

## Association between ionic composition of fine and coarse aerosol soluble fraction and peak expiratory flow of asthmatic patients in São Paulo city (Brazil)

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### Abstract

Air pollutants are associated with adverse respiratory effects mainly in susceptible groups. This study was designed to assess the impact of the ionic composition of particulate matter on asthmatic respiratory functions in São Paulo city. From May to July 2002, fine and coarse particulate matter fractions were collected and their respective chemical composition with respect to major ions ( $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{NH}_4^+$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$  and  $\text{SO}_4^{2-}$ ) were determined in each aqueous-extract fraction. The results showed predominant concentrations of  $\text{SO}_4^{2-}$  (48.4%),  $\text{NO}_3^-$  (19.6%) and  $\text{NH}_4^+$  (12.5%) in the fine fraction, whereas  $\text{NO}_3^-$  (35.3%),  $\text{SO}_4^{2-}$  (29.1%),  $\text{Ca}^{2+}$  (13.1%) and  $\text{Cl}^-$  (12.5%) were the predominant species in the coarse fraction. The association between the chemical components of both fractions and the daily peak expiratory flow (PEF) measurements (morning and evening) of the 33 asthmatic individuals were assessed through a linear mixed-effects model. The results showed a significant negative correlation (decrease of PEF) between morning PEF and coarse chloride (3-day moving average) and between evening PEF and coarse  $\text{Na}^+$  (3-day moving average), coarse  $\text{Mg}^{2+}$  (3-day moving average) and coarse  $\text{NH}_4^+$  (2- and 3-day moving average). A significant negative correlation has also been observed between morning and evening PEF and  $\text{Mg}^{2+}$  in the fine fraction. These results suggest that some particle chemical constituents may increase the responsiveness of airways and that coarse particles that deposit in the upper airways may be more relevant for asthmatic response and irritation. However, the results do not prove a clear causal relationship.

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## 1. Introduction

Air pollution is a serious environmental problem, mainly in urban areas. Industrial and automotive emissions were the main reasons for air quality deterioration that occurred since the beginning of the 20th century in many regions of the world. Exposure to air pollutants can increase incidence and prevalence of, at least, two main groups of adverse health outcomes: respiratory and cardiovascular diseases. These effects may be the consequence of both short- and long-term exposures, and they have been reported by many researchers in different countries. These results reinforce the causal relationship between criteria pollutants (particulate matter smaller than  $10\ \mu\text{m}$ — $\text{PM}_{10}$ , sulfur dioxide— $\text{SO}_2$ , nitrogen dioxide— $\text{NO}_2$ , carbon monoxide— $\text{CO}$  and ozone— $\text{O}_3$ ) and adverse health outcomes (Brunekreef and Holgate, 2002).

Respiratory diseases are one of the most important causes of emergency room visits, hospital admissions and deaths (Lotufo and Bensenor, 1999) in the city of São Paulo. Different from that observed for other diseases, the prevalence of respiratory symptoms (with or without wheezing) has increased among children (Benício et al., 2000). This result is in agreement with studies carried out in many countries where asthma, which is characterized by an airway chronic inflammation, is considered a public health issue. Studies carried out in São Paulo city have focused on air pollution acute effects on both respiratory and cardiovascular diseases. Especially in the respiratory system, air pollution exposure has shown increased respiratory mortality (Gouveia and Fletcher, 2000; Martins et al., 2004) and morbidity (Braga et al., 1999; Gouveia and Fletcher, 2000; Braga et al., 2001; Martins et al., 2001, 2002) among children and elderly people and always associated with, at least, one of the criteria pollutants.

However, the full scenario of air pollution health effects on respiratory system in São Paulo city is far from being revealed because some other pollutants, population groups and health outcomes have not been analyzed due to the lack of pollutant measurements and availability of medical records, respectively.

Among air pollutants, the atmospheric suspended particulate matter turned to be an important environmental issue in the last decade due to its impact on human health, directly on the lung tissues or indirectly as a transfer vector of toxic substances

adsorbed on it. The sources characteristics and health hazard of the fine ( $d < 2.5\ \mu\text{m}$ ) and coarse particulate matter ( $2.5 < d < 10\ \mu\text{m}$ ) are distinct. It is admitted that the impact of particles, which are smaller than  $2.5\ \mu\text{m}$  ( $\text{PM}_{2.5}$ ), is larger than the impact of coarse ones ( $\text{PM}_{2.5-10}$ ) because these particles go deeper in the respiratory tract and become trapped on it, which affects the lung function. Moreover, chemical composition varies between the coarse and fine fractions.

In most of the studies about air pollution, the total elementary chemical composition of the particulate matter is usually the subject of concern. However, the characterization of the aqueous extract of the aerosols can assign information about elemental speciation of the chemical constituents, their origin and specific emission source or their bioavailability (Fernandez Espinosa et al., 2002). Chemicals of anthropic origin (vehicular emissions, soil dust re-suspension, industrial emissions) occur mainly in an easily water-soluble form (Fernandez Espinosa et al., 2002; Kyotani and Iwatsuki, 2002). Fernandez Espinosa et al. (2002) also stress that this fraction could be biologically available for the human respiratory tract and Adamson et al. (1999) suggest that it is the soluble fraction of the particulate matter that originates toxicity.

Asthmatic patients present an increased susceptibility to air pollutants exposure (Zmirou et al., 2004) and, in the last decade, its prevalence has increased worldwide and in all age groups (Fiori and Fristcher, 2001). On the other hand, air pollution health effects studies in São Paulo have not addressed adequate questions regarding the association between air pollutants and asthma. Therefore, we decided to analyze the effects of particulate matter on pulmonary function which is used in the assessment of asthma of asthmatic patients attended at the University Hospital Asthmatic Clinics, using coarse ( $\text{PM}_{2.5-10}$ ) and fine ( $\text{PM}_{2.5}$ ) fractions of particulate matter and their inorganic chemical composition as a tracer for the symptoms exacerbation.

## 2. Materials and methods

### 2.1. Sampling site

The Metropolitan Area of São Paulo (MASP) with an approximate area of  $8000\ \text{km}^2$ , located in Southeastern Brazil ( $23^\circ\text{S}$  and  $46^\circ\text{W}$ ), has about 17.5 millions inhabitants distributed over an

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