Seasonality and Air Quality Effect in Health

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Abstract: - The air pollution effect on respiratory system is a complex issue. Environmental factors, such as air pollution and meteorological conditions, are possible causes or can trigger off symptoms in people already with the disease. The purpose of the study is to investigate seasonality and air pollution effects on a children population who attend Barreiro city hospital emergency room (ER), Portugal. The method used consists in statistical work. Children related data were crossed with wind speed and direction, temperature and outdoor pollutants concentration (carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2), particle matter (PM) and ozone (O_3)). A numerical model was used to predict outdoor air pollutants dispersion in the city, to verify the most affected areas.
CO and NO_x were positive correlated to the emergencies attendance, as well as humidity. Temperature was negatively correlated. Winter was the worst season regarding the raise of emergencies attendance and some air pollutants concentration. Considering the results, and taking into account that CO is an important pollutant from fireplaces, one possible explanation to this positive correlation is the fact that children spend more time indoor near these sources, in winter.

Key-Words: - Seasonality, Children respiratory problems, Urban air quality

1 Introduction

In the last decades the concern about air quality has grown, manly due to the increase of atmospheric pollutants sources. These sources can be anthropogenic, caused by man, like industrial activities and traffic, or can be natural, caused by the nature through chemical reactions, erosion or other phenomenon.

With the population growth, urban environment is frequently contaminated by industries and traffic pollutants, like NO_x, PM, CO and SO_2.

Vehicle number had a huge increased in the past years raising the pollutants concentration near the surface where citizens circulate.

Most serious pollution episodes, mainly in urban environment, are a mix of high pollutants level and adverse meteorological conditions. This is a fundamental parameter to understand pollutants behaviour, since that is in the atmosphere that most of chemical reactions are made, as well as the transportation and dispersion of pollutants [1] [2]. For this reason it is important to know the capacity of atmosphere to disperse and transport pollutants.

The air pollution effects on respiratory system is a complex issue, due to the difficulty of attributing causes to some respiratory diseases as asthma and bronchitis, as well as due to the limited understanding on cellular and molecular levels and also because of the complex temporal and spatial pattern of human exposure to air pollution.

In spite of the difficulty, there are some known factors, as air pollutants and meteorology, which can trigger off the symptoms. These factors can interact between themselves turning the relation more complex.

Seasonality has also an important role in pollutants concentration and formation and in short term respiratory health effects.

However it’s not easy to understand how theses factors can affect health. For this reason, the purpose of the study is to investigate atmospheric environment and seasonality effects in a children population observed in Barreiro city hospital emergency room (ER), Portugal.

2 Context

2.1 Study area

This study was performed in Barreiro city, about 40km of Lisbon (Fig.1). This is a small city, over 34km^2 and 80000 inhabitants, with industry near the centre and typical city traffic. Since the proximity, some pollution effects from Lisbon are felt, with the right meteorological conditions.

Barreiro is almost flat, with the highest point at approximately 10 meters above sea level. The weather is temperate, with no severe seasons.

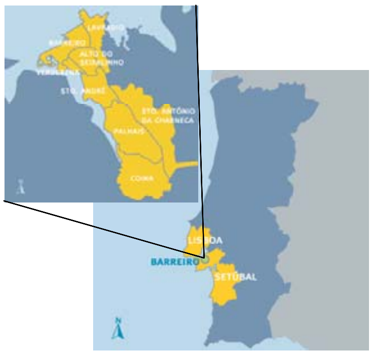


Fig.1 – Barreiro city, Portugal

2.2 Pollutants Sources

The main industrial activity is developed in the industrial area, near the city centre. A power plant and some chemical industries are the main industrial sources. The most important pollutants released from this source are NO_x, SO_2 and PM. These pollutants are monitored periodically and the concentrations, as well as some effluent characteristics and chimney dimensions were given by the industries.

Traffic is the major pollutant source, like in other cities, due to the continuous population growth in urban areas and lack of efficient public transports. Light duty vehicles (LDV) constitute the most important traffic fraction, however and due to the proximity of the industrial area, high duty vehicles (HDV) have an important contribution in pollutants concentration.

A traffic characterization was carried out in Barreiro city streets, considering the number of vehicles per type, used fuel, velocity, street characteristics and the time of the day when the field campaign was made.

Other sources, such as residual, poorly-defined or diffuse emissions in urban areas, like minor roads [3], were also considered, as well as the background pollutant concentrations.

These data were introduced in the air quality management model used to simulate pollutants dispersion and concentration in the city.

2.3 Pollutants and meteorological data

Barreiro city air quality is monitored by an air quality monitoring network. Pollutants such as NO_x, NO, NO_2, O_3, SO_2 and PM_{10} are hourly monitored by four stations scattered by the city. Data from September 2003 to December 2005 was statistically treated.

The city has also a climatic acquisition station, to measure hourly meteorological conditions, as wind speed and direction, temperature and humidity. Meteorological conditions are a fundamental parameter to understand pollutants behaviour, since most of chemical reactions, as well as the transportation and dispersion of pollutants are made in the atmosphere. Available data from September 2003 to December 2004 plus a few more days of 2005, was statistically treated.

To study the effect of seasonality, a separation between cold season and hot seasons was made, considering winter time to be from September 21st to Mach 20th and summer time from Mach 21st to September 20th.

Pollutant and meteorological data were used to correlate air quality, meteorological conditions and ER data.

3 Methods

3.1 Simulation work

To understand pollutants behaviour in the city, ADMS-Urban 2.0 from CERC was used. This model is a dispersion of pollutants released from industrial, domestic and traffic sources model, witch allows understanding air pollutants behaviour in the urban environment [3].

Road Sources and grid sources were introduced in MOBILE 6.2 which calculate the traffic emission factor to be introduced in ADMS-Urban 2.0.

FLOWSTAR 7.0, incorporated in ADMS-Urban 2.0, uses meteorological data, as well as the topography and roughness data to calculate air flow and turbulence over a complex terrain [4].

The outputs of these models were used by ADMS-Urban, as well as industrial sources data and pollutants background concentration, to calculate air pollutants concentration and dispersion.

ArcView 3.1 is a Geographical Information System that among others functionalities allow graphical visualization of the results.

The model was validated with the air quality measurements from the city network.

Fig.2 represents schematically the simulation work.

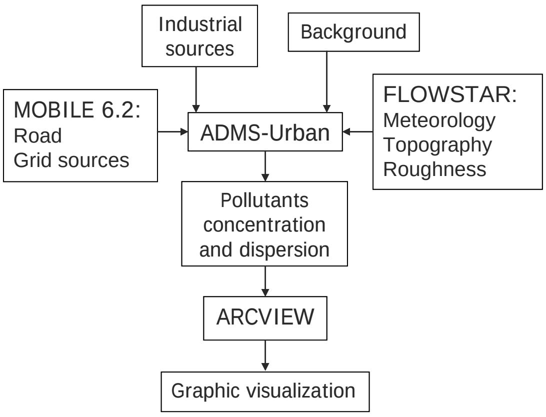


Fig.2 – Schematic representation of simulation work

Simulation work is essential to understand how pollutants dispersion is made in different meteorological conditions and the importance of different parameters, such as sources, meteorology and topography, as well as streets characteristics. It allows also locate the areas with higher concentrations. These areas can be studied particularly to understand children's living environment.

3.2 Environmental factors and health

To study the role of seasonality and air pollution in health a children population under 15 years old who attend ER with asthma related symptoms, was studied.

Children were chosen since they are a risk population, given that their respiratory system is still in development and the airways and alveoli are more vulnerable, as well as the immunity system. Also their ventilation is increased, breathing more air per kilogram of body weight than adults [5] [6].

Paediatric physicians from Nossa Senhora do Rosário Hospital, supplied children related information, such us number of observed children per day, age, gender, residence place and presented symptoms.

This information was treated and correlated with pollutants concentration and meteorological conditions of attendance days, through descriptive statistical work and Pearson correlation coefficients.

Fig.3 shows the influence of variables like air pollution and meteorology in health.

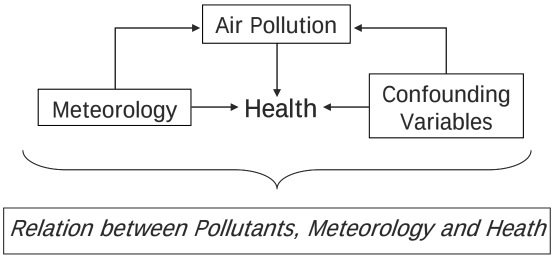


Fig.3 – Schematic representation of statistical data treatment

As is shown in the figure, meteorology has an important impact in air pollution and in health. Confounding variables, such as weekends, holidays, atypical events like fires and epidemic episodes have also a role in health problems. These variables are considered confounding since they can interfere in the relation between air pollution and heath, changing the real correlation.

The correlation coefficients were calculated between each pollutant, pollutants and meteorological data, pollutants and health data, each meteorological data, meteorological data and health data and each health data. For this purpose Statistical Package for the Social Sciences (SPSS 10.0) for windows software was used.

In spite of the importance of confounding variables, the effects of these parameters weren't taken into account in this study, since a more complex model is needed and will be used for further results.

4 Results and discussion

4.1 Simulation work

In simulation results industrial sources have a greater contribution to pollutants such as SO_2 and PM, while traffic sources are more important to the concentration of NO_x and CO.

In summer SO_2 and PM_{10} concentration are higher, mostly due to greater SO_2 and PM_{10} background in this season. The opposite applies to NO_x and CO concentration since the background of these pollutants is greater in winter. These can be due to the great number of road traffic in winter time, due to adverse meteorological conditions and because some citizens are on vacation in summer, away from the city. CO is also a fireplaces characteristic pollutant, this is also a reason to the highest value of this pollutant in winter. Also NO_x is used in the O_3 formation, a photochemical pollutant with greater concentrations on summer due to higher radiation. This chemical reaction decrease NO_x concentration in this season.

In winter raining days, PM_{10} tends to deposit, decreasing PM_{10} concentration in this season. Also thermal inversions occur frequently, detaining pollutants near the surface. In winter the thermal inversion is lower, mainly at night, causing more problems with traffic pollutants, since some times the chimneys are higher than the warmer layer.

Fig.4 shows CO concentration and dispersion on both seasons.

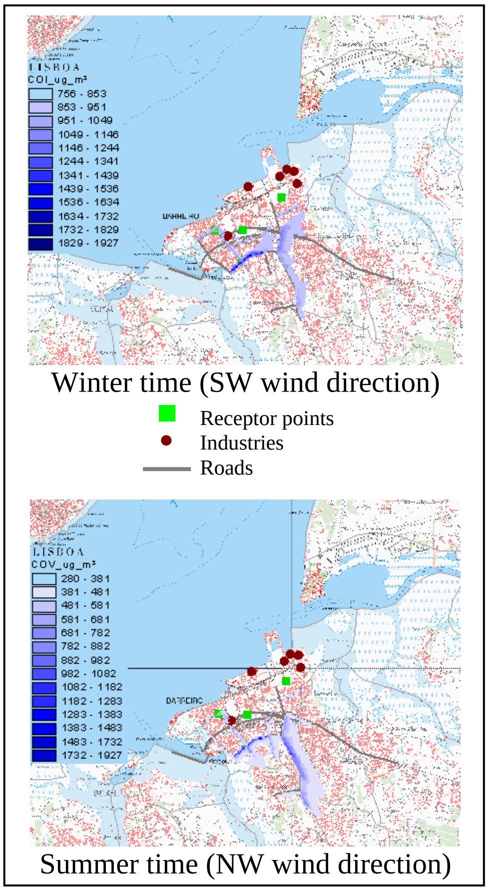


Fig.4 – CO dispersion and concentration, in both seasons

Table 1 presents the simulation results of pollutants concentration range, for each pollutant, in most frequent winter and summer conditions.

	Winter	Summer
SO_2 (µg/m^3)	7-65	12-76
PM_{10} (µg/m^3)	43-81	52-92
NO_x (µg/m^3)	86-163	49-132
CO (µg/m^3)	756-1927	280-1483

Table 1. Simulation results of pollutants concentration

Traffic affects more the city in both seasons, mostly because the pollutants are released near the surface affecting in a directly way the citizens. Therefore the worst locations are near the roads, specially the busiest ones.

In general, winter is the worst season concerning pollutants concentration. However since the industrial area is in the northeast part of the city, summer seems to be less favourable to the city centre, considering the predominant wind direction in this season, NW. (Fig.5)

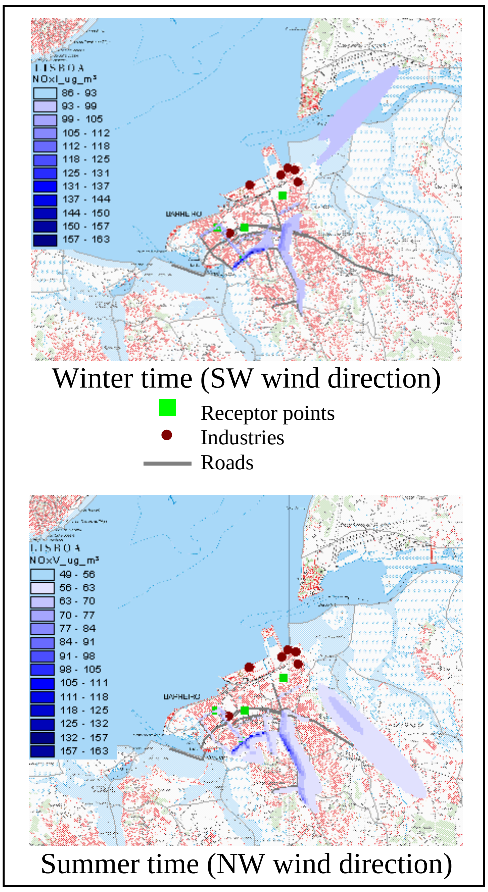


Fig.5 – NO_x dispersion and concentration, in both seasons

Some statistical work was done to calculate the correlation between pollutants and meteorological variables, through Pearson correlation coefficient (Table 2).

A positive correlation between temperature and the pollutants O_3, SO_2 and PM_{10} was found. O_3 needs radiation to be formed, for this reason it is natural to observe the positive correlation. Also, and as it was seen, SO_2 and PM concentration is higher in summer, that's a reason for the positive correlation.

On the other hand, CO and NO_x have higher concentration in winter, being positively correlated to humidity and negatively with temperature.

		CO	O_3	SO_2	PM_{10}	NO_x
Temperature	Pearson Correlation	-0.468(**)	**0.317**(**)	**0.204**(**)	**0.090**	-0.123(**)
	Sig. (2-tailed)	0.000	0.000	0.000	0.074	0.011
	N	460	447	346	395	425
Temperature max	Pearson Correlation	-0.421(**)	**0.338**(**)	**0.216**(**)	**0.150**(**)	-0.063(**)
	Sig. (2-tailed)	0.000	0.000	0.000	0.003	0.197
	N	460	447	346	395	425
Temperature min	Pearson Correlation	-0.378(**)	**0.190**(**)	**0.188**(**)	-0.013	-0.156(**)
	Sig. (2-tailed)	0.000	0.000	0.000	0.801	0.001
	N	460	447	346	395	425
Humidity	Pearson Correlation	**0.466**(**)	-0.500(**)	-0.327(**)	-0.070	**0.106**(*)
	Sig. (2-tailed)	0.000	0.000	0.000	0.166	0.029
	N	461	448	347	396	426
Humidity max	Pearson Correlation	**0.344**(**)	-0.433(**)	-0.357(**)	-0.162(**)	**0.164**(**)
	Sig. (2-tailed)	0.000	0.000	0.000	0.001	0.001
	N	457	444	344	392	423

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

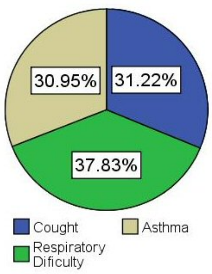
Table 2. Correlation between meteorological variables and pollutants

4.2 Environmental factors and health

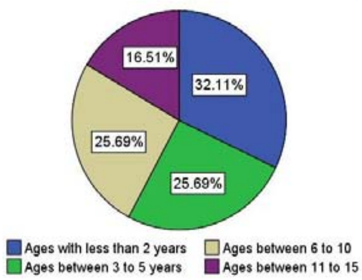
1238 children between 0 and 15 years old were observed in hospital ER, due to complain of non infectious respiratory issues.

From the 1238 cases observed, about 31% had cough, other 31% asthma and the remaining 38% respiratory difficulty (Fig.6 (a)).

Children with less than 2 years old contribute with 32% of the sample, followed by 26% of children with ages between 3 and 5, 26% from 6 to 10 and 16% from 11 to 15 years old (Fig.6(b)).



(a)



(b)

Fig.6 – Attendance to ER distribution

Considering warm and cold seasons, 72% of children were observed in cold seasons. In cold weather, deep breaths evaporate moisture within the airways, causing cooling and drying of the airways which can be a trigger off an asthma attack. This can be a reason for the increase of respiratory illness in winter [7].

However, despite the generality of children visit ER predominantly in winter, when age's classes are considered, the percentage of children from 3 to 10 is higher in summer. This may be due to children in scholar ages spend more time outdoor in the summer, as a result of better weather conditions (Fig.7).

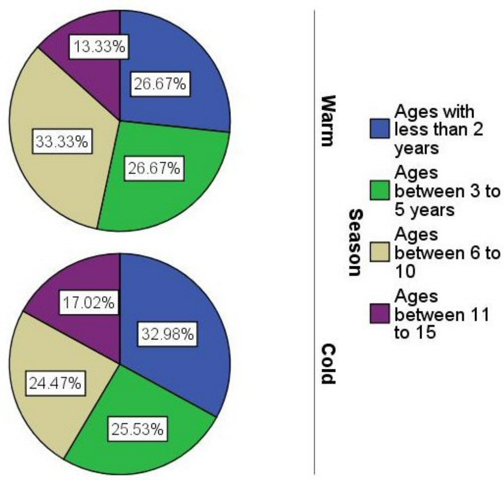


Fig.7 – Attendance to ER by age in both seasons

From the total of patients, 59% were male. According to the literature, it is usual children and adolescent males to suffer this kind of diseases more than females, but in adult age, the opposite happens [8].

Data from children observed in the ER, from air pollutants and meteorology measurements where crossed and Pearson correlation coefficients were calculated.

Table 3 shows Pearson correlation coefficients between each meteorological variables and the number of children admitted in ER in Barreiro city hospital.

		Children admitted in ER	Temperature	Temperature max	Temperature min	Humidity	Humidity max
Children admitted in ER	Pearson Correlation	1	-0.341(**)	-0.342(**)	-0.253(**)	**0.191**(**)	**0.165**(**)
	Sig. (2-tailed)		0.000	0.000	0.000	0.001	0.005
	N		285	285	285	285	285
Temp.	Pearson Correlation		1	**0.959**(**)	**0.782**(**)	-0.413(**)	-0.265(**)
	Sig. (2-tailed)			0.000	0.000	0.000	0.000
	N			460	460	460	456
Temp. max	Pearson Correlation			1	**0.659**(**)	-0.507(**)	-0.328(**)
	Sig. (2-tailed)				0.000	0.000	0.000
	N				460	460	456
Temp. min	Pearson Correlation				1	-0.172(**)	-0.129(**)
	Sig. (2-tailed)					0.000	0.006
	N					460	456
Humidity	Pearson Correlation					1	**0.765**(**)
	Sig. (2-tailed)						0.000
	N						457
Humidity max	Pearson Correlation						1
	Sig. (2-tailed)						
	N						

** Correlation is significant at the 0.01 level (2-tailed).

Table 3. Correlation between each meteorological variables and number of children admitted in ER

As it was expected, since 72% of children were observed in cold seasons, the correlation between ER admissions and humidity is positive and with temperature is negative, since in Portugal winter is humid and cold. Naturally and considering each meteorological variable, humidity is negatively correlated with temperature, especially with the maximum temperature.

Figures 8 and 9 show graphically this correlation.

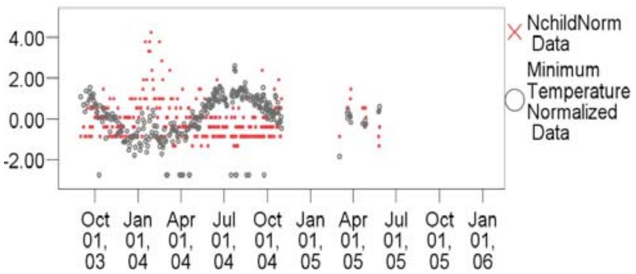


Fig.8 – Temperature and number of children observed in ER.

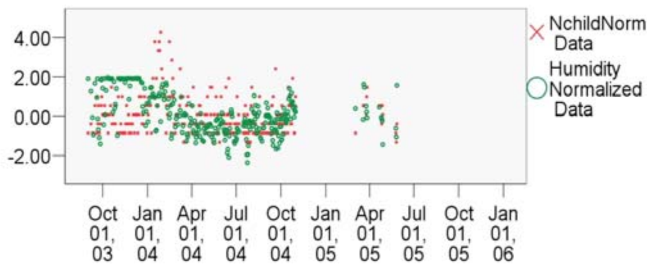


Fig.9 – Humidity and number of children observed in ER.

In figure 8 it can be seen the higher number of children in the cold season, decreasing in the warmer season and the opposite to temperature values. The humidity, figure 9, has a much similar behaviour with children number.

Table 4 shows Pearson correlation coefficients between each air pollutant and the number of children admitted in ER in Barreiro city hospital.

From the results it is possible to see a positive correlation between the number of children admitted in ER and the pollutants CO and NO_x, in spite of the bad significance of NO_x correlation.

Other pollutants have negative correlation.

		CO	O_3	SO_2	PM_{10}	NO_x	Children admitted in ER
CO	Pearson Correlation	1	-0.465(**)	-0.200(**)	**0.512**(**)	**0.476**(**)	**0.148**(*)
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.002
	N		827	689	771	814	432
O_3	Pearson Correlation		1	**0.199**(**)	**0.124**(**)	-0.302(**)	-0.194(**)
	Sig. (2-tailed)			0.000	0.001	0.000	0.000
	N			669	747	790	414
SO_2	Pearson Correlation			1	**0.078**(*)	-0.048	-0.104
	Sig. (2-tailed)				0.048	0.220	0.050
	N				641	661	353
PM_{10}	Pearson Correlation				1	**0.353**(**)	-0.022
	Sig. (2-tailed)					0.000	0.661
	N					761	385
NO_x	Pearson Correlation					1	**0.018**
	Sig. (2-tailed)						0.723
	N						410
Children admitted in ER	Pearson Correlation						1
	Sig. (2-tailed)						
	N						

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 4. Correlation between each air pollutant and number of children admitted in ER

In Fig.10 it is possible to see graphically the good correlation between CO and Number of children admitted in the ER.

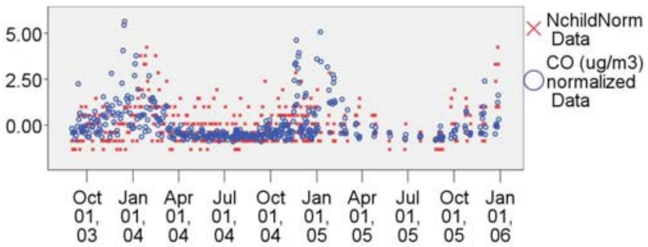


Fig.10 – CO concentration and number of children observed in the ER.

As already mentioned in subsection 4.1, CO is a fireplace pollutant, consequently a winter pollutant. Since people spend more time indoors in this season, and considering that the fireplace is alight, there is a good probability of considering this pollutant a trigger off to respiratory problems.

In spite of the results reached for CO, it is not possible to conclude that pollutants contribute to respiratory diseases aggravation.

5 Conclusion

Seasonality and air quality effect in health is a complex issue, especially air pollutants effects, since there are many factors which interfere in this relation, as this study shows.

In spite of this difficulty, the achieved statistical results have showed positive correlation between the number of children who attend ER and pollutants like CO and NO_x.

Simulation work have showed that the main sources of this pollutants is traffic, and since they are released near the ground level at which citizens circulate, without much dispersion, these source affects more directly the population.

CO is also an important pollutant from fireplaces, and other reached result was the increase of assisted children in winter, for more than the double. One possible explanation to the positive correlation between these factors is the fact that children spend more time indoor near these sources at this time of the year.

Also in cold weather and increased humidity, the breaths are deeper, evaporating the moisture within the airways, causing cooling and drying of the airways which can be a trigger off for an asthma attack.

As expected the correlation between ER data and humidity is positive and with temperature is negative.

Considering the total of ER data, children visit ER predominantly in winter, however when age's classes were considered, a bigger percentage of children from 3 to 10 went to ER in summer. This may be due to the fact that children on these ages spend more time outdoor in the summer, as a result of better weather conditions.

Most children who were attended in ER with respiratory problems had below 2 years old. According to the leterature, normally one half of children with asthma-like symptoms below age 2 do not have asthma by the time they start school. This can explain the decrease of the number of older children with respiratory related problems, attended on the ER

Other interesting achievement was the fact that males represented about 60% of the sample, which according to the literature, is usual in children and adolescents but not in adults.

With the statistical methods used, it is not possible to conclude more about the other pollutants. However new statistical software is being used and better results are expected.

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