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Correlations between outdoor air pollution and hospital admission for asthma in children living in Bucharest municipality, 2004-2007

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ABSTRACT

Objective: *assessing the association between exposure to outdoor air pollutants and hospitalization for asthma attack in the pediatric population of Bucharest municipality.*

Methods: *in the study group we enrolled children (1-18 years of age), resident in Bucharest municipality, admitted to "Grigore Alexandrescu" emergency university clinic for asthma attack (ICD-10 codes: J45, J46) during the period 2004-2007. Daily mean levels of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3) and particulate matter with aerodynamic diameter lower than 10 microns (PM10) measured in the ambient air of Bucharest, via a network of 8 fixed samplers have been considered as exposure variable and daily frequency of hospital admission for pediatric asthma has been used as outcome variable, in time series assembled by matching exposures to outcome for the same calendar day. The nature and the force of the correlation between exposure and outcome were analyzed by linear regression in single pollutant model, firstly in a round year temporal approach (whole data set) and secondary in a seasonal one (i.e. winter and summer). Logistic regression has been used in multipollutant models aiming to find independent exposure-outcome association(s) in each of the temporal approaches considered. Based on Pearson coefficient's sign a correlation was designated as positive or negative; similarly a "p" value lower than 0,05 designated a significant association.*

Results: *in single pollutant model – round year temporal approach, the outcome was significantly correlated ($p< 0.01$ or $p < 0.05$) with ambient air levels of all four air pollutants analyzed but in different ways: positively with NO_2, SO_2 and PM10 and negatively with O_3. However through multivariate analysis (logistic regression) it was found that only NO_2 was independently associated to the outcome both in the year round temporal approach and also during the winter season [Odds Ratio (OR): 1.0148; 95% Confidence Interval (95%CI): 1.0040-1.0256 and OR: 1.0147; 95%CI: 1.0018-1.0277, respectively), but not during the summer season ($p = 0.1121$).*

Conclusions: *our findings suggest that exposure to ambient levels of air pollution is an important determinant of hospital admission for pediatric asthma in Bucharest municipality. As the main source of pollutants analyzed here appears to be represented by fossil fuels burning in cars' engines, we think that traffic control may be an effective intervention for preserving important health resources.*

Key words: pediatric asthma, outdoor air polution

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INTRODUCTION

There is robust scientific evidence that exposure to air pollutants can affect human health in a variety of ways ranging from subtle biochemical and physiological changes to severe illness and death (1). WHO (2) and American Thoracic Society (ATS) (3) have provided guidance of definitions of what constitutes an adverse effect of air pollution. ATS, for example, has identified a broad range of respiratory health effects associated with air pollution that should be considered "adverse". These range from respiratory diseases associated death to reduced quality of life, and including some irreversible changes in physiological function.

The broad array of health effects associated to air pollution is partially explained by differential susceptibilities to pollutants depending on both host and environmental factors (4).

Young children, for instance, are among the most susceptible to effects of air pollution (4-6). Children have higher breathing rates than adults and therefore a higher intake of air pollutants per unit of body weight. They also spend more time outdoors than adults, thereby adding to their exposure potential (6, 7). The developing lung may have a limited metabolic capacity to address toxic insults. Since 80% of alveoli are formed postnatal, and changes in the lung continue throughout adolescence, exposure to air pollutants poses a serious risk to this population group (7, 8).

In Bucharest, one of the most polluted cities in Europe (9) the municipal public health authority is currently running a program aiming to asses the health effects related to outdoor air pollution; as part of this project, in this paper, there are reported the results of analysis of associations found by us, between ambient air pollutants and pediatric asthma exacerbation. ❑

METHODS

Exposure: air quality in Bucharest municipality is routinely surveyed via a network of 6 fixed samplers placed inside town and other 2 placed in the city's periphery (semiurban). Each monitoring sampler is recording hourly levels of gaseous, particulate pollutants and meteo indexes. For this study daily means of each sampler records were aggregated in a daily pooled city mean and these values were considered as exposure.

Outcome: the outcome was represented by the daily frequency of children aged 1-18 years, resident in Bucharest, and admitted between 2004 and 2007 from "Grigore Alexandrescu" emergency university clinic with asthma (ICD-10 codes J45 – J46) as main diagnosis.

Time series – same day exposures and outcome values were entered, along to the calendar date, in a MS Excel® spreadsheet row, to obtain a record. Initially for a round year temporal approach analysis, a master worksheet was generated by filling in all available records from 01/01/2004 to 31/12/2007; for a seasonal temporal approach analysis, the sequences of records representative for specific periods of time were cut from the master spreadsheet and pasted together in two separate worksheets, one representing the winter (01/10-31/03) and the other the summer (01/04-30/09) seasons.

Analysis – single pollutant exposure-outcome relation have been assessed through linear regression both in a round year and also in the seasonal temporal approach analysis. Correlations detected through single pollutant model analysis have been further assessed as independent associations through logistic regression with Epi Info software (Epi Info 3.4.3, CDC, Atlanta, GA, USA). ❑

RESULTS

During 2004-2007 time period the frequency of children with residence in Bucharest municipality admitted in our clinic for asthma complains ranged between 98 and 176 cases per year.

Pollution model – Table 1 presents the distribution of the all four pollutants' air levels and in the Figure 1 it is provided an example (e.g. NO_2) of winter-summer discrepancies observed in the prevalence of days with peaks of air pollution in Bucharest municipality.

Inter pollutants correlations – Through linear regression NO_2 air level was found to be highly correlated ($p < 0.01$) in a positive way with SO_2 and PM10 ambient air levels, irrespective of season; NO_2 air level was also highly correlated with ambient O_3 air level, positively during winter and negatively during the summer seasons (Table 2).

Exposure-outcome correlations – through linear regression (Table 2) the daily frequency of pediatric hospital admissions for asthma

Pollutant	Time	Daily Mean	Standard Deviation	Percentiles				
				0	25	50	75	100
SO_2	Year	14	9.7	1	7	10	16	80
	Summer	9	5.0	3	6	8	11	57
	Winter	18	11.4	1	9	15	23	80
NO_2	Year	55	28.9	12	36	49	64	254
	Summer	44	16.8	12	62	42	53	111
	Winter	67	33.9	14	44	59	80	254
PM10	Year	52	23.2	13	37	48	64	282
	Summer	46	15.9	13	35	73	56	116
	Winter	59	27.7	18	40	54	72	282
O_3	Year	40	16.9	3	27	40	52	104
	Summer	48	13.1	16	38	48	56	89
	Winter	33	17.3	3	19	30	45	104

TABLE 1. Distribution of air pollutants levels (mg/m[3]) by year and season in Bucharest municipality, 2004-2007

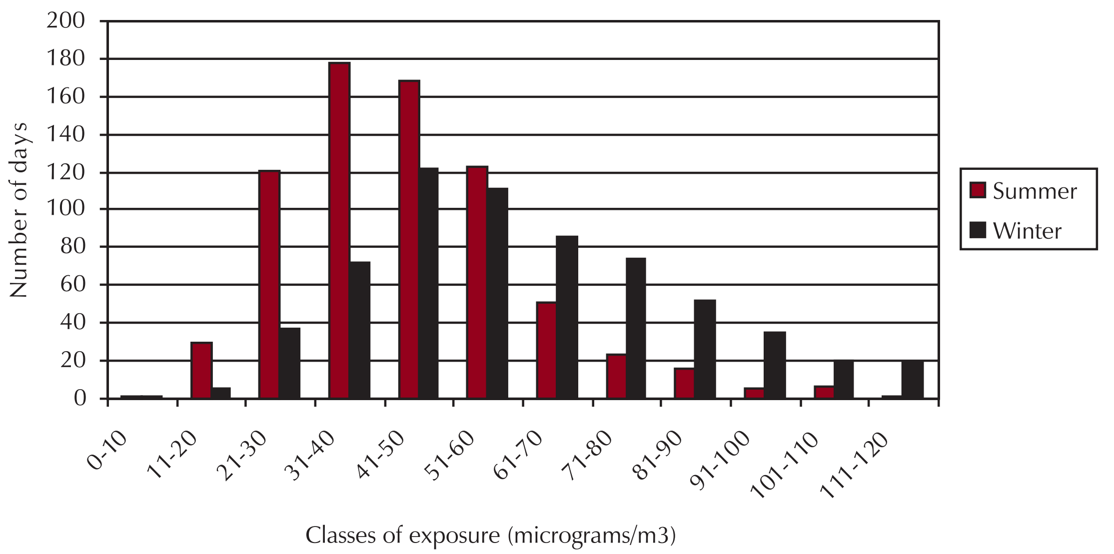

FIGURE 1. Frequencies of days with different levels of nitrogen dioxide air pollution in Bucharest municipality, 2004-2007*)

*) Classes range voluntary truncated at upper edge, considered irrelevant

Time	Pollutant	Pearson Coefficients by temporal approach				
		O_3	NO_2	SO_2	PM10	Cases
All year Round	O_3	1.00	- 0.146**	- 0.04	-0.304**	- 0.076*
	NO_2		1.00	0.481**	0.613**	0.103**
	SO_2			1.00	0.284**	0.070*
	PM10				1.00	0.100*
Winter	O_3	1.00	0.136**	0.342**	-0.313**	0.015
	NO_2		1.00	0.394**	0.612**	0.060
	SO_2			1.00	0.196**	0.013
	PM10				1.00	0.063
Summer	O_3	1.00	- 0.241**	0.042	0.075	- 0.107*
	NO_2		1.00	0.150**	0.428**	0.101*
	SO_2			1.00	0.043	0.063
	PM10				1.00	0.050

TABLE 2. Pearson's correlation coefficients between daily mean levels of outdoor air pollutants and daily frequencies of hospital admissions for asthma attacks in pediatric population, Bucharest municipality, 2004-2007

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

Time	Pollutant	Odds Ratio	95%CI	Coefficient	p value
All year Round	NO_2	1.0148	1.0040-1.0256	0.0147	**0.0071***
	O_3	0.9974	0.9848-1.0102	- 0.0065	0.6880
	PM10	0.9959	0.9863-1.0056	- 0.0041	0.4051
	SO_2	1.0097	0.9905-1.0292	0.0098	0.3235
Winter	NO_2	1.0147	1.0018-1.0277	0.0146	**0.0249***
	O_3	1.0162	0.9967-1.0361	0.0161	0.1031
	PM10	0.9984	0.9872-1.0097	- 0.0016	0.7802
	SO_2	0.9998	0.9766-1.0236	-.0002	0.9886
Summer	NO_2	1.0159	0.9963-1.0360	0.0158	0.1121
	O_3	0.9853	0.9633-1.0077	- 0.0148	0.1972
	PM10	0.9953	0.9752-1.0158	- 0.0047	0.6535
	SO_2	1.0035	0.9547-1.0548	0.0035	0.8906

TABLE 3. Associations between daily mean levels of outdoor air pollutants and daily frequencies of hospital admissions for asthma attacks in pediatric population of Bucharest municipality, 2004-2007; logistic regression performed on multipollutant model by year and season

*Association is significant at the 0.05 level and independent from other pollutants studied.

attacks was found to be highly correlated ($p < 0.05$ or $p < 0.01$) with ambient air levels of all four pollutants, either positively (NO_2, SO_2 and PM10) or negatively (O_3).

However through logistic regression (Table 3) only the NO_2 ambient air level was found to be independently associated ($p < 0.05$) with the daily frequency of hospital admission as follows: (a) in the round year temporal approach (OR: 1.0148; 95%CI: 1.0040-1.0256), (b) in the winter season temporal approach (OR: 1.0147; 95%CI: 1.0018-1.0277) but (c) not in the summer season temporal approach ($p = 0.1121$). ❑

DISCUSSIONS

Many of the epidemiological studies of outdoor NO_2 exposure have found associations between exposure to the pollutant and health effects, including accident and emergency room visits (10-12), hospital admissions (13-16), mortality (17,18), increased symptoms (19, 20) and reduced lung function (21,22).

In the study presented here, through time series analysis, we found that increased exposure to NO_2 was independently associated with pediatric hospitalizations for asthma in Bucharest municipality. Our findings are strongly externally validated by other studies based on time series or case-crossover design analysis, conducted worldwide.

For instance in Europe the study by Sunyer et al (15) considered three cities (Helsinki, London and Paris) with data available in children aged 0-14 years during the period 1987-1992. The strongest and most statistical significant effect was found for nitrogen dioxide and no effect was found for ozone. More recently the series of observations in London are of importance. Using a single pollutant model in the 1987-1992 data set from London, Anderson et al (23) found that only nitrogen dioxide and sulfur dioxide were significantly related with children's hospital admissions. Even more recently the analysis of the association between outdoor pollutants and visits to emergency departments for respiratory complains in London during 1992-1994 (24) revealed a strong relationship between nitrogen dioxide and asthma visit in children, especially during the warm season.

The results found in the time series analysis of respiratory admissions in Rome during 1995-1997 were very similar to what has been suggested by the London studies with regard to children's asthma admissions: nitrogen dioxide was strongly related to total respiratory admissions, and in particular to acute respiratory infections and asthma among children (25).

Similarly to studies on time series performed in Europe the detrimental effect of nitrogen dioxide on asthmatic children was reported from other continents including Americas (26, 27), Australia (28) and Asia (29).

Plausible mechanisms of NO_2 toxicity, (i.e. inducing airway inflammation and broncho-constriction), have been well described (30). In experimental exposure studies of adults with mild asthma adverse pulmonary effects of NO_2 have generally been demonstrated at levels of exposure a magnitude higher then reported here (31). However this contrasts ours and other recent epidemiological findings (32-35) showing associations of asthma outcomes with low ambient air levels of NO_2.

Outdoor NO_2 is strongly influenced by local traffic density (36) and similar to other authors (37) and based on the highly significant correlation found in our data set between NO_2 and PM10 air levels (TABLE 3), we believe the NO_2 levels we found are more likely to have served as a marker for traffic-related air pollutants. These pollutants may be causally related to asthmatic responses induced through oxidative stress responses triggered by pollutants highly correlated with NO_2 (38, 39).

On this end, based both on observations reported by others (40-42) and also on our personal perceptions, we may postulate that burning of fossil fuels (mainly diesel) in the engines of Bucharest's fleet of cars represents the main human activity-related source of air pollution; consequently the traffic control in Bucharest municipality appears to be a key intervention for reducing the ambient air pollution related health impact and preserve in this way the health resources. Obviously air pollution's control in Bucharest municipality is out of the power of the health system; however the health system is responsible for revealing credible evidences of air pollution's health impact. Beside their scientific background these evidences may serve as incentive to determine the policy-makers in implementing with priority, of the most effective interventions (including the traffic control), targeting a clean ambient air. ❑

CONCLUSION

Our findings suggest that exposure to ambient levels of air pollution is an important determinant of hospital admissions for asthma in children aged under 18 years.

Because we think that all pollutants correlated to the outcome we studied are mainly produced through fossil fuels burning in cars' engines we are strongly confident that the traffic control in Bucharest is the key intervention for preserving health resources. What is adding new this study is that the NO_2 outdoor level, by its position of air pollution marker, can be use to evaluate the progress and the effectiveness of air pollution control measures. Although we found that NO_2 outdoor air level is highly and independently correlated to pediatric asthma attacks (see TABLE 3) we are not sustaining a causal relation between this two variables; what we like to emphasize is that NO_2 appears as an reliable marker of whatever factor is actually triggering the asthma attack; based on this NO_2 feature the progress and effectiveness air pollution control measures might be monitorized. ❑

LIMITS

The main limit of this study is deriving from datasets we were able to handle namely hospitalized cases on one hand and the city mean atmospheric levels of gaseous pollutant routinely monitorized via a network of fixed samplers, on other hand. As a natural consequence of this it was assumed that all residents of Bucharest municipality, including children with asthma, were similarly exposed in term of pollutants levels, assumption which, in the real world it is not necessary true. However, in the near future there are viable perspective for us to search after cases in populations living in territories with well defined pollution levels based GIS (Geographic Information System) technology.

Also another limit of this study might be that in the analysis model the changes in weather values (temperature, relative humidity and pressure) were assessed globally, in an seasonal (winter vs summer) approach, but not in a daily one. Finally due to the study design we didn't followed the Canadian authors practice of excluding from our dataset those cases with comorbid conditions like respiratory acute viral infections or cases which in the hospitalization day visited the ER several times and this might be a reason for biasing of our results. ❑

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