Original article

Respiratory function in subjects with Chronic Obstructive Pulmonary Disease (COPD) and atmospheric pollution in the city of Parma. Preliminary analysis

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Abstract. A hospital case record study was carried out enlisting urgently hospitalized subjects for chronic obstructive pulmonary disease (COPD) in order to study the percentage values variations of Vital Capacity (VC), Forced Vital Capacity (FVC) and maximum expiratory volume in 1 second (FEV1) based on atmospheric pollution trend in Parma city evaluated by PM_{10}, NO_2 and O_3 concentrations. The results showed an association only between PM_{10} and hospitalizations for COPD with statistically significant differences between PM_{10} concentrations assessed 3-4 days before hospitalizations of the study subjects and the ones established in the days without any hospitalization. The regression analysis between PM_{10} and respiratory function concerning PM_{10} concentration at 24, 48, 72, 96 hours before the hospitalization showed significant association between FVC% and FEV1% and PM_{10} concentrations at 96 hours. The calculated Odd Ratio resulted equal to 1,016 (L.C. 1,001-1,032) which corresponds to an increase of hospitalization probability for COPD equal to 1,6% for PM_{10} increment unit. (www.actabiomedica.it)

Key words: COPD, spirometric test, air pollution, PM_{10}

Introduction

Previous studies assessed the negative effects of atmospheric pollution affecting in particular both the cardiovascular and respiratory systems (1, 2, 4-6, 11, 13, 15, 16, 20, 23, 25, 29]. The functional and anatomical changes stemming from pollution depend on the type of exposure, and concentration and kind of pollutant. The pollutants which are mainly involved are the particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO) and ozone (O_3). Owing to its great variety of sizes, composition and origin, the particulate matter turns out to be the most important contaminant capable of causing several, serious, acute and chronic effects on human health (3).

Whereas the coarse and medium-sized particulate matter mainly settles in the nasopharyngeal and tracheobronchial areas, the breathable fraction with a diameter lower than 10 μm (PM_{10},) may even reach the pulmonary alveoli.

The results obtained from many epidemiological studies carried out in the last decade corroborate the dangerousness of PM_{10} (7-10, 12, 18, 19, 27, 30).

A special attention must be paid to asthma and chronic obstructive pulmonary disease (COPD) (14) among the respiratory pathologies that suffer from the negative effects of atmospheric pollution to a greater extent and incur frequent processes of relapse.

COPD is a chronic inflammatory disease characterized by airflow obstruction which is not com-

pletely reversible. It is a multi-factorial disease caused by genetic, behavioural and environmental factors.

The most important and documented risk factor for developing this pathology is cigarette smoke (21), however several research studies showed the influence exerted by atmospheric pollution on COPD, in particular on its evolution and episodes of relapse. These studies related the daily concentrations of specific pollutants and the number of hospitalizations [21, 22, 24, 26, 28]. We tried to take a further step forward as regards to these studies: until now only a few studies have tried to establish a correlation between the pollutant levels and the values of respiratory function of patients with pathologies of interest, in particular COPD (17). Our purpose was to search for an actual correlation between the increase of certain pollutants in atmospheric concentrations and changes in spirometric values of patients with COPD, hospitalized for COPD exacerbation.

Methods

The Hygiene Division of the Department of Public Health of the University of Parma carried out a study of hospital case record from 1/07/2008 to 31/3/2009. This study was carried out by enlisting the subjects residing in Parma who were urgently hospitalized in the Respiratory Clinic of the University of Parma, diagnosed by clinicians as COPD or its exacerbation: these were the only criteria for selecting the study population. These patients were interviewed using a specific questionnaire to collect personal information, and the results regarding spirometry (Vital Capacity VC, Forced Vital Capacity FVC and maximum expiratory volume in 1 second FEV1) were gathered from each of them. Tests were performed after 7-10 days of hospitalization to gain the picture of the patient's overall respiratory status, hence to allow to define the degree of COPD.

Data relating to atmospheric pollution were obtained by Regional Agency for Environmental Protection, air monitoring station, and regarded values for PM_{10}, NO_2 and O_3. For these pollutants means with standard deviations and correlation coefficients were calculated.

The mean concentrations regarding those days when hospitalizations occurred were calculated and compared with those of days without hospitalizations (lag 0) and even with the previous days (up to 96 hours - lag4).

Percentages of parameters of respiratory function were later evaluated based on pollutant values, analyzing the variations of these parameters through regression with the concentrations of pollutants several hours after hospitalization.

The statistical analysis was carried out using Pasw Statistic 18.

Results

Trend of pollutants

Table 1 shows the mean concentrations with standard deviation and minimum and maximum values for PM_{10}, NO_2 and O_3 established during the period of investigation taken into consideration. As indicated, only PM_{10} showed a maximum value which is definitely high, whilst NO_2 and O_3 showed relatively moderate maximum values.

Cases of COPD and Pollutants

We studied 31 subjects: their age ranged between 51 and 90 years old (mean age 73 years), of which 61.3% males and 38.7% females. The 96.3% of these subjects are smokers (pack-years 60,8) or ex-smokers (pack-years 72,2). Taking into consideration data regarding hospitalizations for COPD and some pollutants, no particular association was established between hospitalizations for COPD and ozone, perhaps owing to the infrequency of cases in the summertime. Even NO_2 did not turn out to be associated with COPD.

Table 1. Atmospheric pollution data

Parameters	Minimum	Maximum	Mean	Standard dev.
PM_{10}, µg/m^3	2.00	144.00	38.34	23.36
NO_2 µg/m^3	14.96	94.25	45.85	14.65
O_3 µg/m^3	2.78	115.91	40.39	28.47

Considering PM_{10} daily mean values – from 1/07/2008 to 30/03/2009 – statistically significant differences between the concentrations observed 3 and 4 days before hospitalization of study subject (p=0,008 and p=0,03 respectively) were pointed out (table 2) compared to those days without any hospitalization.

Considering these data subdivided between summertime (table 3) and wintertime (table 4), no statistically significant differences were pointed out. According to the trend of mean concentrations, it can be deduced that higher concentrations do not seem to affect hospitalizations as much as their rapid increment which is especially observed in the summertime (tables 3, 4).

The same analysis was carried out by comparing the values of VC, FVC and FEV1 for PM_{10} values lower and higher than 50 µg/m³. As expected, for PM_{10} values higher than 50 µg/m³, lower percentage values were found for the three parameters of respiratory function (table 5).

Then the analysis of regressions between PM_{10} and the percentage variations of FVC and FEV1 was carried out, considering the concentration of PM_{10} at 24, 48, 72, 96 hours before hospitalization.

The variations of FVC% and FEV1% associated with concentrations of PM_{10} at 96 hours proved to be significant (table 6).

In view of the results of the variations of respiratory parameters based on PM_{10} concentrations 4 days before hospitalization, the probability of hospitalization event for COPD through a logistic regression was calculated; it leads to a relative risk of 1,016 (L.C. to 95% 1,001-1,032) which corresponds to an increase in the probability of hospitalization for COPD equal to 1,6% per PM_{10} increment unit.

Table 2. PM_{10} mean concentrations in µg/m³: values of 3rd and 4th day before hospitalization for COPD exacerbation

	PM_{10} Lag 3*		PM_{10} Lag 4**	
	Hospitalization	No hospitalization	Hospitalization	No hospitalization
Mean	46.96	38.04	48.37	38.14
Standard deviation	24.42	22.50	22.04	22.95

* Lag 3- Mean concentrations 3 days before hospitalization
** Lag 4- Mean concentrations 4 days before hospitalization

Table 3. PM_{10} mean concentrations in µg/m³ in summertime: values of 3rd and 4th day before hospitalization for COPD exacerbation

	Summer			
	PM_{10} Lag 3*		PM_{10} Lag 4**	
	Hospitalization	No hospitalization	Hospitalization	No hospitalization
Mean	46.00	34.06	49.30	33.56
Standard deviation	21.07	21.91	30.43	20.70

* Lag 3- Mean concentrations 3 days before hospitalization
**Lag 4- Mean concentrations 4 days before hospitalization

Table 4. PM_{10} mean concentrations in µg/m³ in the winter: values of 3rd and 4th day before hospitalization for COPD exacerbation

	Winter			
	PM_{10} Lag 3*		PM_{10} Lag 4**	
	Hospitalization	No hospitalization	Hospitalization	No hospitalization
Mean	47.53	42.47	47.82	43.17
Standard deviation	26.80	22.42	16.37	24.30

* Lag 3- Mean concentrations 3 days before hospitalization
**Lag 4- Mean concentrations 4 days before hospitalization

Table 5. Percentage variation of spirometric parameters based on values of PM_{10} lower and higher than 50 µg/m³ in patients with COPD

Spirometric parameters	$PM_{10} < e > 50$ µg/m³	N. of patient	Mean	Standard deviation	p
VC %	< 50	7	79.71	10.44	0,004
	> 50	5	58.40	3.22	
FVC %	< 50	10	70.20	15.78	NS
	> 50	6	56.00	15.47	
FEV1 %	< 50	10	58.90	20.28	NS
	> 50	6	41.00	15.66	

Table 6. Variations of the respiratory function in subjects with COPD as PM_{10} concentrations vary before hospitalization.

Spirometric parameters	Time before hospitalization	PM_{10}		
		B	SE	p
FVC %	24 h	-0.38	0.21	0.09
	48 h	-0.11	0.12	0.45
	72 h	-0.04	0.15	0.78
	96 h	**-0.48**	**0.17**	**0.02**
FEV1 %	24 h	-0.35	0.27	0.21
	48 h	-0.24	0.16	0.14
	72 h	-0.11	0.18	0.56
	96 h	**-0.54**	**0.22**	**0.03**

B = regression coefficient
SE = standard error
P = significance

Discussion

The trend of the main parameters of atmospheric pollution in the city of Parma has been monitored by our Hygiene Division of the Department of Public Health since 1992 in order to comprehensively evaluate the concentrations of several pollutants and to assess the temporal trend. At the same time analyses to study the associations between the different parameters and daily mortality rate and urgent hospitalizations for specific diseases were carried out (22).

The main results deriving from the analysis of the temporal series regard the association between high concentrations of PM_{10} and an increase in the mortality rate and hospitalizations, in particular for respiratory pathologies. Also the association between hospitalizations for respiratory diseases and NO_2 concentrations were more significant (24).

The study on the relationship between atmospheric pollution in the city of Parma and urgent hospitalizations for respiratory and cardiovascular pathologies and urgent hospitalizations for all the causes (traumatisms excluded) continued in 2008 until early 2009. In that period a new investigation on the relationships between atmospheric pollution in the city of Parma and hospitalizations for chronic obstructive pulmonary disease (COPD) was carried out through the analysis of the variations of the respiratory function of COPD patients hospitalized for COPD exacerbation.

With reference to the data of pollutants, daily mean values were observed equal to 38,34 µg/m³ as regards PM_{10}, 45,85 µg/m³ as regards NO_2 and 40,39 µg/m³ as regards O_3. With reference to the patients hospitalized for COPD exacerbation, they are mainly male subjects, with an age ranging from 50 to 90 years old; almost all smokers. The results of the analysis of association between PM_{10} daily mean values and hospitalizations for COPD exacerbation are definitely interesting, showing statistically significant differences between the concentrations of PM_{10} 3-4 days before hospitalization and the concentrations registered on days without hospitalizations. Also subdividing the data of pollutants for summer and winter, significant differences may not be noticed between the concentrations of PM_{10} 3-4 days before hospitalization and the concentrations registered on days without hospitalizations with a mean difference which is much higher in the summertime. These data make us to assume that the rapid increases in PM_{10} have repercussions on relapses more than extreme values. The analysis for PM_{10} concentrations was carried

out with reference to the values of VC, FVC and FEV1; in this case the only statistically significant difference was shown for VC and values of PM_{10} lower and higher than 50 $\mu g/m^3$. The evaluation of the variations of respiratory function in subjects with COPD exacerbation performed through regression between values of PM_{10} and FVC% and FEV1% pointed out a good trend correlated for exposures at 96 hours before hospitalization for both parameters, whether the hospitalization was caused by heart failure or infection.

The relative risk calculation gave a mean result of 1,016, that is an increment by 1,6% of hospitalizations for COPD per PM_{10} incremental unit. The results we obtained fall into line with the investigation carried out by the researchers of the Institute of Health, who pointed out a short-term negative impact of the exposure on atmospheric pollutants and parameters of respiratory function especially in subjects with already impaired lung function. In particular – as it also appears from our results – PM_{10} is an important risk factor for COPD exacerbation (17).

Few data on the relationship between lung function and daily variations of fine particles are obtained, so we intend to continue the research on the hospital case record of hospitalization for COPD in the area of Parma city in order to better define the pollution critical situations and hence intervene with suitable prevention methods for subjects at risk.

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