneumonia disease and meteorological data was studied using the Pearson correlation analysis method; the mortality rates of the patients receiving treatment were calculated by assuming that the patients are bordered within the

Kastamonu central population. Our data were grouped biweekly in accordance with Ostroff's study (1993) in order to see the relationships more clearly and to observe the effect of seasonal conditions on possible patients. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

Kastamonu city center has a population of 146.103 according to the results of a search of the Address Based Population Registration System (Address Based Population Registration System, 2017) dated December 31, 2016. Age and sex patterns of the population are shown in Figure 1.

According to State Hospital Emergency Service records, between 1 August 2016 and 31 July 2017, 822 patients were treated following a diagnosis of pneumonia; 68 of these patients received repeat therapy. Of the patients, 329 were females and 493 were males. Of the 605 inpatients, 106 were in intensive care, and 217 individuals were outpatients. The age and sex distribution of these patients is given in Figure 2.

Of the patients diagnosed with pneumonia in our study, 59.2% had at least one accompanying chronic disease. This rate was 63.4% in men and 53% in women. In our study, 276 patients had COPD, 57 patients had diabetes mellitus (DM), 45 patients had heart disease (heart failure and coronary artery disease), 30 patients had asthma, 60 patients had neurological disease (dementia cerebrovascular disease, epilepsy, or Alzheimer's), 19 patients had bronchiectasis, seven patients had chronic renal failure, and four patients had hyperthyroidism. Figure 3 shows the distribution of comorbidities according to age and sex.

While the rate of incidence of pneumonia in women increased by an average of one point every five years in the age group of 60-64 years, it was observed that the incidence rate in men increased more rapidly as their age progressed. It is clearly seen that pneumonia risk in men is higher than that in women, and this risk also increases with age (Figure 4).

In order to determine the relationship between seasonal effects and pneumonia, daily readings were taken on the reference dates for duration of sunshine $(SO_2)$ $(\mu g/m^3)$, particulate matter $(PM_{10})$ $(\mu g/m^3)$, atmospheric pressure, precipitation $(kg/m^2)$, average temperature, average humidity and maximum wind velocity. The values of these variables on the related dates are shown in Figure 5.

It is observed that there is a strong, positive and significant relationship between the number of patients diagnosed with pneumonia in the emergency service
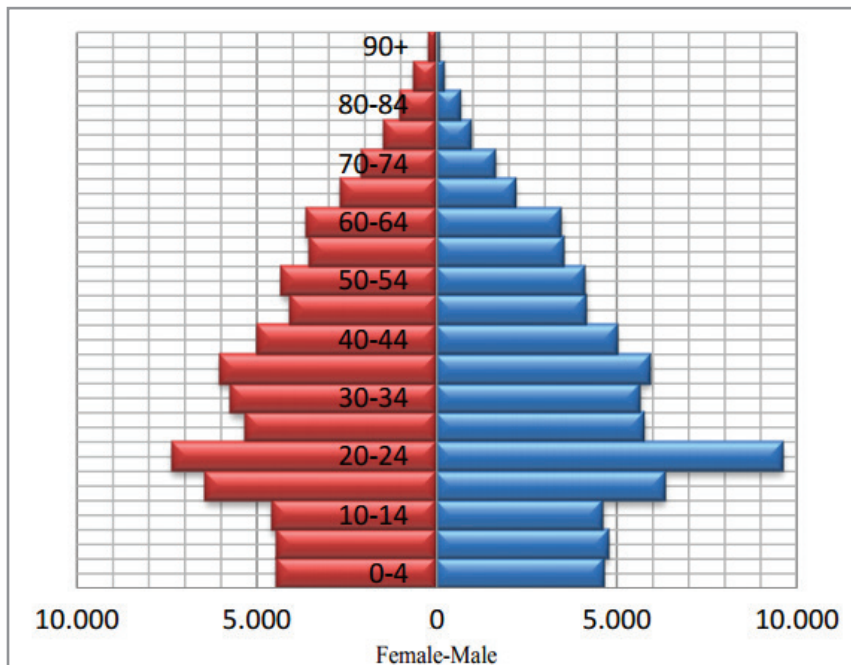


**Figure 1.** Age and gender patterns in the population of Kastamonu, 2016.
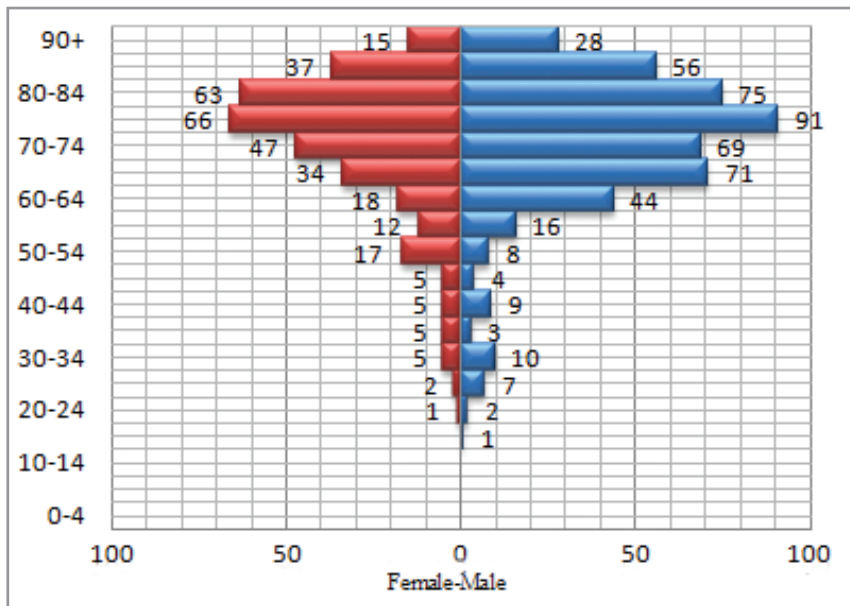
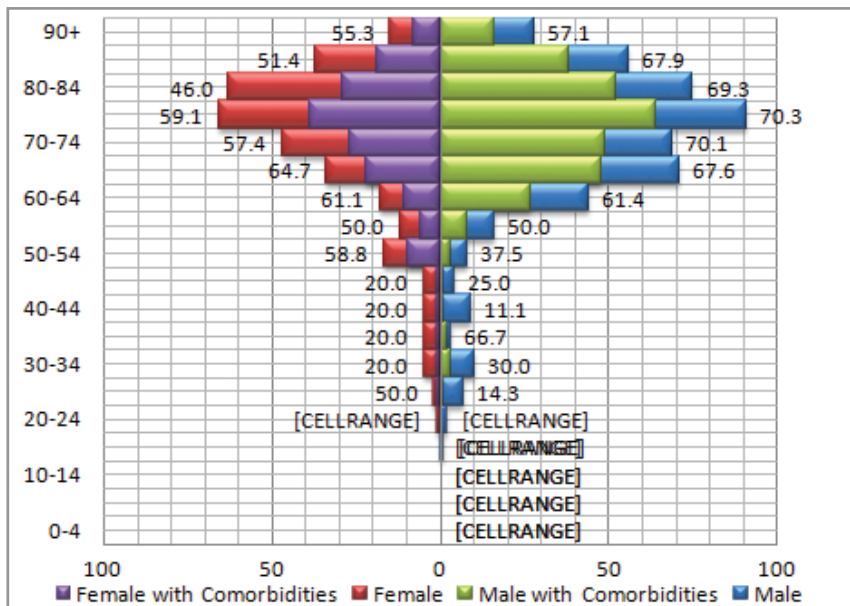**Figure 2.** Age and gender distribution of pneumonia patients.



**Figure 3.** Distribution of comorbidities according to age and gender (%).

and the sulfur dioxide ($SO_2$) concentration (r= 0.740; p< 0.01). Similarly, there is a strong, negative and significant relationship between the number of the patients and atmospheric pressure (r= -0.691; p< 0.01); a strong, positive and significant relationship with the wind velocity (r= 0.777; p< 0.01); an average, negative and significant relationship with the average humidity rate (r= -0.454; p< 0.05) and finally, a strong, positive and significant relationship with

the duration of sunshine (r= 0.475; p< 0.05). In the analysis, no statistically significant relationship was found between the number of the patients and particulate matter ($PM_{10}$), precipitation and temperature indicators (Table 1).

When a comparison was made between those with and without concomitant lung disease, in terms of the meteorological events and pneumonia, it was
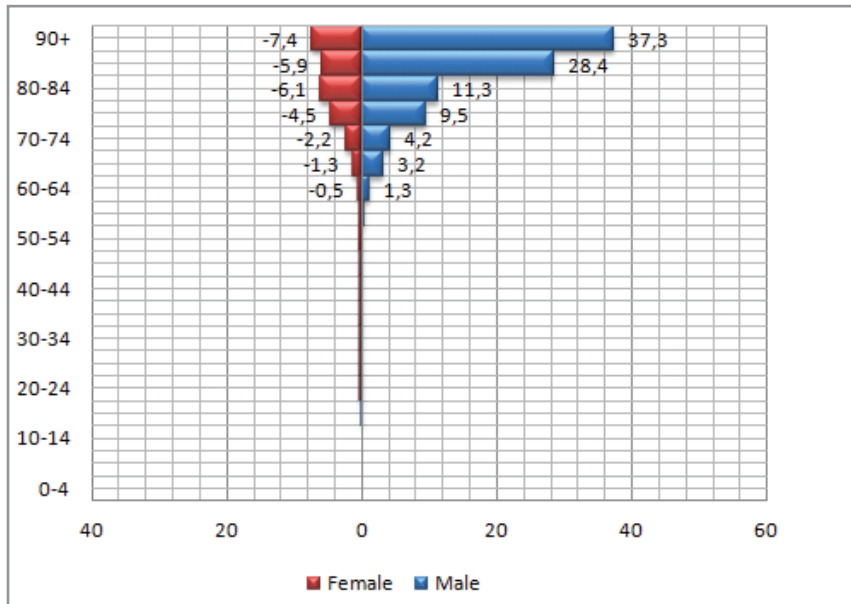
**Figure 4.** Pneumonia incidence rate according to age group and gender (%).

determined that pneumonia was more common in patients with chronic lung disease (CLD). When the number of patients with CLD who had pneumonia was compared with meteorological data, a positive significant relationship was found between the atmospheric sulfur dioxide level (r= 0.45; p= 0.022) and maximum wind speed (r= 0.57; p= 0.002). A negative correlation was found between the number of patients with CLD and atmospheric pressure (r= -0.45; p= 0.022) and mean humidity level (r= -0.48; p= 0.012). However, when we excluded the patients with CLD, who accounted for almost one third of the total number of pneumonia patients, no correlation was detected with the meteorological data (Table 2).

The male and female patients were compared in terms of the meteorological data. According to the obtained results, on average, negative and significant result was observed between the male patient number and atmospheric pressure and humidity (r= –0.543/–0.407; p< 0.05), and a strong, positive and significant relationship was observed between the patient number and wind velocity (r= 0.764; p< 0.01). On average, a positive and significant relationship was found between the female patients and sulfur dioxide (SO$_2$) intensity (r= 0.420; p< 0.05); on average, positive and significant relationship was found with the particulate matter (PM$_{10}$) (r= 0433; p< 0.05); and on average, negative and significant relationship was identified with the average temperature (r= –0.401; p< 0.05).

The patients were divided into three groups according to their treatment modalities as outpatient, inpatient in service and in intensive care unit (ICU). The numbers of outpatients and patients followed up in the ICU were not statistically related with meteorological parameters. However, a statistically significant relationship was found between the number of hospitalized patients (except the ones who were followed up in ICU) and atmospheric SO$_2$ (r= 0.44; p= 0.026) and maximum wind speed (r= 0.50; p= 0.01). A negative statistical correlation was found with the average humidity (r= -0.40; p= 0.042) (Table 3).

## DISCUSSION

Changes in the meteorological parameters increase respiratory mortality and morbidity of the adults who have co-morbidities (COPD, asthma, bronchiectasis). While the temperature and high rate of humidity cause clinical deterioration in people with asthma, cold weather and exposure to cold increase the risk of infection, particularly in people who especially have COPD (5).

Similar to the literature, in our study, more correlations were found between meteorological changes and pneumonia frequency in patients with CLD compared to those without CLD.

Meteorological factors weaken the body's immunity and thus make it easy for the pathogens causing infection to spread (6,7). There are many studies
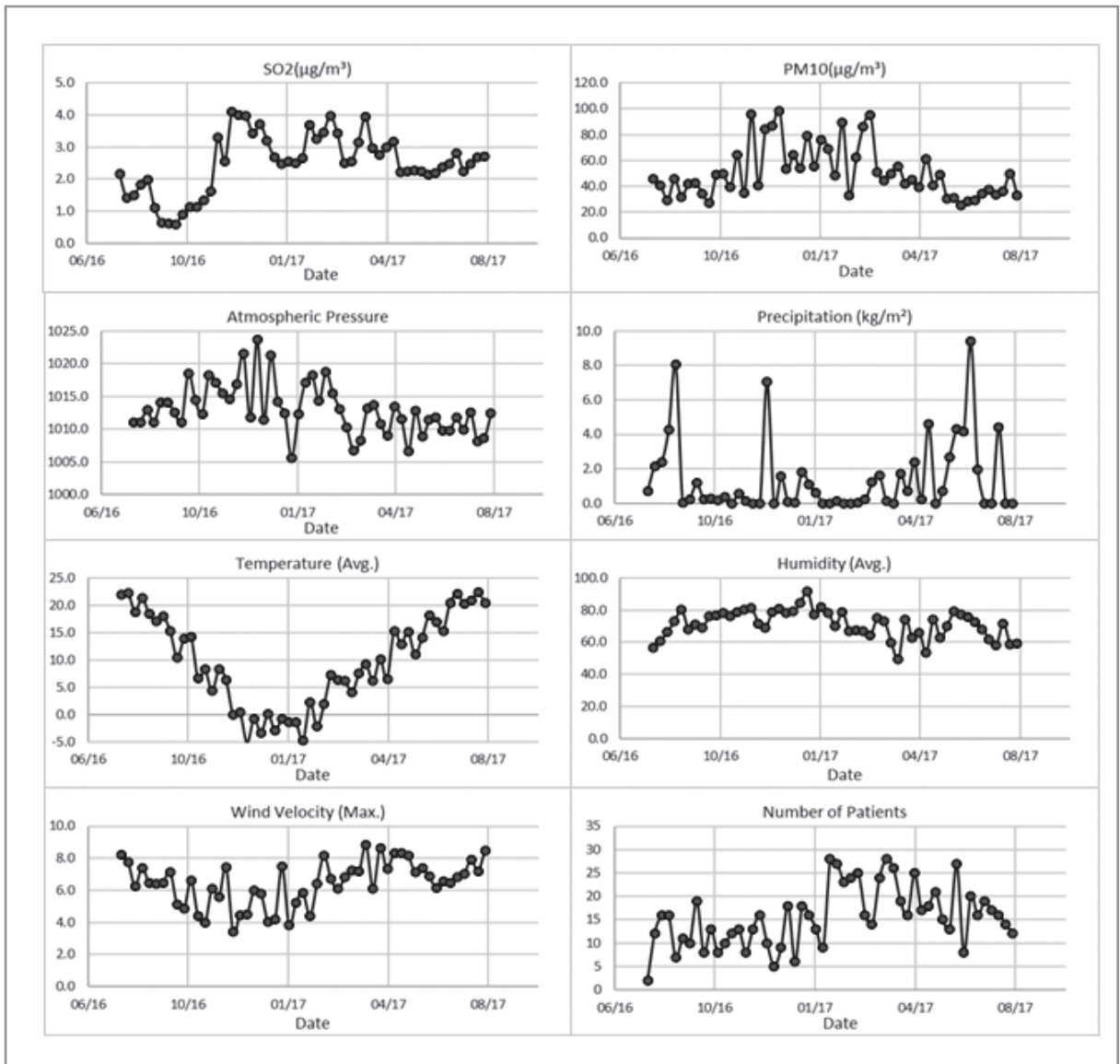
**Figure 5.** Kastamonu city seasonal indicator, 2016-2017.

**Table 1.** Correlation of the number of patients with pneumonia with meteorological data

|   | Comorbidity | SO$_2$ (µg/m³) | PM$_{10}$ (µg/m³) | Atmospheric Pressure | Wind Velocity (Max.) | Precipitation (kg/m²) | Temperature (Avg.) | Humidity (Avg.) | Sunshine duration |
|---|---|---|---|---|---|---|---|---|---|
| r | .781** | .740** | -0.36256 | -.691** | .777** | -0.050 | -0.125 | -.454* | .475* |
| p | 0.000 | 0.000 | 0.097 | 0.000 | 0.000 | 0.826 | 0.541 | 0.020 | 0.019 |

showing that cold weather increases the risk of infection. Gautret et al. have expressed the fact that the frequency of viral respiratory tract infections increase in cold weather (8). *S. pneumonia*, *H. influenzae* and *M. catarrhalis* are the most frequently isolated bacte-

ria as a factor of pneumonia, especially in cold weather (9,10).

However, in our study, we determined that while there was no correlation between atmospheric temperature and the progress of pneumonia in all

**Table 2.** Correlation of the groups with and without chronic lung disease with meteorological data

| | | SO$_2$ (µg/m³) | PM$_{10}$ (µg/m³) | Atmospheric Pressure | Wind Velocity (Max.) | Precipitation (kg/m²) | Temperature (Avg.) | Humidity (Avg.) | Sunshine duration |
|---|---|---|---|---|---|---|---|---|---|
| Chronic lung disease (+) | r | **0.45** | **0.05** | -0.45 | **0.57** | -0.07 | -0.03 | **-0.48** | 0.135 |
| | p | **0.022** | **0.827** | 0.022 | **0.002** | 0.736 | 0.894 | **0.012** | 0.512 |
| Chronic lung disease (-) | r | 0.23 | -0.03 | -0.11 | 0.28 | -0.05 | -0.15 | -0.13 | 0.075 |
| | p | 0.255 | 0.899 | 0.593 | 0.164 | 0.816 | 0.454 | 0.514 | 0.715 |

**Table 3.** Correlation of the number of outpatients, inpatients and ICU patients with meteorological data

| | | SO$_2$ (µg/m³) | PM$_{10}$ (µg/m³) | Atmospheric Pressure | Wind Velocity (Max.) | Precipitation | Temperature (Avg.) | Humidity (Avg | Sunshine duration |
|---|---|---|---|---|---|---|---|---|---|
| OP | r | 0.33 | 0.13 | -0.35 | 0.34 | -0,2 | -0.24 | -0.09 | -0.09 |
| | p | 0.11 | 0.55 | 0.087 | 0.101 | 0.342 | 0.245 | 0.668 | 0.677 |
| IP | r | **0.44** | -0.02 | -0.38 | **0.50** | 0.10 | -0.01 | **-0.40** | 0.16 |
| | p | **0.026** | 0.918 | 0.056 | **0.01** | 0.625 | 0.963 | **0.042** | 0.427 |
| ICU | r | 0.07 | 0.23 | 0.25 | 0.01 | -0.21 | -0.01 | -0.31 | 0.19 |
| | p | 0.737 | 0.272 | 0.237 | 0.945 | 0.319 | 0.969 | 0.143 | 0.371 |

OP: Outpatients, IP: Inpatients, ICU: Intensive care unit.

patients, there was an increase in the risk of pneumonia in women with a decrease in the temperature. This may be due to the weaker immunity of women compared to that of men. Although in the studies conducted by Liu et al. (7) and Taşçı et al. (11), no relationship has been found between wind speed and pneumonia, an increase in the frequency of pneumonia was determined in our study with an increase in the wind velocity. This risk was more prominent in male patients. This may be due to the fact that men tend to work in the outdoor environment more than women, so wind velocity makes it easy for the infection agents to spread among men. SO$_2$ is formed during the combustion of fossil-type oils, especially in cold weather, and forms sulfide matters and aerosolizes into the air. In controlled human experiments previously carried out with SO$_2$, it has been observed that it causes mucosal edema in the upper respiratory tract, hypersecretion, an increase in smooth muscle tonus and changes in the cilia (12). A significant relationship has been detected between the SO$_2$, whose toxic effects increase with the cold weather, and pneumonia (13).

In our study, a positive relationship was determined between the progress of pneumonia and SO$_2$. The rate of pneumonia increases, especially in women, when the amount of SO$_2$ in the atmosphere increases. This may be due to the higher indoor exposure of women. The infection risk of the respiratory tract increases as the rate of humidity decreases (7).

Although there is a negative relationship between the lower and upper respiratory tract and humidity, some bacteria (*M. catarrhalis*) and viruses (*influenza*) are more likely to cause infection when humidity increases (10,14).

Similarly, although Taşçı et al. have reported that the risk of pneumonia increased with increasing humidity, in our study we determined the negative relationship between the rate of humidity and the frequency of pneumonia. We think that this might have resulted from the fact that these studies are carried out in different areas and therefore, the factors of pneumonia differ. Shaman and Kohn have stated it is easier for the virus to spread and live in low-pressure areas (15). There is a strong, negative relationship between the number of the patients diagnosed with pneumonia and the atmospheric pressure. Increased risk of pneumonia is detected, especially with age. In our study, we found that the incidence of pneumonia increases with age (over >75) and is higher in males. The weaker immune system and therefore the higher incidence of infection may explain the higher admission rate for ≥75 years of age. (16). Increased rates of pneumococcal and influenza vaccination and the development of new vaccines may reduce this rate in the advanced age group.

In our study, no correlation was found between outpatients and meteorological data. However, a statistically significant correlation was found between the

number of inpatients and $SO_2$ amount, air pressure and average humidity. The reason for this can be considered by the severity of the disease. However, none of the meteorological parameters correlated with ICU admission. The number of patients hospitalized in the ICU may be statistically insignificant in our study. We did not find a correlation related to the severity of the disease in hospitalized patients in our study. The risk of developing pneumonia due to air pollution had been found higher in patients with COPD (17). Another statistically significant result in our study was the relationship between the number of patients with chronic disease and pneumonia and meteorological data. Both the number of inpatients and the number of pneumonia patients with chronic disease were correlated with similar meteorological parameters. Approximately 70% of the patients in our study had comorbid diseases.

Our results suggest that the individuals with comorbid diseases (especially CLDs) are more closely related to the risk of developing pneumonia with meteorological data.

There are some limitations to this study. Patient data were obtained from the hospital information system since they were retrospective; therefore, the history of smoking in patients could not be achieved. We were also unable to obtain the patients' mortality data. We were therefore unable to determine the relationship between meteorological parameters and mortality.

## CONCLUSION

Meteorological changes (humidity, atmospheric pressure, wind velocity, the amount of $SO_2$ levels) and comorbidities (especially CLDs) increase pneumonia incidence; and the male sex and old age are the other risk factors for pneumonia. The risk of pneumonia related to $SO_2$ increases especially in women. The use of a mask especially for those with chronic lung disease may be protective. The risk of pneumonia, mortality and morbidity will be reduced by preventing the use of fossil fuels indoors, taking necessary environmental measures, and increasing vaccination rates and options.

**Ethical Committee Approval:** Approval for the study was obtained from the General Secretariat of the Public Hospitals Union of Kastamonu (3 August, 2017; no. 91379769/604.02).

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