The relationship between air pollution caused by fungal spores in Mexicali, Baja California, Mexico, and the incidence of childhood asthma

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Abstract

Air pollution has affected human life progressively since its sources of origination. It is present in all cities around the world. It has caused harm to humans and other living organisms. This situation has led studies to determine the impact of concentrations of air pollutants in the respiratory ailments. Mexico has developed similar investigations, but unlike other countries' advanced studies on pollutants aerobiology, Mexico's studies have not been conducted in depth, and there is virtually no research work that identifies the air pollutants of fungal spores and their association with respiratory disorders in children. The purpose of this article is to analyze the relationship between air pollution by fungal spores, and the incidence of childhood asthma in Mexicali, Baja California, Mexico. Diagnostics of asthma on children living in the city of Mexicali that received medical care were studied. The records of weather and climatic variables were provided by the Department of Meteorology at the Engineering Institute of UABC. The data of air pollution caused by fungal spores were obtained in three monitoring stations with collectors' rotation and impact of sampling. Mainly four groups of different spores (*Alternaria sp., Cladosporiun sp., Bipolaris and Stemphylium*) were registered in the atmosphere of Mexicali, with an average of 515 spores/m^3 and a standard deviation of 248 spores/m^3. The average annual relative humidity was 42.3%. The average temperature showed two different facets; a hot season with temperatures between 22ºC and 44ºC, and a cold season with temperatures between 8.9ºC and 22ºC. The incidence of childhood asthma presented a rate twice the national average (505 cases/one hundred thousand children). The multiple linear regression model proposed showed a significant relationship with a R2=0.86 (p=0.5), which established a direct association between air pollution by fungal spores, and the incidence of childhood asthma.

Keywords: childhood asthma, aerobiological contamination, fungal spores, asthma and weather conditions, Mexicali.

1   Introduction

Air pollution is a problem impacting all cities around the world, especially those places with a high production of pollutants due to technological development. It causes various diseases in the respiratory system. The concern about the harmful effects caused by air pollution is higher every day; an affection that has led to investigate the relation between the concentrations of air pollutants and respiratory tract problems in different age groups, as well as to find meaningful relationships in epidemiological terms [1, 2].   In such studies are taken in consideration different concentrations of air pollutants, weather variations, time of exposure and its health impacts on different age groups [3, 4].

Within this group, it is of great interest to address the effects of aerobiological pollutants in children   which asthma is presented as a major disease caused by these types of pollutants that show the immune response characteristic to the allergens that float in the air [5]. In atopic children is usually presented as a chronic disease, which can last up to adolescence, and in some cases to adulthood which represents a problem of public health [6]. Pulimood (2008) conducted in 2002 an investigation in the United Kingdom on children during an increased in medical consultations due to asthma attacks which exceeded the usual medical consultation for this type of attacks, and found a direct correlation between levels of atmospheric pollution by *Alternaria* and *Cladosporium* spores, and the increase in the incidence and severity of the symptoms [7]. In Mexico similar correlations have been obtained [8–10]. Unfortunately, studies covering the weather conditions and aerobiological pollutants focus on respiratory infections have not been performed in Mexicali, Baja California, Mexico as of today [11] and it may be said that there are no conclusive studies on how to analyze the relationship between the atmospheric concentration of particles of biological origin such as pollen or fungal spores and its harmful effect on the airways in children.

Mexicali is the capital of state of Baja California, Mexico, with a population of approximately eight hundred and fifty-five thousand people [12], located on the northern border of Mexico adjacent to Imperial Valley, California, United States of America, sharing the same atmospheric basin [13]. On the other hand its location north of the Sonora's desert determines an extreme climate with long summers, with maximum temperatures reaching 42ºC to record temperatures of up to 53°C, contrasting with short winters with low temperatures that can reach below 7ºC, with a desert ecosystem that benefits from the tributaries of the Colorado River which contributes to the development of a strong agricultural activity, whose main crops are; wheat, barley, cotton, alfalfa, oats, sesame, safflower, sorghum forage, rye grass, vegetables and crops, and in a smaller scale watermelons, cantaloupes, corn, grapes, beans and prickly pear [14].   The objective of this study was to analyze the relationship between air pollution caused by fungal spores and the rising incidence of childhood asthma in the city of Mexicali.

2 Material and methods

The period of investigation covered one year (1/09/2004 to 31/08/2005). The studied population was composed by three different children's ages: One year and under, from 1 to 4 years, and 5 to 14 years old, all residents in different areas of the city of Mexicali and who received medical attention in governmental health facilities. The data was obtained from medical reports of all medical units of the Mexican Institute of Social Security (IMSS), Institute of Social Security of the State Workers (ISSSTE), Institute of Social Security for the State Workers of Baja California (ISSSTECALI), and Secretary of Health and Assistance (SSA). It was considered the total number of medical consultations from the first time by bronchial asthma among children between the ages selected. The cases were identified by age group and sex, according to medical diagnostics focused on the weekly report of new cases of disease (SUIVE) provided by the management of Epidemiology of the Health Secretariat of the State of BC, following the International Classification of Diseases, in its tenth revision (ICD-10). To facilitate the handling of official reports, were consolidated into a single record cases of asthma and status asthmaticus (CIE10: J45 and J46).

2.1 Meteorological data and air pollution

The meteorological variables were selected with an epidemiological approach, taking in consideration the records of the Relative Humidity Average (RHA) and Monthly Mean Temperature (MMT) data that was provided daily by the Department of Meteorology of the Institute of Engineering at the Universidad Autonoma de Baja California (UABC).

The atmospheric concentration of fungal spores data was obtained from the study conducted by Quintero (2006) [15], based on a sampling system using three monitoring stations, and strategically distributed in the city of Mexicali. The sampling of air pollutants was performed using a collector of rotation and impact type, Rotorod 40. It was estimated the rate of lung exposure (RLE) for fungal spores, considering the average exposure for 24 hours, as the product of the average concentration of spores/m^3 (ACS) in relation to the average daily volume of breathing in (AVB): RLE = [(ACS) (AVB)].

2.2 Statistical analysis

A descriptive analysis was performed from the obtained data: atmospheric concentration of fungal spores, the monthly mean temperature (MMT), relative humidity average (RHA) and the incidence of childhood asthma by age and sex, using graphic time series and frequency distribution for quality control. It was performed an independent analysis of the relationship between each of the variables proposals and cases of childhood asthma, taking into account each of the three age groups for the study. Finally, it was made an analysis focusing all cases of childhood asthma in a single group having its variations by sex. To interpret the association between the variables studied, it was designed a multiple linear regression model which allowed a reduction to a minimum statistical error

and limitation of partiality. The handling of the data was performed with SPSS 12.

3 Results

During the years of the study there were a total of 1,212 new cases of childhood asthma registered, with a rate of 505 cases/one hundred thousand children, of whom 57% were males. The cases of asthma were more frequent in the 5 to 14 years age group (63%), with 766 cases, and in second place, the 1 to 4 group aged (31%,) and 373 cases, and with less involvement the children age of one year under, with 73 cases (six percent). The overall incidence of asthma showed a higher frequency in the months of March with 125 cases, 102 cases in June, 130 cases in October, 143 cases in November and December with 156 cases, as shown in table 1.

Table 1:   Incidence of childhood asthma by age group and sex.

Months	>1	1 to 4	5 to 14	Total	Sex	
					F	M
S2004	2	31	63	96	50	57
O2004	10	34	86	130	57	72
N2004	8	49	86	143	51	77
D2004	6	66	84	156	47	68
E2005	6	37	55	98	42	48
F2005	6	3	67	76	40	46
M2005	7	50	68	125	54	76
A2005	5	27	58	90	38	49
M2005	9	23	67	99	39	52
J2005	8	29	65	102	46	62
J2005	3	15	33	51	25	39
A2005	3	9	34	46	34	43
Total	73	373	766	1212	523	689

Source: Health Secretary of Mexico 2006.

The incidence of asthma in general showed a cyclical behavior of bimodal type, with an initial plateau in December (156 cases), and a second plateau in March with 121 cases.

Regarding the atmospheric concentration of fungal spores, mainly 4 different groups of spores were identified, they were selected by its atmospheric concentration and its epidemiological significance; *Alternaria sp., Cladosporiun sp., Bipolaris y Stemphylium,* table 2. The general behavior of the atmospheric concentration of fungal spores with a cyclical behavior, showed an increased in concentration spores/m^3 in three stages: the first in March (503 spores/m^3), the

Table 2:   Spores found in the sampling of a year, in Mexicali`s atmosphere.

Months	*Alternaria*	*Cladosporium*	*Stemphylium*	*Bipolaris*	Total
S2004	107	0	10	63	180
O2004	62	85	12	129	288
N2004	127	94	56	78	355
D2004	29	110	168	35	342
E2005	300	287	201	82	870
F2005	171	151	251	31	604
M2005	278	86	96	43	503
A2005	146	133	40	23	342
M2005	186	156	67	56	465
J2005	167	172	48	84	471
J2005	443	126	65	147	781
A2005	1203	303	183	297	1986
Total	3219	1703	1197	1068	7187

Source: Atmospheric sampling 2006.

second was in August (986 spores/m^3), and the third in January (870 spores/m^3) to February (604 spores/m^3). The descriptive statistics showed that the atmosphere of Mexicali, presents an annual average of 515 spores/m^3 with a standard deviation (SD) of 248 spores/m^3, and an average daily. As a result of calculating the rate of lung exposure to fungal spores (RLE), which may happen in a typical day, there is a possibility that on average 164 spores/day make contact with the mucus of the airways. Concentrations which become very important considering the potential of pathogenic fungi spores, and the atmospheric concentration limit to produce a case clinical of asthma.

$$RLE = [(ACS) (AVB)] \tag{1}$$

As a result

$$RLE = [(19 \text{ spores/m}^3) (8.64 \text{ m}^3/\text{day})] = 164 \text{ spores/day} \tag{2}$$

The annual relative humidity average (RHA) was 42.3%, with monthly range from 25% to 63% and an upward trend from august to February with a record of increase in humidity as shown in table 3.

The monthly mean temperature (MMT) records showed two different facets, one in the cold season that starts in November and continues until February, reached its minimum 8°C average, and a warm season, which starts virtually in may (28°C), increasing gradually up to august (35°C), with a record peak in the month of July that reached 44°C, as shown in table 4.

This means that in a typical day, a child resident in the city of Mexicali has an 86% probability to present the clinical symptoms of bronchial asthma.

The application of the multiple linear regression model was developed to analyze the behavior of the incidence of childhood asthma based on the epidemiological variables studied (monthly average spores/m^3, MMT and RHA) reflects a percentage of reliability with an $R^2 = 0.86$ (P < .05).

Table 3:   Relative humidity averages in Mexicali.

Months	R.H. Maximum	R.H. Minimum.	R.H. Average
S2004	57.9	15.3	32.9
O2004	66	23.5	42.9
N2004	72.8	26.4	49
D2004	74	30.8	52.5
J2005	83.2	37.9	62
F2005	93.2	33.5	63.6
M2005	61.2	37.8	44.5
A2005	51.8	13.7	28.9
M2005	53.7	14.3	30.9
J2005	48.1	12.5	25.8
J2005	62.1	14.4	34.1
A2005	69.9	21.7	41.2

Source: Department of Meteorology of the Institute of Engineering, UABC, 2006.

Table 4:   Monthly mean temperature in Mexicali.

	T°. Maximum.	T°. Minimum.	T°. Average
S2004	37.9	22.6	30.25
O2004	32.9	17.6	25.25
N2004	24.1	10.7	17.4
D2004	21.7	8.9	15.3
J2005	22.3	10.6	16.45
F2006	22.3	11.4	16.85
M2006	27.7	14.0	20.85
A2005	32.5	15.0	23.75
M2005	36.0	20.9	28.45
J2005	39.7	23.4	31.55
J2005	44.0	28.6	36.3
A2005	42.8	28.7	35.75

Source: Department of Meteorology of the Institute of Engineering of the UABC, 2006.

4   Discussions

There are several epidemiological studies realized at a number of cities in Mexico's northern border, where the relationship between changes in human health and the concentration of air pollutants was analyzed, which only few considered; aerobiological pollutants and the increased incidence of childhood asthma in the specified form were found [16, 17]. It may be said that there are virtually no studies that specifically analyzed the air pollutants such as fungal spores and the incidence of childhood asthma, despite the high concentrations of air pollutants of this type, reported in taxonomic studies carried out in different parts of Mexico, [18–20]. Papers published in other regions such as Europe and USA, analyzed this type of pollutant and its potential to cause health damage [21–24].

Mexicali is a border town in northern Mexico, with an economy based on the in bond industry and agriculture, where plants are grown mainly for family of *Gramineas* such as wheat or corn, whose harvests leaves are easily invaded by fungi. On the other hand the waste of most agricultural products are a fertile ground for the incubation of fungi, as *Alternaria* and *Cladosporium* [25]*,* coupled with weather and specific topographical conditions (on average 11 meters below sea level), contribute to an higher concentration of fungal spores in the atmosphere that can be associated with the high index of lung exposure of 164 spores/day, combined with the type of spores observed and its association with the incidence of asthma. Special Comment demand registration of 1986 spores/m^3 observed in August, which takes place in the fallowing of farmland, which involves the removal of land by releasing the *Ascospores* and *Conidias,* specialized structures that were adapted by fungi order to remain in latent form in different time periods in dry soil, waiting for moisture and a biological substrate to reproduce and germinate.

Halomen (1997), established a direct relationship between the spores of *Alternaria* and childhood asthma, in similar studies which showed a positive relationship between the atmospheric concentration of spores, and the presence of specific alterations of human health [26–28], which helps to explain the presence of a rate of childhood asthma 505/one hundred thousand children, that represents approximately the national average two folded [29]. The largest percentages of these were observed in males at the age before puberty, as it was reported by Sears (2008) in its study on the epidemiology of asthma [30].

By observing the incidence of childhood asthma it has been appreciated a bimodal type behavior with a well-defined subsequent relationship to the maximum levels of air pollution by fungus spores. The subsequent relationship is explainable as a delayed response caused by the amount of dispersion time and deposition in the lung epithelium, [31], joined to a physio-pathological response with a latency period of 5 days on average, and a belated reaction family, which could last up to 7 days after contact, before the severity of the clinical data required a visit to a physician [32]. In relation to the application by sex shows a higher percentage of males, similar to the reported in national records.

Finally the implementation of the proposed regression model showed a significant relationship with an R2 = 86 (p = 0.05) among the epidemiological variables (average relative humidity, temperature and atmospheric concentration of fungal spores/m^3) and the increase in the incidence of childhood asthma in the city of Mexicali

5   Conclusions

This study provides an analysis of the impact of air pollution caused by fungal spores of *Alternaria, Cladosporiun, Bipolaris* and *Stemphylium* on children's respiratory system in Mexicali, as a response to a combination of the unique characteristics of Mexicali and its Valley such as extreme temperatures, moisture levels, diverse crops plantation, type of plants and bushes and the topographical features of the region. The results of the linear regression model proposed, allowed to establish a 86% probability, a positive relationship between levels of atmospheric pollution by fungal spores, the increase in the temperature rates, air humidity and behavior of the incidence of childhood asthma.

It is important to note that the findings of air pollutants by fungal spores encountered in this work derived from the only study carried out in the region.

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