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From pollution to exacerbation in chronic obstructive pulmonary disease

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Abstract

English:

Air pollution is increasing every year, especially due to the continuous process of industrialization and modernization. In this observational study, we included 38 COPD patients with frequent exacerbating phenotypes and we wanted to see if the values of microparticles with a size of 1.0, 2.5 and 10 µm, recorded in their homes, are above the values recommended by the World Health Organization (WHO). An air quality monitoring source was installed in each patient's home for at least 24 hr and microparticles with a size of 1.0, 2.5 and 10 µm, temperature, pressure and humidity were measured. MEAN PM2.5 values were higher than the values recommended by the WHO, 25.33 µg/m^3 vs. 15 µg/m^3. Our analysis showed that the levels of microparticles in the homes of patients with COPD, and frequently exacerbating phenotype, are above the limits recommended by the WHO.

Keywords

exacerbation • COPD • air pollution • particulate matter

De la poluare la exacerbare în boala pulmonară obstructivă cronică

Rezumat

Romanian:

Poluarea aerului crește în fiecare an, mai ales datorită procesului continuu de industrializare și modernizare. În acest studiu observațional, am inclus 38 de pacienți cu BPOC cu un fenotip frecvent exacerbator și am dorit să vedem dacă valorile microparticulelor cu dimensiunea de 1,0, 2,5 și 10 microni înregistrate în locuințele lor sunt peste valorile recomandate de Organizația Mondială a Sănătății. La fiecare pacient a fost instalată o sursă de monitorizare a calității aerului timp de cel puțin 24 de ore și s-au măsurat microparticule cu dimensiunea de 1,0, 2,5 și 10 microni, temperatura, presiunea și umiditatea. Valorile medii ale PM2,5 au fost mai mari decât valorile recomandate de OMS, 25,33 µg/m^3 vs. 15 µg/m^3. Analiza noastră a arătat că nivelurile de microparticule din casele pacienților cu BPOC și fenotip frecvent exacerbator sunt peste limita recomandată de OMS.

Cuvinte-cheie

exacerbare • BPOC • poluare a aerului • particule în suspensie

Introduction

One of the top three causes of death worldwide is due to chronic obstructive pulmonary disease (COPD) (1). According to the World Health Association (WHO) in 2019, there were 7 million premature deaths due to indoor and outdoor air pollution. Of these, 19% were through COPD (2). COPD appears as a result of constant exposure to harmful inhaled

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substances and it is characterized by persistent symptoms such as cough, expectoration or dyspnea (1). Smoking is the main risk factor, but pollution, which is increasing globally, is also affecting non-smokers. Until recently, it was considered a disease that affects people >50 years, but its emergence appears to be sooner due to exposure to air pollution early in life (3,4).

Air pollutants are classified into primary and secondary air pollutants. The primary air pollutants are released directly into the atmosphere by a source, whereas the secondary air pollutants are formed in the atmosphere with the help of other compounds (5). Atmospheric pollutants can have a low solubility, such as ozone (O_3) or nitrogen dioxide (NO_2), causing a greater penetration into the respiratory system and affecting the lower airways. Atmospheric pollutants that have an increased solubility, such as sulfur dioxide (SO_2), will settle in the upper respiratory tract, causing symptoms such as rhinitis or laryngitis (6).

Objectives

The objective of this study was to measure atmospheric values and particulate matter (PM1.0, PM2.5 and PM10) in the homes of frequently exacerbating patients to compare them with the WHO values. Patients with a frequently exacerbating phenotype are represented by those who have one or more exacerbations per year that require continuous hospitalisation or have two moderate exacerbations that require antibiotic treatment and/or systemic corticosteroid treatment (7,8). Thus, the goal was to see if the recorded values are higher or lower than the WHO recommended values.

Materials and methods

Study design

This is an observational study. In this study, all subjects were patients diagnosed with COPD and were recruited from the Pneumology Clinic of the 'Victor Babeș'Clinical Hospital in Timisoara, located in the western region of Romania. The study period was for six months, between September 2020 and March 2021.

Participants

According to the Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD), patients diagnosed with mild or moderate forms of COPD (stages I and II) with FEV1 >50% were excluded, and the patients who were <45 years old with FEV1/FVC >0.7% or those who were in an acute exacerbation were also excluded. This study was carried out in the homes of patients with more advanced stages (III and IV), having FEV1 <50%, with a frequently exacerbating phenotype, but stable without being in an acute exacerbation.

Air quality monitoring

An uRADMonitor SMOGGIE-PM air quality monitoring source was installed in each patient's home for at least 24 hr. This is a fixed, automatic monitoring station, and its functions are to measure the humidity, atmospheric pressure, temperature and PM2.5, PM10 and PM1.0 particles. The detector connects to the Internet via WiFi. The data measured by it are recorded using the Internet and can be accessed on the manufacturer's website (Figure 1).

World Health Organization values

The normal values recommended by the WHO are lower than in previous guidelines. Annual average concentrations of PM2.5 must not be >5 μg/m^3 (although in previous guidelines, the value was <10 μg/m^3), and the average values for 24 hr must be <15 μg/m^3, with the exception of 3–4 days/year (in previous guidelines, the recommendation was that this value should be <25 μg/m^3, with the exception of not >3 days/year) (9).

Regarding PM10, the annual average concentrations must not be >15 μg/m^3 (although in previous guidelines, the value was <20 μg/m^3), and the average values for 24 hr must be



Figure 1. uRADMonitor SMOGGIE-PM.

<45 μg/m³ (in previous guidelines, the recommendation was <50 μg/m³ (9).

Results

Patient characteristics

A group of 38 patients diagnosed with COPD were recruited for this study. Most of the patients lived in urban areas (71.1%). The mean age was 63.47 ± 9.64 years. Among these patients, the highest percentage was represented by men *n* = 30 (78.9%) and in terms of education, only 13.15% had a university degree. The vast majority have finished elementary school or junior and senior high school. Most individuals live at a distance >200 m from a main road *n* = 19 (50%) and have a living area >60 m², *n* = 18 (47.36%) (Table 1).

Table 1. Demographic data.

Parameter	Value
Age (years)	63.47 ± 9.64
Gender	
Women	8 (21.1)
Men	30 (78.9)
Education	
Elementary school (Grades 1–8)	16 (42.1)
Junior and senior high school (Grades 1–12)	17 (44.73)
University degree	5 (13.15)
Residence	
Urban	27 (71.1)
Rural	11 (28.9)
Road distance (m)	
<50	11 (28.94)
50–200	8 (21.05)
>200	19 (50)
Living area (m²)	
<30	6 (15.78)
30–59	14 (36.84)
>60	18 (47.36)
COPD stage	
GOLD 3	18 (47.36)
GOLD 4	20 (52.6)
Home oxygen	
Yes	27 (71.05)
No	11 (28.95)

COPD, chronic obstructive pulmonary disease; GOLD, Global Initiative for Chronic Obstructive Pulmonary Disease.
Data were presented as *n* (%).

The distribution of patients with stages III and IV was almost equal and a percentage of 71.05% had oxygen therapy at home during the study period (Table 1).

Air quality measurements

In this group, the MEAN PM2.5 value recorded was 25.330 [IQR = 92.76] with a 95% CI of [14.69; 73.38]. Furthermore, the MAX PM2.5 value recorded was 240.47 μg/m³ [IQR = 644.15] with a 95% CI of [130.00; 457.00]. The MIN PM2.5 was 3.00 μg/m³ [IQR = 9.39] with a 95% CI of [1.58; 7.00] (Table 2).

At the same time, the measurements of MEAN PM10 values were 36.59 μg/m³ [IQR = 97.88] with 95% CI of [13.59; 55.68]. MAX PM10 values measured were 266.05 μg/m³ [IQR = 534] with 95% CI of [173.25; 489.50], and MIN PM10 values recorded were 2.89 μg/m³ [IQR = 9.42] with 95% CI of [0.75; 5.75] (Table 2).

In addition to PM10 and PM2.5, we were also able to measure the amount of PM1.0. The value for MEAN PM1.0 was 23.04 μg/m³ [IQR = 88.71] with 95% CI of [14.51; 53.60]. The value for MAX PM1.0 was 232.34 μg/m³ [IQR = 349.8] with 95% CI of [104.67; 350.46]. The value for MIN PM1.0 was 2.39 μg/m³ [IQR = 7.33] with a 95% CI of [1.00; 5.00] (Table 2).

Atmospheric parameters

We also measured the minimum, maximum and mean temperatures in the patients' houses. The MEAN temperature values in residences of frequently exacerbating patients were 26.675°C [IQR = 6.06] with 95% CI of [24.23; 28.13]. Even more, the MAX temperature values recorded were 28.99°C [IQR = 6.25] with 95% CI of [27.74; 30.78] while the MIN temperature values recorded were 21.96°C [IQR = 7.95] with 95% CI of [17.55; 23.86]. In addition to the temperature, we were also able to measure the atmospheric pressure and humidity values within their residences (Table 3).

Table 2. Air quality parameters.

Parameter (μg/m³)	Median [IQR]	95% CI
MAX PM1.0	232.34 [349.8]	[104.67; 350.46]
MIN PM1.0	2.39 [7.33]	[1.00; 5.00]
MEAN PM1.0	23.04 [88.71]	[14.51; 53.60]
MAX PM2.5	240.47 [644.15]	[130.00; 457.00]
MIN PM2.5	3.00 [9.39]	[1.58; 7.00]
MEAN PM2.5	25.330 [92.76]	[14.69; 73.38]
MAX PM10	266.05 [534]	[173.25; 489.50]
MIN PM10	2.89 [9.42]	[0.75; 5.75]
MEAN PM10	36.590 [97.88]	[13.59; 55.68]

PM, particulate matter.

Table 3. Atmospheric parameters.

Parameters	Median [IQR]	95% CI
MAX temperature (°C)	28.99 [6.25]	[27.74; 30.78]
MIN temperature (°C)	21.96 [7.95]	[17.55; 23.86]
MEAN temperature (°C)	26.675 [6.06]	[24.23; 28.13]
MAX pressure (hPa)	1015.54 [8.56]	[1013.55; 1017.05]
MIN pressure (hPa)	1004.00 [12.29]	[1001.44; 1007.69]
MEAN pressure (hPa)	1009.255 [8.99]	[1007.87; 1012.24]
MAX humidity (RH)	55.21 [8.97]	[53.50; 58.00]
MIN humidity (RH)	38.25 [6.9]	[36.00; 40.00]
MEAN humidity (RH)	44.725 [6.74]	[42.39; 45.78]

Discussions

The observational study, which we conducted, showed that the MEAN PM2.5 values were higher than the values recommended by the WHO. The values recommended by the WHO for PM2.5 are <15 μg/m^3, and the MEAN values recorded by us were >20 μg/m^3, with a MIN value of 3 μg/m^3 and a MAX value of 240.47 μg/m^3. The MEAN PM10 recorded was 36.59 μg/m^3, having a MIN value of 2.89 μg/m^3 and a MAX value of 266.05 μg/m^3. According to the WHO recommendations, the MEAN PM10 values were within normal limits, but the MAX values were four times higher. In a study conducted in Colombia for 1 year on 250 patients, it was observed that the PM values were higher than those recommended by the WHO, 48 hr before the installation of an exacerbation (10). Also, 59 patients in different stages of GOLD were enrolled in a study that took place in Thailand between March and August 2016. Their lung function was better during August, when PM10 values were lower, compared to March when they were higher (11).

A study, similar to ours, took place in Taiwan between March 2014 and May 2016. It was observed that patients had more severe symptoms and a higher risk of exacerbation in residences where the micro-particle values were higher in the kitchen and living room (12). In our study, the air quality measurement unit was installed in the place where the patient spent most of the time. This is much more significant because this way the measurement is more precise.

Short-term exposure to different atmospheric pollutants can impact patients with COPD differently (13). In our study, the patients did not have acute exacerbations, but in a study carried out in China, it was observed that for every 10 μg/m^3 increase in PM2.5 on the day of the onset of an exacerbation, there is a 1.05% risk of hospitalisation due to this one (14).

Limitations

This study has several limitations. First, the study included only 38 patients. Second, results would have been even more accurate if patients from all stages of COPD had been evaluated and monitored. However, patients who are in stages I and II, according to the GOLD, are more active and carry out their activities outside their homes. Third, the role of the sensor would have been unjustified considering that these patients would not always be at home. Finally, the duration of monitoring was too short. A longer monitoring period would be more specific. The longer the duration, the more relevant it is because in this way we could observe when air pollution and the atmospheric factors can cause an exacerbation or a greater degradation of the lung function.

More studies should be conducted to see how strongly and quickly air pollution affects COPD patients and whether these phenotypes are caused by air pollution.

Conclusions

The fact that we live in an increasingly polluted world can have devastating effects on the quality of life. This invisible risk factor is increasingly harmful and exposure to it can have devastating effects on vulnerable patients. Although this study was carried out on a small group of patients, the measured values in the residences were clearly above the values recommended by the WHO.

Measurement of air pollution levels should be performed constantly and it would significantly contribute to the prevention of an acute COPD exacerbation.

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Authors contributions

All authors have contributed equally to this work.

Conflicts of interest

The authors declare no conflict of interest.

Institutional review board statement

The study was conducted according to the Declaration of Helsinki's guidelines and approved by the local Ethical Commission. The Hospital of Infectious Disease and Pneumophtisiology 'Dr. Victor Babes', Timisoara approved the protocol on August 18th, 2020, no. 6111.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

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