Effect of Air Pollution in Frequency of Hospitalizations in Asthmatic Children

Medhi Alizadeh[1], Leila Ghasemi Hashtroodi[1], Zahra Chavoshzadeh[2], and Nima Rezaei[3,4,5]

[1] *Department of Pediatrics, Mofid Children Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[2] *Pediatric Infections Research Center, Mofid Children Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[3] *Research Center for Immunodeficiencies, Pediatrics Center of Excellence, Children's Medical Center, Tehran University of Medical Sciences, Tehran, Iran*

[4] *Department of Immunology, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran*

[5] *Network of Immunity in Infection, Malignancy and Autoimmunity (NIIMA), Universal Scientific Education and Research Network (USERN), Tehran, Iran*

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Abstract- Asthma is one of the most common diseases in childhood, which has been increased during last decade because of epidemiological pattern changes with climate and industrialization of the communities. There are some controversies on the relationship between air pollution and asthma. Tehran, as the capital of Iran, is one of the densest populations and is one of the most polluted cities in the world. This study was performed to search effects of various air pollutants using GIS-based modeling on the rate of hospitalizations due to asthma in children in Tehran. Information of patients who were admitted with a diagnosis of asthma in a referral pediatric hospital was checked and the total number of admissions in the same age range (2 to 14 years) during a 2-year period (March 2009-March 2011) were calculated. Information about air pollutants including carbon monoxide, nitrogen dioxide, ozone, and sulfur dioxide, obtained from the air quality control center. Days of the year divided into GOOD and NONGOOD days according to the guideline for reporting of the daily air quality index (AQI). Two thousand two hundred nineteen cases enrolled in the study and asthma admission to total admission ratio compared with air pollutants data in admission day (725 days), using nonlinear regression method. Analysis of the data revealed that there is a significant relationship between NONGOOD nitrogen dioxide (P=0.01), ozone (P=0.01), and sulfur dioxide (P=0.04), levels and admission due to asthma in children, but There was no significant relationship between carbon monoxide levels and asthma admission in children. A significant relationship between nitrogen dioxide, ozone and sulfur dioxide concentration in air and admission due to asthma at levels other than GOOD, reveals air pollutants levels can be significantly harmful to children before AQI reaches to hazardous levels.
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Introduction

Asthma is a common chronic disease that manifests as recurrent episodes of breathlessness and wheezing, which this chronic illness has a great impact on children health. Although the etiology of asthma has not been completely understood, genetic susceptibility and environmental factors are both involved in its development. Environmental factors that have a role in developing asthma include indoor and outdoor allergens, air pollution, tobacco smoke and chemical irritants (1). Air pollution and its adverse effects to human's health have been reviewed extensively, and there is evidence that several pollutants possibly cause or exacerbate asthma (2,3). However, there is some evidence that does not support this general belief about air pollution effects on children asthma (4,5). Pollutants pose a great risk to human health, but their role in threatening our health is different according to their type. Particulate matters, Ozone, NO_2 and SO_2 are the main air pollutants that for achieving a healthy air quality their levels should be monitored. Several guidelines are developed for controlling these pollutants. These guidelines can be used internationally, but each country depending on its

Corresponding Author: Z. Chavoshzadeh
Pediatric Infections Research Center, Mofid Children Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
Tel: +98 21 22439963, Fax: +98 21 22439964, E-mail address: zahra_chavoshzadeh@yahoo.com

own needs and resources can set national standards for air quality control. The rationale behind these guidelines is the evidence that shows pollutants at specific levels have adverse effects on human's health. Environmental Protection Agency had developed a framework for monitoring and reporting air quality index. Air quality index (AQI) is calculated by using formula in Table 1, pollutant concentration data and air quality breakpoints (Table 2). AQI has six categories including Good, Moderate, Unhealthy for sensitive groups, Unhealthy, Very unhealthy and Hazardous. Pollutant concentration in air can be determined by numerous samplings in multiple air quality control stations, but a novel way is using GIS (Geographic Information System) based modeling for estimating air pollutant concentration in a wide area far from sampling stations. Tehran that is the capital of Iran has a dense population and polluted air; so, it is a good place for studying, adverse effects of air pollution.

Table 1. Calculating the AQI by using pollutant concentration data

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}}(C_p - BP_{Lo}) + I_{Lo}$$

Where I_p = the index for pollutant p
C_p = the rounded concentration of pollutant p BP_{Hi} = the breakpoint that is greater than or equal to C_p
BP_{Lo} = the breakpoint that is less than or equal to C_p
BP_{Hi} = the breakpoint that is greater than or equal to C_p
I_{Hi} = the AQI value corresponding to BP_{Hi}
I_{Lo} = the AQI value corresponding to BP_{Lo}

Table 2. Breakpoints for the AQI

AQI		O_3 (ppm) 8-hour	O_3 (ppm) 1-hour1	PM10 (µg/m3)	PM2.5 (µg/m3)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)
Good	0-50	0.000-0.059	--	0-54	0.0-15.4	0.0-4.4	0.000-0.034	(2)
Moderate	51-100	0.060-0.075	--	55-154	15.5-40.4	4.5-9.4	0.035-0.144	(2)
Unhealthy for Sensitive Groups	101-150	0.076-0.095	0.125-0.164	155-254	40.5-65.4	9.5-12.4	0.145-0.224	(2)
Unhealthy	151-200	0.096-0.115	0.165-0.204	255-354	65.5-150.4	12.5-15.4	0.225-0.304	(2)
Very unhealthy	201-300	0.116-0.374 (0.155-0.404)4	0.205-0.404	355-424	150.5-250.4	15.5-30.4	0.305-0.604	0.65-1.24
Hazardous	301-400	(3)	0.405-0.504	425-504	250.5-350.4	30.5-40.4	0.605-0.804	1.25-1.64
Hazardous	401-500	(3)	0.505-0.604	505-604	350.5-500.4	40.5-50.4	0.805-1.004	1.65-2.04

1. Areas are required to report the AQI based on 8-hour ozone values. However, there are areas where an AQI based on 1-hour ozone values would be more protective. In these cases, the index for both the 8-hour and the 1-hour ozone values may be calculated, and the maximum AQI reported.
2. NO2 has no short-term NAAQS and can generate an AQI only above a value of 200.
3. 8-hour O_3 values do not define higher AQI values (≥ 301). AQI values of 301 or higher are calculated with 1-hour O_3 concentrations.
4. The numbers in parentheses are associated 1-hour values to be used in this overlapping category only.

Materials and Methods

The total number of hospital admissions per day in the study period was obtained from medical records departments. The study period was conducted in the Mofid Children's Hospital, one of the main referral center for pediatric patients, affiliated to Shahid Beheshti University of Medical Sciences, during two consecutive years based on Iranian calendar from March 2009 to March 2011. The detailed information of patients aged between 2 to 14 years, who admitted to hospital with a primary diagnosis of asthma (ICD-10 code J-45) also was obtained and patients whom final diagnosis was not asthma excluded from the study. Information about air pollutants was obtained from Tehran air quality control company that is affiliated to Tehran municipality and is responsible for air quality control. This company estimates and report air pollutant concentrations by GIS-based modeling. The initial review reviled that information on Ozone, NO_2, SO_2 and co concentrations are available, but there was no acceptable data about particulate matters. Days of the study, there was not enough information about pollutants were excluded from the study and study period was reduced to 725 days. Based on Environmental Protection Agency guidelines, days of study period are divided by good and nongood days for each pollutant. Then the mean ratio of hospitalization due to asthma to a total number of hospitalizations is compared in two categories of study days.

Results

In 725 days of the study period, 2219 patients were hospitalized due to asthma that their descriptive data in detail, is presented in Table 3.

Table 3. Descriptive statistics of study variables

	Range	Minimum	Maximum	Mean	SD	Variance
Total admissions	117	245	362	304.58	34.44	1185.90
Total asthma admissions	11	0	11	3.06	2.08	4.32
Female asthma admissions	7	0	7	1.25	1.20	1.43
Male asthma admissions	8	0	8	1.81	1.53	2.33
CO level	8.78	0.9774	9.76	3.66	1.54	2.37
NO2 level	586.80	32.40	619.20	139.62	107.21	11494.12
SO2 level	87.43	1.35	88.78	10.53	10.09	101.90
O3 level	586.80	32.40	619.20	139.61	106.77	11399.19

When days of the study are divided into good and nongood days based on maximum mean 8-hour concentration of CO, there is no significant difference in hospitalization of children due to asthma (P=0.6). However, if this division is based on maximum 1-hour NO_2, mean 24-hour SO_2 or maximum 1-hour ozone concentration, there are significant differences in children hospitalization due to asthma (P.values of 0.01, 0.04, and 0.01, respectively) (Tables 4 and 5).

Table 4. AIQ distribution based on different pollutants

	AIQ	Frequency	Frequency percent
CO	Good	526	72.6
	Non-Good	199	27.4
NO_2	Good	556	76.7
	Non-Good	169	23.3
SO_2	Good	702	96.8
	Non-Good	23	3.2
Ozone	Good	567	78.2
	Non-Good	158	21.8

Table 5. Comparing mean admission ratio in different AIQ based different pollutant and their significance

	AIQ	Mean admission ratio	Admission ratio SD	*P*-value
CO	Good	0.010067	0.0073670	
	Non-Good	0.010398	0.0070699	0.4
	Total	0.010158	0.0072833	
NO2	Good	0.009358	0.0065787	
	Non-Good	0.012791	0.0087483	0.01
	Total	0.010158	0.0072833	
SO2	Good	0.010056	0.0072563	
	Non-Good	0.013270	0.0075836	0.04
	Total	0.010158	0.0072833	
Ozone	Good	0.009386	0.0065903	
	Non-Good	0.012926	0.0088420	0.01
	Total	0.010158	0.0072833	

After detection of these differences, we examined the correlation between pollutant concentrations and asthma hospitalization ratios. These analyses showed that there are moderate correlations between pollutant levels and asthma hospitalization in children. Maximum correlation was between NO_2 concentration and asthma hospitalization with r=0.3. The presence of moderate correlation between these variables suggests the presence of a nonlinear relationship between them. There are nonlinear regression charts between different pollutants and hospital admission due to asthma in children (Figure 1).

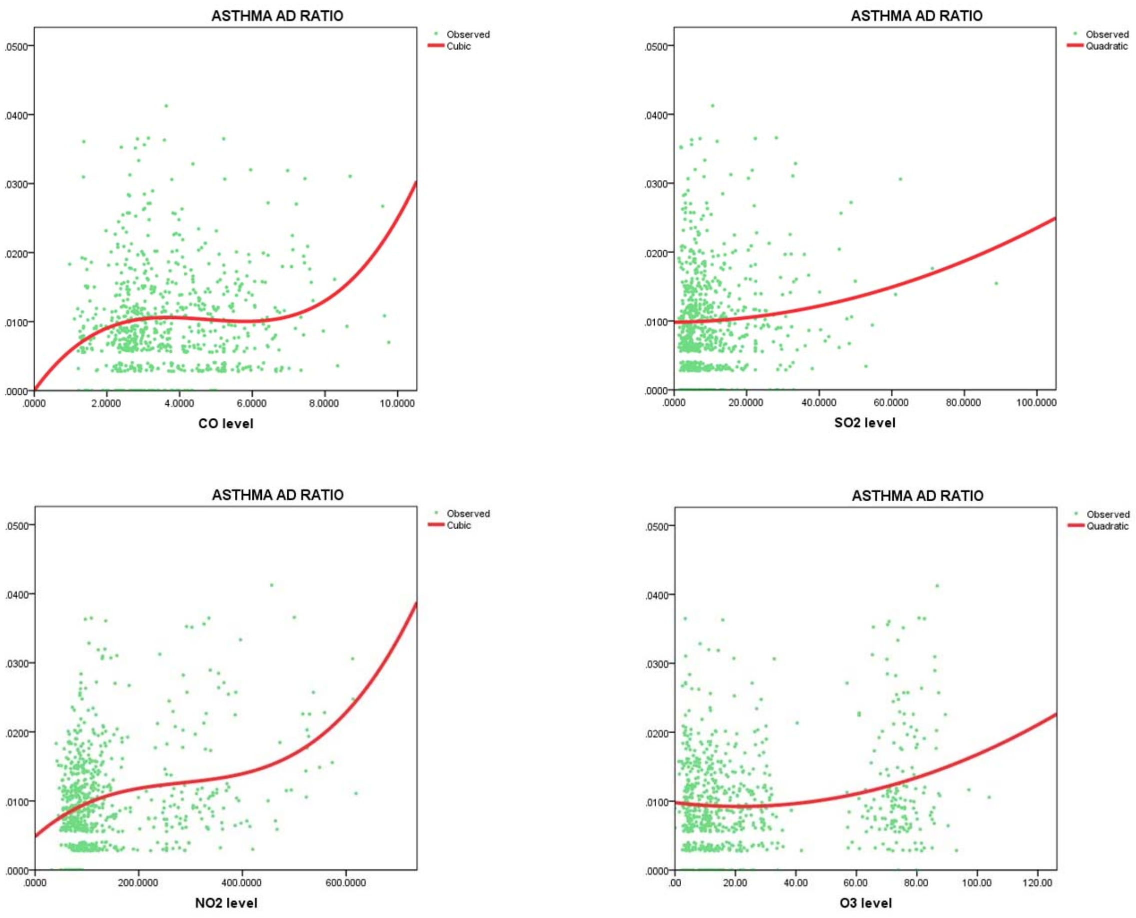

Figure 1. Non-linear regression charts between asthma admission ratio and different ambient air pollutant

Discussion

One of the most extensive reviews of evidence about adverse effects of air pollution to children health is performed by world health organization at 2005 (4). Reviewed evidence in this study showed that there is little evidence for an increase in incidence and prevalence of asthma due to NO_2 concentrations in ambient air. Equal evidence that showed a positive and negative association between NO_2 levels and symptoms of asthma in children. This study also cannot show clear evidence that exposure to ozone can increase asthma incidence and prevalence. Furthermore, Anderson's study in 2012 showed that exposure to traffic pollution is not associated with asthma prevalence at the community level (6). At the opposite side, a recent meta-analysis that performed by Gasana in 2012, concluded that exposure to more vehicle air pollutants causes an increase in incidence and prevalence of asthma in children (7). Studies that are more recent agree with adverse effects of ambient air pollutants on children asthma (8-10). The results of this study revile when air quality index is not good, the number of hospital admissions due to asthma increase significantly in children these findings are consistent with studies that believe ambient air pollution have adverse effects on asthma in children. Another interesting issue that must be emphasized is that in this study, the days are divided into good and nongood days and still, there are more asthma admissions despite the presence of non-hazardous levels in air quality index. This may be a sign of the need to redefining of air quality indexes. Air quality in this study was estimated by using GIS-based modeling and its consistent finding with other studies can demonstrate that this modeling can be used in studies, which investigate effects of air quality to human health. The main restriction of this study lacks data related to particulate matters.

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