Received: 21 March 2023 / Accepted: 12 April 2023 / Published online: 30 April 2023

DOI 10.34689/SH.2023.25.3.024

UDK 616.24-002.2:614.7

THE INVESTIGATION OF RELATIONSHIP BETWEEN METEOROLOGICAL AND AIR POLLUTION PARAMETERS WITH COPD EXACERBATION

Faruk Kurt[1], Cemil Kavalci[2], Tamer Colak[1], Kaan Celik[1], Beliz Oztok Tekten[1], Bahattin Isık[3]

[1] Abant Izzet Baysal University, Faculty of Medicine, Emergency Medicine Department, Bolu, Türkiye;
[2] Health Science University of Türkiye, Antalya Training and Research Hospital, Emergency Medicine, Antalya, Türkiye;
[3] Diskapi Yildirim Beyazit Training and Research Hospital, Emergency Medicine Department, Ankara, Türkiye.

Abstract

Aim: The aim of the present study was to determine the relationship between meteorological and air pollution parameters [temperature, humidity, wind, sulfur dioxide (SO2), PM (10] with COPD exacerbation

Materials and Methods: Our study was conducted by retrospectively screening the files of the patients followed up due to COPD exacerbation in the emergency department between 01.06.2016 and 01.06.2017. The chi-square test was used to compare the categorical variables. Mann-Whitney U test was used to compare numerical variables between COPD exacerbation admission and non-admission days and chi-square test was used to investigate relationship between admission and event (rain). The lag analysis was used to determine the factors affecting the development of COPD exacerbation during the last four days.

Results: The temperature level was statistically significantly lower on the days of admission due to COPD attack ($p<0.05$). On the other hand, there was no statistically significant difference in humidity and wind levels between the days with and without admission ($p>0.05$) The SO2 level was statistically significantly lower on the days of admission due to COPD attack ($p<0.05$). In PM 10 levels, there was no statistically significant difference between the days with and without admission ($p>0.05$)

Conclusion: On days with COPD admission, the air temperature was lower and the SO2 level was higher. Humidity, wind and PM levels on admission days were similar to those in non-admission patients.

Keywords: COPD exacerbation, meteorology, air pollution

Резюме

ИССЛЕДОВАНИЕ СВЯЗИ МЕТЕОРОЛОГИЧЕСКИХ ПАРАМЕТРОВ И ПОКАЗАТЕЛЕЙ ЗАГРЯЗНЕНИЯ ВОЗДУХА С ОБОСТРЕНИЕМ ХОБЛ

Фарук Курт[1], Чемиль Кавальчи[2], Тамер Чолак[1] Каан Челик[1], Белиз Озток Тектен[1], Бахаттин Исик[3]

[1] Университет Абант Иззет Байсал, Медицинский факультет, Отделение неотложной медицины, г. Болу, Турция;
[2] Университет медицинских наук Турции, Учебно-исследовательский госпиталь Анталии, Отделение неотложной медицинской помощи, г. Анталия, Турция;
[3] Учебно-исследовательская больница Diskapi Yildirim Beyazit, Отделение неотложной медицины, г. Анкара, Турция.

Цель: Цель настоящего исследования состояла в том, чтобы определить взаимосвязь между метеорологическими параметрами и параметрами загрязнения воздуха [температурой, влажностью, ветром, диоксидом серы (SO2), PM (10) с обострением ХОБЛ.

Материалы и методы. Исследование проведено путем ретроспективного скрининга карт пациентов, находившихся под наблюдением по поводу обострения ХОБЛ в отделении неотложной помощи в период с 01.06.2016 по 01.06.2017. Тест хи-квадрат использовался для сравнения категориальных переменных. Критерий Манна-Уитни U использовался для сравнения числовых переменных между днями госпитализации при обострении ХОБЛ и днями отсутствия госпитализации, а критерий хи-квадрат использовался для исследования взаимосвязи между госпитализацией и событием (дождь). Для определения факторов, влияющих на развитие обострения ХОБЛ в течение последних четырех дней, использовали лаг-анализ.

Результаты. Уровень температуры был статистически значимо ниже в дни поступления в связи с приступом ХОБЛ ($p<0,05$). С другой стороны, не было статистически значимой разницы в уровнях влажности и ветра между

днями с госпитализацией и без нее (p>0,05). Уровень SO2 был статистически значимо ниже в дни госпитализации из-за приступа ХОБЛ (p<0,05). В уровнях PM 10 не было статистически значимой разницы между днями с госпитализацией и без нее (p>0,05).

Заключение. В дни поступления ХОБЛ температура воздуха была ниже, а уровень SO2 выше. Уровни влажности, ветра и PM в дни госпитализации были аналогичны таковым у пациентов без госпитализации.

Ключевые слова: *обострение ХОБЛ, метеорология, загрязнение атмосферного воздуха.*

Түйіндеме

ӨКПЕНІҢ СОЗЫЛМАЛЫ ОБСТРУКТИВТІ АУРУЫНЫҢ ӨРШУІНІҢ АУАНЫҢ ЛАСТАНУ КӨРСЕТКІШТЕРІ МЕН МЕТЕОРОЛОГИЯЛЫҚ ПАРАМЕТРЛЕРДІҢ БАЙЛАНЫСЫН ЗЕРТТЕУ

Фарук Курт[1], Чемиль Кавальчи[2], Тамер Чолак[1] Каан Челик[1], Белиз Озток Тектен[1], Бахаттин Исик[3]

[1] Абант Иззет Байсал университеті, Медицина факультеті, жедел медициналық көмек кафедрасы, Болу, Түркия;
[2] Түрік медицина ғылымдары университеті, Анталия оқу-зерттеу ауруханасы, жедел жәрдем бөлімі, Анталия, Түркия;
[3] Дискапи Йылдырым Беязит оқу-зерттеу ауруханасы, шұғыл медицина бөлімі, Анкара, Түркия.

Мақсаты: Бұл зерттеудің мақсаты метеорологиялық көрсеткіштер мен ауаның ластану параметрлері [температура, ылғалдылық, жел, күкірт диоксиді (SO2), PM (10) ӨСОА өршуімен байланысты анықтау болды.

Материалдар мен тәсілдер. Зерттеу жедел жәрдем бөлімінде 01.06.2016 және 06.01.2017 аралығында ӨСОА өршуіне бақылауда болған науқастардың жазбаларын ретроспективті скрининг арқылы жүзеге асырды. Категориялық айнымалыларды салыстыру үшін хи-квадрат тесті қолданылды. Mann-Whitney *U* сынағы ӨСОА өршуі бойынша ауруханаға жатқызылған күндер мен госпитализациясыз күндер арасындағы сандық айнымалы мәндерді салыстыру үшін пайдаланылды, ал госпитализация мен оқиға (жаңбыр) арасындағы байланысты зерттеу үшін хи-квадрат сынағы қолданылды. Соңғы төрт күн ішінде ӨСОА өршуінің дамуына әсер ететін факторларды анықтау үшін лаг-талдауы қолданылды.

Нәтижелер. ӨСОА ұстамасына байланысты түскен күндері температура деңгейі статистикалық тұрғыдан айтарлықтай төмен болды (p<0,05). Сонымен қатар, ауруханаға жатқызылған және емделмеген күндер арасында ылғалдылық пен жел деңгейінде статистикалық маңызды айырмашылық болған жоқ (p>0,05). ӨСОА ұстамасына байланысты госпитализация күндерінде SO2 деңгейі статистикалық тұрғыдан айтарлықтай төмен болды (p<0,05). Ауруханаға жатқызылған және емделмеген күндер арасында PM 10 деңгейінде статистикалық маңызды айырмашылық жоқ (p>0,05).

Қорытынды. ӨСОА өршуімен түскен күндері ауа температурасы төмендеп, SO2 деңгейі жоғары болды. Ауруханаға жатқызылған күндердегі ылғалдылық, жел және PM деңгейлері ауруханаға жатқызылмаған науқастардың деңгейімен бірдей болды.

Түйін сөздер*: ӨСОА-ның өршуі, метеорология, ауаның ластануы.*

Bibliographic citation:

Kurt F., Kavalci C., Colak T., Celik K., Tekten B.O., Isık B. The investigation of relationship between meteorological and air pollution parameters with COPD exacerbation // *Nauka i Zdravookhranenie* [Science & Healthcare]. 2023, (Vol.25) 3, pp. 178-184. *doi 10.34689/SH.2023.25.3.024*

Курт Ф., Кавальчи Ч., Чолак Т., Челик К., Тектен Б.О., Исик Б. Исследование связи метеорологических параметров и показателей загрязнения воздуха с обострением ХОБЛ // Наука и Здравоохранение. 2023. 3(Т.25). С. 178-184. *doi 10.34689/SH.2023.25.3.024*

Курт Ф., Кавальчи Ч., Чолак Т., Челик К., Тектен Б.О., Исик Б. Өкпенің созылмалы обструктивті ауруының өршуінің ауаның ластану көрсеткіштері мен метеорологиялық параметрлердің байланысын зерттеу // Ғылым және Денсаулық сақтау. 2023. 3 (Т.25). Б. 178-184. *doi 10.34689/SH.2023.25.3.024*

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is an important cause of morbidity and mortality. The prevalence of COPD in adults over the age of 40 in the world is 20%, and in our country according to the pilot study conducted in Adana it is 19.1% [3]. It is known that COPD exacerbations negatively affect the quality of life and life span of patients (7, 6, 15, 32). COPD exacerbations are an important cause of morbidity and mortality [3], increasing costs due to treatment and hospitalizations.

The effect of meteorological events on various diseases has been investigated for a while. Their effects on cerebrovascular diseases, pneumonia and coronary artery diseases were examined already [32, 18, 36,41].

Changes in environmental factors such as the ratio of the components of the inhaled air, temperature, humidity,

and air pollution can exacerbate airway inflammation and cause COPD exacerbation. Meteorological variations especially set the ground for tracheitis, bronchitis, bronchial asthma, pneumonia, and other respiratory infections [41]. Other factors such as infection, social factors, and medical treatment can modify the response of COPD patients to environmental stimuli [48]).

The aim of the present study was to determine the relationship between meteorological and air pollution parameters [temperature, humidity, wind, sulfur dioxide (SO2), PM [8]] with COPD exacerbation.

Materials and Methods

Our study was conducted by retrospectively screening the files of the patients followed up due to COPD exacerbation in the emergency department of Izzet Baysal University between 01.06.2016 and 01.06.2017 after obtaining the approval from the Ethics Committee.

Izzet Baysal University Hospital is a tertiary foundation university hospital. In our adult emergency department, annual averages of 30000 patients are treated.

The histories, physical examination findings, the results of chest X-rays and computed tomography (CT) laboratory findings, frequency of admission to the emergency department, frequency of hospitalizations, and emergency service outcomes of all cases were examined. The meteorological variables on the days when the diagnosis of COPD exacerbation was made and meteorological variables on the days when the diagnosis of COPD exacerbation not made were compared.

Meteorological data were received from the IBM web-site of https://www.wunderground.com whereas the weather monitoring data were received from the https://www.havaizleme.gov.tr website of the Republic of Turkey Ministry of Environment and Urbanization.

The patients who were admitted to the ER with shortness of breath/respiratory distress and diagnosed with diseases other than COPD exacerbation (pulmonary embolism, pneumonia, etc.), who aged below 65 years and whose files could not be accessed, were excluded from the study.

All statistical analyses were performed by using SPSS version 24.0 for windows. Model analyzes were performed using the MGCV library in the R package version 3.4.1. The conformity of the data to the normal distribution was tested with the Kolmogorov-Smirnov test. The descriptive data were expressed as mean standard deviation (SD), median, interquartile range (IQR), minimum, maximum, patient number (n), and %. The chi-square test was used to compare the categorical variables. Mann-Whitney U test was used to compare numerical variables between COPD exacerbation admission and non-admission days and chi-square test was used to investigate relationship between admission and event (rain). The lag analysis was used to determine the factors affecting the development of COPD exacerbation during the last four days. Generalized additive regression models were built to investigate effects of meteorological variables, gases, and lag effects on COPD exacerbation admission.

Relationships between meteorological measurements were tested with the Spearman correlation coefficient. The effect of the main and lag effects of meteorological variables on hospital admission were tested with generalized additive logistic regression analysis, and the effect on the number of admissions was tested with the generalized additive Poisson regression method. Odds ratio and 95% confidence intervals were given to show the effect size of the estimates. A p value smaller than 0.05 was accepted as statistically significant.

Results

A total of 353 patients diagnosed with COPD exacerbation were included in the study. The mean age of patients was 71.6±9.7 years. Of the patients, 271 (76.8%) were male and 82 (23.2%) were women.

It was observed that 102 (28.9%) of the patients were non-smokers, 112 (31.7%) of the patient's way of heating their home was natural gas, and 241 (68.3%) of the patient's way of heating their home were wood or coal. The most common comorbid disease seen in the patients was hypertension (figure 1).

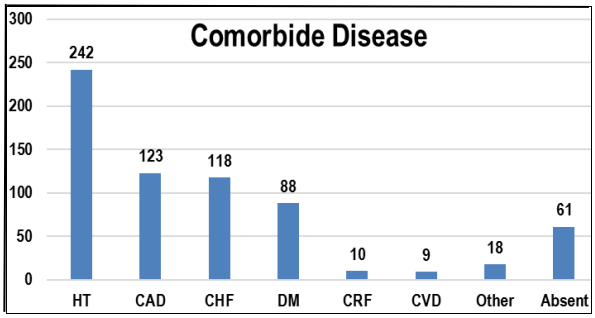

Figure 1. Comorbige Disease.

The most frequent patient was admitted during the winter season (figure 2).

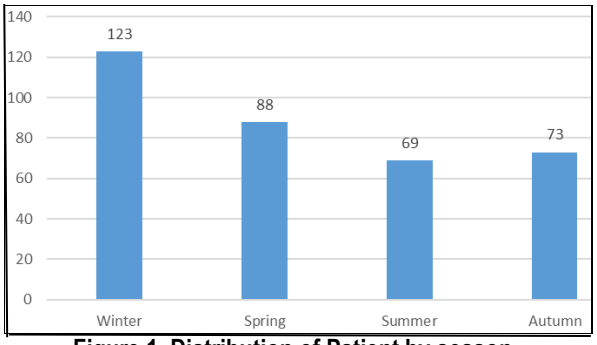

Figure 1. Distribution of Patient by season.

The median pH value of the patients included in our study is 7.42 (0.09), the median partial oxygen pressure (pO2) is 48 mmHg (17 mmHg), the median partial pressure of carbon dioxide (pCO2) is 39 mmHg (15mmHg), bicarbonate (HCO3) median value was 23 mmol/L (5mmol/L) and lactate median value was 1.53 mEq/L (mEq/L).

It was found that 14 (4%) of the patients applied to the emergency department once due to COPD, 122 (34.6%) two or three times, 217 (61.5%) 4 or more times between the specified dates.

Of the patients, 217 (61.5%) were discharged from the ER, 127 (36%) were hospitalized, 3 (0.8%) died in the ER, six (1.6%) left the hospital at own request.

At least one patient admission was detected in 228 (62.5%) of 365 days taken into evaluation. It was determined that one case applied in 136 days (59.6%), two cases in 64 days, three cases in 23 days and 4 cases in 5 days.

The mean temperature value was 9.74 ± 8.6°C. Other meteorological and air pollution parameters are summarized in the table. (Table 1).

Table 1.

Descriptive statistics of temperature parameters.

	Mean	SS	Median	IQR	Minimum	Maximum
Temperature (°C)	9,74	8,64	9,7	15	-8,70	25,60
Humidity (%)	72,40	11,06	71,5	15,3	45,80	99,00
Wind speed (m/S)	1,38	0,34	1,4	0,4	0,60	2,70
PM 10	30,66	20,91	25	19,5	2,00	149,00
SO2	15,78	13,17	12	12	2,00	74,00

The temperature level was statistically significantly lower on the days of admission due to COPD attack ($p<0.05$). On the other hand, there was no statistically significant difference in humidity and wind levels between the days with and without admission ($p>0.05$) The SO2 level was statistically significantly lower on the days of admission due to COPD attack ($p<0.05$). In PM 10 levels, there was no statistically significant difference between the days with and without admission ($p>0.05$) (Table 2).

Table 2.

Relationship between pneumonia visits and air pollution parameters.

	Present (n=228)	Not Present (n=137)	p
Temperature	8,7 (13,4)	12,8 (12,8)	**0,006**
Humidity	71,5 (16,5)	71,5 (15,1)	0,555
Wind	1,4 (0,5)	1,4 (0,4)	0,234
PM 10	26 (20)	23 (17,5)	0,093
SO2	12 (15)	10 (9)	**0,003**

There was a negative correlation between the number of applicants with temperature and wind, and a positive correlation between PM10 and SO2 ($p<0.05$); No correlation was found between moisture and humidity ($p>0.05$) (Table 3).

Table 3.

The relationship between the frequency of admission and meteorological factors.

	r	p
Temperature	-0,193	**<0,001**
Humidity	0,068	0,198
Wind	-0,124	**0,018**
PM 10	0,106	**0,044**
SO2	0,181	**0,001**

It was found that there was no statistically significant relationship between the temperature status of the last 4 days and the presence of COPD admitted to hospital ($p>0.05$) (Table 4).

Table 4.

The relationship between the last 4-day weather parameters and the presence of hospital admission due to COPD.

	Day 0	1 day before visit	2 day before visit	3 day before visit	4 day before visit
Temperature	0,996 [0,944-1,050]	0,996 [0,929-1,067]	1,000 [0,933-1,071]	0,997 [0,930-1,068]	0,984 [0,934-1,038
P	0,884	0,916	0,997	0,938	0,570
Humidity	1,003 [0,987-1,019]	1,003 [0,985-1,020]	1,002 [0,984-1,019]	1,002 [0,984-1,019]	1,004 [0,988-1,019]
P	0,677	0,726	0,815	0,814	0,599
Wind	0,796 [0,497-1,276]	0,890 [0,539-1,470]	0,852 [0,517-1,404]	0,890 [0,540-1,467]	0,814 [0,509-1,302]
p	0,344	0,650	0,531	0,648	0,392
PM 10	1,003 [0,994-1,012]	1,001 [0,990-1,012]	1,003 [0,992-1,013]	1,001 [0,990-1,011]	1,004 [0,994-1,012]
p	0,448	0,813	0,598	0,829	0,442
SO2	1,010 [0,994-1,026]	1,005 [0,986-1,023]	1,005 [0,986-1,023]	1,004 [0,986-1,023]	1,009 [0,993-1,025]
p	0,219	0,597	0,614	0,630	0,269

It was found that there was no statistically significant relationship between the humidity status of the last 4 days and the presence of COPD patients admitted to hospital ($p>0.05$) (Table 4).

It was determined that there was no statistically significant relationship between the wind condition of the last 4 days and the presence of COPD patients admitted to hospital ($p>0.05$) (Table 4).

It was determined that there was no statistically significant relationship between PM 10 level in the last 4 days, presence of COPD patients admitted to hospital and the number of admissions ($p>0.05$) (Table 4).

It was determined that there was no statistically significant relationship between SO2 level in the last 4 days, presence of COPD patients admitted to hospital and the number of admissions ($p>0.05$) (Table 4).

Discussion

Changes in meteorological factors usually affect the respiratory system. They cause especially bronchial asthma, tracheitis, pneumonia, and other respiratory tract pathologies [10]. Meteorological factors act by reducing the resistance of the human body to infection and by facilitating the spread of infection- causing pathogens [11, 12].

Chronic obstructive pulmonary disease is a progressive disease of the respiratory tract and progresses with attacks. Most of these attacks are due to infective causes, and the other part is due to air pollution and other substances that irritate the respiratory tract [13]. Meteorological factors act

by reducing the resistance of the human body to infection and facilitating the spread of pathologies that cause infection [14, 15]. It was determined that the air pollution increased non-infectively and the respiratory function was 0.8% dead. The patient group included in our study presented with mild symptoms, the patients responded to the treatment due to normal or mild changes in vital signs such as blood gas, blood pressure, and respiratory rate, and the oxygen saturation returning within normal values after the treatment, which ensured that the patients were discharged from the emergency department, we think that slight changes in the vital signs and blood gases of the patients who did not respond fully to the treatment allowed the patients to be admitted to the ward. We think that patients have frequent attacks due to infective or non-infective causes.

Karlıkaya C. et al. stated in their study that the frequency of admission due to COPD attacks is in the autumn and winter months [25]. Taşçı et al. stated that the majority of patients applied with pneumonia, COPD exacerbation, and bronchiectasis super infection due to the cold effect in winter months [23]. Tuan et al. stated that the level of PM increases in cold months and plays an active role in respiratory system pathologies [26]. It has been stated that the frequency of infection and related respiratory pathologies increase in winter months [27, 28]. In our study, it was found that COPD development was more common in winter months. We are of the opinion that the increasing use of fuels such as coal used for heating purposes, and particles formed by liquid and gaseous fuels due to vehicle use, play a major role in increasing infections in winter.

When the relationship between air temperature and the frequency of COPD attacks is examined; In some publications, it has been reported that hot air increases the frequency and severity of COPD attacks [29-32] and in some publications, cold weather increases the frequency and severity of COPD attacks [33-37]. In our study, it was determined that the rate of admission to COPD exacerbations was more common on cold days, and there was a negative correlation between the frequency of admission and the temperature. By increasing the infective causes of cold weather, the frequency of COPD attacks with infective background increases; On the other hand, we believe that it increases the frequency of non-infective COPD attacks due to bronchospasm that develops in cold weather and the increase in the amount of solid/liquid fuel used.

It has been known for a long time that living in damp houses significantly affects respiratory health and is a cause of respiratory disease. [38-41]. When the relationship between humidity and the frequency of COPD attacks is examined; some authors reported that high humidity rates increase the frequency of COPD attacks [31], while some authors reported that low humidity rates increase the frequency of COPD attacks by causing bronchoconstriction [42]. In our study, no relationship was found between humidity rate and the number of days admitted due to COPD attack and the frequency of admission. Considering the increase in the frequency of COPD attacks due to bronchospasm in periods of low humidity, and the increase in the frequency of attacks caused by infective agents at high humidity levels; It can be explained that there is no relationship between humidity and attack frequency.

When the relationship between wind and COPD attack frequency is examined; some authors reported that the wind increased the frequency of COPD attacks [43], and some authors reported that there was no correlation [42]. In our study, it was determined that the number of admission days with COPD attack was unrelated to the wind speed, and there was a negative correlation between the frequency of admission and the wind speed. We believe that the number of COPD attacks during the day decreases as the wind removes harmful gases and particles from the region.

Previous studies have associated air pollution with respiratory diseases [44-47]. Some authors reported that the increase in the levels of substances such as PM 10 increases the frequency of COPD attacks [16,26, 42,48-50]. In our study, on the days when COPD admission was common; PM 10 level was found to be high, albeit insignificantly. A positive correlation was found between the frequency of admission and the PM 10 level. We are of the opinion that air pollutants cause an attack by directly damaging the alveoli and disrupting the inflammation.

When the relationship between SO2 level and the frequency of COPD attack is examined; In our study, we observed that the frequency of COPD exacerbations increased on days with high SO2 levels. A positive correlation was found between the frequency of admission and the SO2 level. In his thesis study, *Yüzer H.* stated that high SO2 levels at the time of application increase the frequency of attacks [42]. Yang et al. stated that air pollutants (PM, SO2, NO2, etc.) cause an increase in the frequency of hospitalization due to COPD [48]. *Tuan T.S. et al.* stated that gases such as SO2 affect respiratory pathologies rather than infection [26]). We think that gases such as SO2 increase the frequency of attacks by damaging the bronchi. [51].

Yüzer H. investigated the relationship between the weather parameters in the last 4 days before an application due to COPD attack and the application due to COPD attack [42]. They reported that high SO2 level on the 2nd day before the COPD attack increased the frequency of COPD [42]. In our study, it was determined that there was no statistically significant relationship between the last 4 days of temperature, humidity, PM 10 and SO2 status and the presence of hospital admission due to COPD. We believe that 4-day changes do not affect the frequency of attacks because only a part of the reason for the frequency of COPD attacks is infective factors, humidity and heat cause an attack through bronchospasm with the effect of the same day, and air pollutants already have a direct effect.

Conclusion

On days with COPD admission, the air temperature was lower and the SO2 level was higher. Humidity, wind and PM levels on admission days were similar to those in non-admission patients. While a negative correlation was found between the number of applications with temperature and wind, and a positive correlation between PM and SO2; No correlation was found between moisture and humidity. It was determined that there was no statistically significant relationship between the last 4 days of temperature, humidity, wind, PM 10 and SO2 status between the presence of hospital applications due to COPD and the number of admissions to the hospital.

Limitations

Our study was conducted in a single center, which might limit the generalizability of our results. We also did not consider the day of the week and seasonal trends in the analysis

This study was presented in Intercontinental emergency medicine congress, 5. Intercontinental critical care congress, 14. Ulusal acil Tıp kongresi. 19-22 Nisan 2018, Belek, Antalya, Turkey

Acknowledgement

Declaration of conflicting interests: *The authors declare that there is no conflict of interest in the present study.*

Funding: *None.*

Author contribution statement: *All authors were equally involved.*

References:

1. *Analitis A., Katsouyanni K., Biggeri A., Baccini M., Forsberg B., Bisanti L. et al.* Effects of cold weather on mortality: results from 15 European cities within the PHEWE project // Am J Epidemiol. 2008. 168(12):1397-408

2. *Ayres J.G., Forsberg B., Annesi-Maesano I., Dey R., Ebi K.L., Helms P.J. et al.* İklim Değişikliği ve Solunum Hastalıkları: Avrupa Solunum Derneği Durum Değerlendirmesi // Eur Res J. 2009. 34:295-302

3. *Bingöl Z., Çağatay T.* Exacerbation Causes İn Patients With Chronic Obstructive Pulmonary Disease (COPD) Diagnosis, Treat ment, And Awareness Of Risk Group Patients // Klinik Tıp Aile Hekimliği Dergisi. 2016. 8(3):21-3.

4. *Borges I.C., Andrade D.C., Cardoso M.-R.A., Meinke A., Barral A., Käyhty H. et al.* Seasonal patterns and association of meteorological factors with infection caused by Streptococcus pneumoniae, Haemophilus influenzae, and Moraxella catarrhalis in childhood community-acquired pneumonia in a tropical region // Infect Dis. 2017. 49:2(147-150).

5. *Colucci M., Maione F., Bonito M.C., Piscopo A., Di Giannuario A., Pieretti S.* New insights of dimethyl sulphoxide effects (DMSO) on experimental in vivo models of nociception and inflammation // Pharmacol Res. 2008. 57(6):419-25.

6. *Connors A.F., Dawson N.V., Thomas C., Harrell F.E., Desbiens N., Fulkerson W.J. et al.* Outcomes following acute exacerbation of severe chronic obstructive lung disease. The SUPPORT investigators (Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments) // American Journal of Respiratory and Critical Care Medicine. 1996, 154:959-67.

7. *Cote C.G., Dordelly L.J., Celli B.R.* Impact of COPD exacerbations on patient-centered outcomes // Chest, 2007. 131:696-704

8. *de' Donato F., Michelozzi P., Goffredo S., Dubinsky Z.* Climate Change, Extreme Weather Events and Health Effects // The Mediterranean Sea. Springer, Dordrecht. 2014. https://doi.org/10.1007/978-94-007-6704-1_38

9. *Deniz S., Özhan M.H.* Infective Exacerbations of Chronic Obstructive Pulmonary Disease with or without Pneumonia // Eurasian J Pulmonol. 2014. 16(1):32-5.

10. *Ehelepola N.D.B., Ariyaratneb K., Jayaratnea A.* The association between local meteorological changes and exacerbation of acute wheezing in Kandy, Sri Lanka // Global health action. 2018. 11: 1482998.

11. *Ferrari U., Exner T., Wanka E.R., Bergemann C., Meyer-Arnek J., Hildenbrand B. et al.* Influence of air pressure, humidity, solar radiation, temperature, and wind speed on ambulatory visits due to chronic obstructive pulmonary disease in Bavaria, Germany // Int J Biometorol. 2012. 56(1):137-43.

12. *Fisk W.J., Lei-Gomez Q., Mendell M.J.* Meta-analyses of the associations of respiratory health effects with dampness and mold in homes // Indoor air. 2007. 17(4):284-96.

13. *Gautret P., Gray G.C., Charrel R.N., Odezulu N.G., Al-Tawfiq J.A., Zumla A. et al.* Emerging viral respiratory tract infections—environmental risk factors and transmission // Lancet Infect Dis. 2014. 14(11):1113-22.

14. *Göçmen H., Ediger D., Uzaslan E., Ege E.* The Relationship between Hospitalization with Spirometric Findings and Emphysema Pattern in Patients with Stable COPD // Fırat Tıp Dergisi. 2009. 14(4):254-9.

15. *Gunen H., Hacievliyagil S.S., Kosar F., Mutlu L.C., Gulbas G., Pehlivan E. et al.* Factors affecting survival of hospitalised patients with COPD // Europ Resp J. 2005. 26:234-41.

16. *Gunnbjörnsdóttir M.I., Franklin K.A., Norbäck D., Björnsson E., Gislason D., Lindberg E. et al.* Prevalence and incidence of respiratory symptoms in relation to indoor dampness: the RHINE study // Thorax. 2006. 61(3):221-5.

17. *Happo M.S., Uski O., Jalava P.I., Kelz J., Brunner T., Hakulinen P. et al.* Pulmonary inflammation and tissue damage in the mouse lung after exposure to PM samples from biomass heating appliances of old and modern technologies // Sci Total Environ. 2013. 443:256-66.

18. *Hurst J.R., Vestbo J., Anzueto A., Locantore N., Mullerova H., Tal-Singer R. et al.* Susceptibility to exacerbation in chronic obstructive pulmonary disease // New Eng J Med. 2010. 363:1128-38.

19. *Jacob B., Ritz B., Gehring U., Koch A., Bischof W., Wichmann H.E. et al.* Indoor exposure to molds and allergic sensitization // Environmental health perspectives. 2002. 110(7):647-53.

20. *Jain S., Williams D.J., Arnold S.R., Ampofo K., Bramley A.M., Reed C. et al.* Community-acquired pneumonia requiring hospitalization among US children // New Eng J Med. 2015. 372(9):835-45.

21. *Karlıkaya C., Türe M., Yıldırım E.* Kronik Obstruktif Akciğer Hastalığı (KOAH) Alevlenmelerinin Mevsimsel Özelliği // Balkan Med J. 2000. 17(3):171-6.

22. *Lin H., Ma W., Qiu H., Vaughn M.G., Nelson E.J., Qian Z. et al.* Is standard deviation of daily PM 2.5 concentration associated with respiratory mortality? // Environ Pollut. 2016. 216:208-14.

23. *Lin Z., Gu Y., Liu C., Song Y., Bai C., Chen R. et al.* Effects of ambient temperature on lung function in patients with chronic obstructive pulmonary disease: A time-series panel study // The Science of the total environment. 2017. 619-620:360-5.

24. *Liu Y., Liu J., Chen F., Shamsi B.H., Wang Q., Jiao F. et al.* Impact of meteorological factors on lower respiratory tract infections in children // J Int Med Res, 2016. 44:30-41. DOI: 10.1177/0300060515586007

25. *Martin K.L., Hanigan I.C., Morgan G.G., Henderson S.B., Johnston F.H.* Air pollution from bushfires and their association with hospital admissions in Sydney,

Newcastle and Wollongong, Australia 1994-2007 // ANZJPH. 2013. 37(3):238-43.

26. *Meng Li Shengqi Chen, Hanqing Zhao, Chengxiang Tang, Yunfeng Lai, Carolina Oi Lam Ung, Jinya Su, Hao Hu.* The short-term associations of chronic obstructive pulmonary disease hospitalizations with meteorological factors and air pollutants in Southwest China: a time-series study // Nature reports. Sci Rep. 202 11:12914 https://doi.org/10.1038/s41598-021-92380-z

27. *Meszaros D., Markos J., Fitzgerald D.G., Walters E.H., Wood-Baker R.* An observational study of PM 10 and hospital admissions for acute exacerbations of chronic respiratory disease in Tasmania, Australia 1992-2002 // BMJ Open Respiratory Research. 2015;2(1):e000063.

28. *Mourtzoukou E.G., Falagas M.E.* Exposure to cold and respiratory tract infections // Int J Tuberculosis Lung Dis, 2007. 11:938–943.

29. *Mu Z., Chen P.L., Geng F.H., Ren L., Gu W.C., Ma J.Y. et al*. Synergistic effects of temperature and humidity on the symptoms of COPD patients // Int J Biometeorol. 2017. 61(11):1919-25.

30. *Pica N., Bouvier N.M.* Ambient temperature and respiratory virus infection // Pediatr Infect Dis J 2014. 33(3):311-3.

31. *Roberts C., Lowe D., Bucknall C., Ryland I., Kelly Y., Pearson M.* Clinical audit indicators of outcome following admission to hospital with acute exacerbation of chronic obstructive pulmonary disease // Thorax. 2002.57(2):137-41

32. *Seemunga T.A., Donaldson G.C., Paul E.A., Bestall J.C., Jeffries D.J., Wedzicha J.A.* Effect of exacerbation on quality of life in patients with chronic obstructive pulmonary disease // American Journal of Respiratory and Critical Care Med. 1998. 157:1418-22.

33. *Sercan E.Ö.* KOAH'ta Alevlenme Nedenleri ve Alevlenmenin Değerlendirilmesi // Solunum Dergisi. 2009. Ek sayı:7-10.

34. *Stafoggia M., Forastiere F., Agostini D., Caranci N., De'Donato F., Demaria M. et al.* Factors affecting in-hospital heat-related mortality: a multi-city case-crossover analysis // JECH. 2008. 62(3):209-15.

35. *Taşçı C., Çanakçı Z., Deniz Ö., Özkan M., Bilgiç H.* The properties of the patients admitting to the emergency service of Eskişehir Military Hospital with a pulmonary disease // Gülhane Tıp Deg. 2009. 51:220-2.

36. *Taşçı S.S., Kavalci C., Kayipmaz A.E.* Relationship of Meteorological and Air Pollution Parameters with Pneumonia in Elderly Patients // Emerg Med Int. 2018 Mar 21;2018:4183203. doi: 10.1155/2018/4183203. eCollection 2018.

37. *Tuan T.S., Venâncio T.S., Nascimento L.F.C.* Air pollutants and hospitalization due to pneumonia among children. An ecological time series study // Sao Paulo Med J. 2015. 133(5):408-13.

38. *Tam P.Y.I., Madoff L.C., O'Connell M., Pelton S.I.* Seasonal variation in penicillin susceptibility and invasive pneumococcal disease // Pediatr infect Dis J. 2015. 34(4):456-7.

39. *Tutuk S.P.M., Altun Ö.Ş.* Determination of Hospital Anxiety and Depression Levels of Patients Admitted to Hospitals with COPD Diagnosis // Sted. 2014. 23(6):216-21.

40. *Trianti S.M., Samoli E., Rodopoulou S., Katsouyanni K., Papiris S.A., Karakatsani A.* Desert dust outbreaks and respiratory morbidity in Athens, Greece // Environmental health. 2017;16(1):72. DOI 10.1186/s12940-017-0281-x

41. *Vestbo J., Hurd S.S., Agusti A.G., Jones P.W., Vogelmeier C., Anzueto A. et al.* Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary // Am J Resp Crit Care Med. 2013. 187:347-65.

42. *Wang K.Y., Chau T.T.* An association between air pollution and daily outpatient visits for respiratory disease in a heavy industry area // PloS One. 2013;8(10):e75220

43. *Wedzicha J.A.* Exacerbations: Etiology and Pathophysiologic Mechanisms // Chest. 2002. 121:136-41.

44. *Wong A.W., Gan W.Q., Burns J., Sin D.D., van Eeden S.F.* Acute exacerbation of chronic obstructive pulmonary disease: influence of social factors in determining length of hospital stay and readmission rates // Can Respir J. 2008. 15:361-4.

45. *Yang C.Y., Chen C.J.* Air pollution and hospital admissions for chronic obstructive pulmonary disease in a subtropical city: Taipei, Taiwan // J Toxicol Environ Health A. 2007 Jul. 70(14):1214-9. doi: 10.1080/15287390701380880. PMID: 17573635.

46. *Yentürk E., Alkan N., Bahar Y., Toraman Y.A., Tuncay E.* Akut atak nedeniyle hospitalize edilen KOAH olgularının özellikleri ve yatış süresini etkileyen faktörler // Akciğer. 2007. 13:16-21.

47. *Yüzer H.* Determination of relationship between hospitalization rate, air pollution and meteorological factors with the chronic obstructive pulmonary disease patients who apply for an emergency service. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=Jt7oA75Nf13fSKRPHW4eKw&no=1WFItEwS9ZkDnnHJj6jkqg

48. *Zanobetti A., Schwartz J., Dockery D.W.* Airborne particles are a risk factor for hospital admissions for heart and lung disease // Environ Health Perspect 2000; 108(11):1071-7.

49. *Zeger S.L., Thomas D., Dominici F., Samet J.M., Schwartz J., Dockery D. et al.* Exposure measurement error in time-series studies of air pollution: concepts and consequences // Environ Health Perspect. 2000. 108(5):419-26.

Corresponding Author:
Cemil Kavalci, Prof. Dr., Health Science University of Türkiye, Antalya Training and Research Hospital, Emergency Medicine, Antalya/Türkiye.
E-mail: cemkavalci@yahoo.com
Phone: +90 505 5762819