AIR POLLUTION AND HOSPITALIZATION FOR RESPIRATORY DISEASES AMONG CHILDREN IN ISFAHAN, IRAN

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SUMMARY

Background: Adverse effects of urban air pollution on human health notably the paediatric age group is of great importance. Limited data exist from developing countries. This study investigates the hospitalization of children because of respiratory diseases and air pollution levels in Isfahan, the second large city in Iran.

Methods: Hospital admission data were collected retrospectively from 120 randomly selected respiratory patients in Pediatric wards from the main referral hospital in Isfahan from March 2005 -2006, and simultaneous air pollution data were collected from two monitoring stations located in south and north parts of the city.

Results: The result of statistical modeling using generalized linear Poisson regression showed that PM_{10} and sulfur dioxide (SO_2) concentrations had statistically significant positive association with number of respiratory admissions of children.

Conclusion: This study confirms the findings of previous studies about the association of air pollutants' levels with hospitalization because of respiratory diseases in young children. Air pollution continues to pose a threat to public health notably in the paediatric age group, and underscores the need to re-examine national environmental health policies and standards in developing countries.

Key words: Air pollution**,** hospitalization**,** particulate matter**,** respiratory disease**,** sulfur dioxide, children

INTRODUCTION

Air pollution is a serious environmental problem with various health threatening outcomes. These adverse effects have been documented even after exposures of short duration.[1]Although the effects of air pollution on health should be underscored in developing countries, [2-4] and children are one of the most vulnerable age groups in this regard, very limited data exist from these countries.

The effect of air pollutants on respiratory diseases is well documented.[5,6] Exposure to particulate matter and gaseous air pollutant concentrations has been associated not only with respiratory tract inflammation, disruption of the respiratory barriers, but also with systemic inflammation.[7,8]

Different studies have documented the association of air pollution with increased oxidation and activation of inflammatory pathways in healthy individuals of different age groups including children, young and old persons as well as patients with coronary ischemic diseases.[7-10] It is suggested that the hazards of air pollution should be considered as a key factor in improving children's health risk assessment.[11] In many studies about hazardous effects of exposure to air pollutants, children have been considered as small adults; ,whereas children have different physiologic responses. Infants and children inhale and retain larger amounts of air pollution per unit of body weight than adults do; the air intake of a resting infant is twice that of an adult .[12, 13]

Air pollutants increase the incidence of acute respiratory infections in children and disrupt the normal development of the children's respiratory system. Moreover, in the case of any damage, children are more likely to develop lung function in adulthood. Because of various health hazards of air pollution on the respiratory system,[14-15] children represent the largest subpopulation prone to the adverse health effects of air pollution.[16] Hospital admission is a more sensitive marker than mortality for assessment of the environmental effects on human health.[17] Particles in the air are a mixture of solids and liquid droplets that vary in size and are often referred to as "particulate matter."

Those particles less than 10 micrometers in diameter (PM_{10}) pose a great health concern because they can pass through the nose and throat and get deep into the lungs.[18,19] According to the US Environmental Protection Agency (U.S EPA), the standard annual mean levels are 50µg/m^3 for PM_{10}, 0.053 ppm for NO_2, and 0.03 ppm for SO_2.[20]

The aim of this study was to investigate the association of air pollution and the incidence of respiratory diseases among children aged younger than 15 years in Isfahan, Iran; and to determine the air pollutants with higher impact on the respiratory health of children.

METHODS

This study was conducted during one year from 20 March (the first day of Iranian year) 2005 to 20 March 2006. We used data from the two existing fixed-site air-monitoring stations in Isfahan city, and simultaneous hospital admissions data on respiratory diseases among children aged less than 15 years.

Study Area

Isfahan is an industrial city with a population of near 1.9 million, located in the center of Iranian plateau, with an average altitude of 1500m from the sea level bounded by NW-SE mountain range of 3000m. The average monthly temperature is 16°C with a maximum of 29°C in July and minimum 3°C in December with mild winds from west and south. The air of this city is predominantly affected by industrial emissions and motor traffic which can lead to increasing air pollutant concentrations during stagnant conditions.[14]

Data on hospital admission

Data from 120, randomly selected patients which were admitted for respiratory diseases in the Pediatric Respiratory ward was collected retrospectively from the referral hospital medical registration department (ICD-9:460-519). Admissions data from 20 March 2005 to 20 March 2006 were used. In addition to diagnosis, data on gender, age (categorized to 0-4.9, 5-9.9 and 10-15years), day of admission, and place of residence were recorded, as well. The patients' addresses were geo-coded and added to the GIS layer of census tracts. To show more visible scattering, the number of patients presented in this section was more than the 120 children who have been randomly selected for the current study.

Air pollutants

Air pollution data were obtained from two monitoring stations (south and north of the city). Concentrations of sulfur dioxide (SO_2), nitrogen dioxide (NO_2) (24-h average), and carbon dioxide (CO) (8-h average) were obtained. The concentration of each air pollutant was calculated as the average of the value from these two stations. PM_{10} data were available only from south station.

Statistical methods

The frequency and percent of total clinic referral age, gender of patients, as well as the season of admissions were calculated. Since the assumptions of the analysis of variance (ANOVA**)** were not met (normality or homogeneity of variance between groups), non-parametric Kruskal-Wallis test was used to compare differences in concentrations of air pollutants in different months. Associations of air pollutant concentrations and hospitalization because of respiratory diseases were assessed by Poisson regression models.

Poisson regression analysis is a technique which allows the modelling of dependent variables that describe count data and study the occurrence of number of counts or events as a function of a set of predictor variables.[21]In this study, the monthly number of admissions for respiratory diseases were considered as the dependent variables in Poisson regression model and the PM_{10} , SO_2, CO and NO_2 concentrations were considered as independent variables, controlling for season of admissions and sex and age groups of children with respiratory sample diseases.

RESULTS

Participants' characteristics

Temporal ,gender and age groups breakdown of patient admissions indicated that 68% of the patients were male, most of the admissions occurred in winter (33%), and the highest frequency of hospitalizations(65%) occurred in children less than 5 years of age (Table 1).

Table1 Distribution of number (%) of admissions for respiratory diseases in Paediatric wards by age group, gender and season of admission

		Season				
Gender	**Age group (years)**	**Spring**	**Summer**	**Fall**	**Winter**	**Total**
Female	0-5	3	1	5	13	22(18%)
	6-10	4	1	4	7	16(13%)
	11-15	1	2	2	1	5(5%)
Male	0-5	12	10	12	9	43(36%)
	6-10	7	2	8	9	26(22%)
	11-15	2	1	3	1	7(6%)
Total		29 (25%)	17 (14%)	34(28%)	40(33%)	120(100%)

The mapping of patients' addresses is demonstrated in Figure 1 and indicates higher incidence of respiratory diseases in the city south area. As mentioned, in order to show more visible scattering, the number of patients in this section was more than the 120 children included in this study.

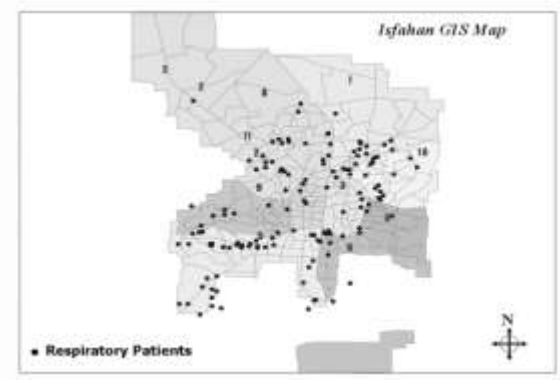

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Figure1 Prevalence of admitted children aged <15 years because of respiratory diseases on GIS map of Isfahan, Iran (2005-2006)

Air pollutants concentrations

Descriptive statistics of air pollutants concentrations are presented in Table 2.

Table 2 Air pollutant concentrations

	PM10	NO2	SO2	CO
Minimum	38	.02	.012	2.6
First quartile	95	.03	.029	3.7
Mean	118.04	.04	.059	5.5
Median	128	.037	.05	5.3
Third quartile	141	.047	.079	6.9
Maximum	173	.09	.171	10.1
Std. deviation	31.6	.013	.036	1.9
Missing data	19%	20%	20%	20%

PM_{10} ($\mu g/m^3$), NO_2 (ppb), SO_2 (ppb), CO (ppm)

There was statistically significant differences among SO_2, CO and PM_{10} concentrations for at least two months ($p<0.001$). Statistical associations showed significant relationships between some of the monthly mean air pollutant concentrations (Table 3).

Further assessments demonstrated statistically significant difference in mean concentrations of SO_2 between north and south monitoring stations, the mean of concentrations for this pollutant being 0.037 and 0.084 respectively($p<0.05$).

The mean of concentrations for this pollutant in north and south monitoring station, was 0.037 and 0.084 respectively and tended to increase for south station temporally.

In the Poisson log-linear regression model in which the number of admissions was the dependent variable, air pollutants were independent variables and demographic characteristics of patients and season of admissions were set as confounder.

Table3: Correlation between air pollutant concentrations

Variables	Pearson correlation coefficient	p-value
SO2-NO2	-0.026	0.953
SO2-CO	0.937	<0.001
SO2-PM10	0.930	<0.001
NO2-PM10	0.111	0.731
NO2-CO	0.10	0.757
PM10-CO	0.952	<0.001

Thus, the mean concentrations of SO_2 (β coefficient = 0.59; $p < 0.001$) and PM_{10} (β coefficient = 0.63; $p < 0.001$) were associated with a statistically significant increment in the count number of hospital admissions, whereas NO_2 (β coefficient = 0.0329; p=0.78) and CO (β coefficient = 0.002; p=0.92) did not have such association. The mean concentrations of NO_2 and CO were higher in south monitoring station; however we did not document significant association between these two air pollutants and hospital admissions.

DISCUSSION

This study aimed to investigate the association of air pollutants (PM_{10}, SO_2, NO_2, and CO) with the incidence of hospital admissions because of respiratory diseases among children younger than 15 years in Isfahan. The results of this study suggest that high concentrations of SO2 and PM_{10} are associated with an increased incidence of respiratory diseases in children.

In our study, the patient selection has been randomized based on the place of residence, so the higher number of admissions from the south part of the city could not be for higher population or poorer socioeconomic status. It may be because of higher concentrations of air pollutants and in turn higher risk for respiratory diseases.

Association of PM_{10} levels and respiratory diseases is in line of other studies that have shown 0.8 to 3.4% increase in respiratory admissions for the high concentration of this air pollutant.[22] PM_{10} is reported as the most sensitive air pollutant parameter associated with upper respiratory tract infection in adults and children; however children are more sensitive to exposure to PM_{10} as compared to adults.

This is because children have a larger lung surface area per kilogram of body weight than adults and under normal breathing they breathe 50% more air per kilogram of body weight than adults.[23] Furthermore, their lung is not fully developed that leads to greater permeability of the epithelial layer. Children also spend more time outdoors than adults, and concentrations of pollutants of an ambient origin are higher outdoors than indoors.

Children playing outdoors also engage in exercise that increases ventilation. This is particularly true in the afternoons, when photochemical pollutant concentrations such as particulate sulfate are highest. In our previous study in Isfahan city, we documented the independent associations between improper air quality and plasma markers of inflammation.[8] It has been suggested that PM_{10} particles are involved in the generation of hydroxyl radicals which leads to oxidative stress at the cellular level.[20]

The finding of the current study about the association between SO_2 level and respiratory admissions was in agreement with several other studies.[24-27] SO_2 is very soluble in the upper respiratory tract and exerts an immediate irritant effect on the respiratory mucosa. Adverse respiratory effects of SO_2 are detectable even at relatively low concentrations.[21, 22]

Although studies in USA and Canada have focused on ambient particles and O_3 as the key pollutants associated with emergency room visits or hospital admissions for respiratory conditions and asthma, [23, 24] the European time-series analyses conducted mostly within the Air Pollution on Health, European Approach (APHEA) study have suggested that gaseous air pollutants are more important determinants of acute hospitalization for respiratory conditions than particulate mass (25). A meta-analysis of results from Western European cities found 50 $\mu g/m^3$ increases of SO_2 associated with pooled relative risks of 1.05 (95% CI, 1.03–1.07) for respiratory conditions.[26]

Synergistic effects between SO_2 and particulate matters have been reported as well.[27] Lack of significant association between NO_2 and respiratory admissions, has been found in other studies.[28,29] For instance, in the PEACE study (30), which investigated the association of airborne particles with exacerbation of respiratory disease in children, there was no consistent relation between NO_2 and respiratory admissions in 14 centers involving 2010 children across Europe. However, there is a large body of evidence showing that outdoor NO_2 air pollution may be important for the development of wheezing and asthma among children.[31-34]

The outdoor NO_2 levels often reflect the degree of traffic pollution so that other associated pollutants may be responsible for respiratory morbidity.[29] Furthermore, it has been suggested that repeated exposure to short-term peaks of NO_2 is more important in pathogenesis than long-term exposure to lower levels of NO_2.[35]

The findings of the current study should be considered with its limitations. As with all ecological studies, this study is limited by the lack of precise exposure estimates, and caution should be considered in inferring cause-effect relations. Another limitation of this study that is shared by all other such studies is that the ambient pollution concentrations may not adequately reflect exposures of individual subjects. We should also acknowledge that we did not study all hospitalized children, however the children studied were a representative sample of patients hospitalized in the main referral hospital of the city.

This study confirms the findings of previous studies about the association of air pollutant levels with hospitalization for respiratory diseases in young children. These findings provide evidence that air pollution continues to have an adverse effect on the public's health. The levels of respirable particles in outdoor air should be controlled at source, whether by transport policies or regulatory changes. Air pollution might be considered as an emerging threat to public health notably in the paediatric age group. It is necessary to re-examine environmental health policies and standards in developing countries.

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