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Association between exposure to particulate matter and hospital admissions for respiratory disease in children

ABSTRACT

The aim of this study was to estimate the association between exposure to particulate matter less than 2.5 microns in diameter and hospitalization for respiratory disease. It was an ecological time series study with daily indicators of hospitalization for respiratory diseases in children up to 10 years old, living in Piracicaba, SP, Southeastern Brazil, between August 1, 2011 and July 31, 2012. A generalized additive Poisson regression model was used. The relative risks were RR = 1.008; 95%CI 1.001;1.016 for *lag* 1 and RR = 1.009; 95%CI 1.001;1.017 for *lag* 3. The increment of 10 µg/m³ in particulate matter less than 2.5 microns in diameter implies increase in relative risk of between 7.9 and 8.6 percentage points. In conclusion, exposure to particulate matter less than 2.5 microns in diameter was associated with hospitalization for respiratory disease in children.

DESCRIPTORS: Pneumonia. Asthma. Respiratory Tract Diseases. Air Pollutants. Air Pollution. Particulate Matter. Child Health. Time Series Studies.

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INTRODUCTION

Respiratory disease may be associated with factors such as air pollution, both that produced by motor vehicles and that form burning biomass.^{3,5,7}

Data from the Brazilian Ministry of Health report more than 70 thousand hospitalizations in 2011 for children aged under 10, costing more than R\$ 60 million (1 US\$ ≈ R\$ 2.00).^a

Among the pollutants implicated in hospitalizations for respiratory disease in children, particulate matter less than 10 microns in diameter⁷ stands out, especially that fraction which is less than 2.5 microns in diameter.^{3,5}

Brazil plays an important role in emitting air pollutants due to biomass burning. Preliminary data of the 2012 to 2013 cane sugar harvest predict that 600 thousand tons will be milled, 56.0% in the state of Sao Paulo.^b In Piracicaba, SP, sugar cane plantations cover around 80.0% of the surface, generating large quantities of particulate matter when the cane is burnt.³

The municipality of Piracicaba is one of the main producers of sugar and sugar cane alcohol in the world and is responsible for emissions of gases and particulates into the atmosphere when the sugar cane is burnt.

The aim of this study was to estimate the association between exposure to PM_{2.5} and hospitalizations in children due to respiratory disease.

METHODS

This was an ecological time series study, with daily indicators of hospitalizations for respiratory disease (ICD 10: J12.0 to J18.9, J45.0, J45.1, J45.8, J45.9 and J46), in children aged from zero to ten years in Piracicaba, from August 1, 2011 to July 31, 2012. These data were obtained from the Datasus.¹ Estimated daily levels of carbon monoxide (CO in ppb), ozone (O₃ in µg/m³), nitrogen oxides (NO_x in µg/m³) and particulate matter (PM_{2.5} in µg/m³) were obtained from the CATT-BRAMS system.^{4,6} The data on temperature and humidity were obtained from the ESALQ-USP web site^c and the apparent temperature was calculated using temperature and humidity.²

Piracicaba is located at latitude 22°43' S and longitude 47°39' W, at an altitude of 547 meters. It is 164 km from the state capital and 75 km from Campinas. The territory covers around 1,400 km² and has a little over 350 thousand inhabitants. There were an estimated 199 thousand automobiles and motorcycles, and 12 thousand buses and vans in 2012 (IBGE).^d

Pearson's correlation test was used to evaluate possible correlations between hospitalizations and estimated levels of PM_{2.5}.

The effects of exposure to air pollution can lead to hospitalization on the same day or on following days. Thus, the effects on the respiratory apparatus were investigated on the day of hospitalization (*lag* 0) and on the five following days (*lag* 1 to *lag* 5). The generalized additive Poisson regression model was used as the outcome is a discrete, quantitative variable. The results of risk of hospitalization refer to exposure to PM_{2.5} adjusted for other pollutants and for the apparent temperature. The Statistica v7 program was used for the analyses.

The estimated effects were relative risk (RR), corresponding to an increment of 10 µg/m³ in the levels of PM_{2.5}. The RR were converted into percentage increases. A level of significance of 5.0% was adopted in the analyses.

RESULTS

In individuals aged zero to ten years, there were 437 hospitalizations for respiratory disease. The daily mean was 1.2 (sd = 1.3), minimum 0.0 and maximum 8.0. The mean daily concentration of PM_{2.5} was 28.6 µg/m³ (sd = 16.7) and it did not exceed the limits set by the CETESB.^e Minimum and maximum values were 1.0 and 113.0 µg/m³ respectively. The daily levels exceeded the established level on some days, reaching the regular standard of air quality. The interquartile difference in PM_{2.5} was 17.2 µg/m³ and the mean daily apparent temperature was 19.8°C (sd = 3.2). Hospitalizations were positively correlated with PM_{2.5} (r = 0.12; p < 0.05). Apparent temperature showed negative correlation with PM_{2.5} (r = -0.08; p > 0.05) and with hospitalizations (r = -0.20; p < 0.01).

^a Ministério da Saúde. DATASUS. Departamento de Informática do SUS. Morbidade Hospitalar do SUS - por local de residência - SP. Brasília (DF); 2013 [cited 2013 Jan 21]. Available from: <http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sih/cnv/nrsp.def>

^b União da Indústria de Cana de Açúcar. Histórico de Produção e Moagem - Safra 2012/2013. São Paulo; 2013 [cited 2013 Jun 23]. Available from: <http://www.unicadata.com.br/historico-de-producao-e-moagem.php?idMn=32&tipoHistorico=4&acao=visualizar&idTabela=1424&safra=2012%2F2013&estado=RS%2CSC%2CPR%2CSP%2CRJ%2CMG%2CES%2CMS%2CMT%2CGO%2CDF%2CBA%2CSE%2CAL%2CPE%2CPB%2CRN%2CCE%2CPI%2CMA%2CTO%2CPA%2CAP%2CRO%2CAM%2CAC%2CRR>

^c Universidade de São Paulo. Escola Superior de Agricultura "Luiz de Queiroz". Departamento de Engenharia de Biosistemas. Piracicaba; 2013 [cited 2013 Jan 18]. Available from: <http://www.leb.esalq.usp.br/posto.html>

^d Instituto Brasileiro de Geografia e Estatística. Cidades: São Paulo - Piracicaba. Brasília (DF); 2013 [cited 2013 Jan 18]. Available from: <http://www.ibge.gov.br/cidadesat/xtras/perfil.php?codmun=353870&search=S%C3%A3o%20Paulo|Piracicaba>

^e Companhia de Tecnologia de Saneamento Ambiental. Padrões de qualidade do ar. São Paulo; 2013 [cited 2013 Jan 18]. Available from: <http://www.cetesb.sp.gov.br/ar/Informa?es-B?sicar/22-Ptr?es-e-?ndices>

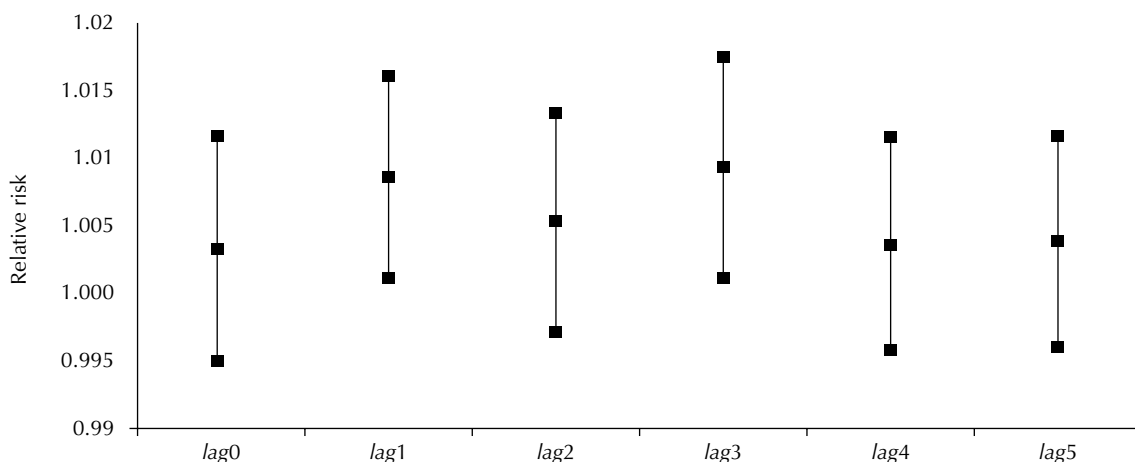


Figure. Relative risk of respiratory disease in children under 10 and respective 95% confidence intervals for the pollutant $PM_{2.5}$ for each lag. Piracicaba, SP, August 1, 2011 to July 31, 2012.

The coefficients of regression and the respective standard errors for $PM_{2.5}$ in each lag showed significant p values for lags 1 and 3 after adjusting for other pollutants and for apparent temperature, and controlled for day of the week and season.

The relative risks and their respective 95% confidence intervals showed a positive association between hospitalizations and $PM_{2.5}$ (RR = 1.008; 95%CI 1.001;1.016 for lag 1 and RR = 1.009; 95%CI 1.001;1.017 for lag 3). The increase of $10 \mu\text{g}/\text{m}^3$ of $PM_{2.5}$ meant an increase of between 7.9 (lag 1) and 8.6 (lag 3) percentage points in the relative risk (Figure).

DISCUSSION

The CATT-BRAMS^{4,6} system used in this study considers the dynamics of the atmosphere. It is a mathematical model covering South America which considers the emission and transport of different gases and aerosol particulates, obtained by satellites that monitor the burning, providing daily estimates for different pollutants. One of the advantages of using this model is its application in cities where there are no pollutant measuring stations. The use of data estimated by this system, validated by Ignotti et al,⁵ enables the costs of research to be lowered and makes the process of analyzing the effects of atmospheric pollution on health easier.

Hospitalizations for respiratory disease in children under ten were positively and significantly associated with $PM_{2.5}$ one day and three days after exposure.

Epidemiological studies show that exposure to polluting gases and particulate matter is associated

with higher incidence of symptoms in the lower respiratory tract, such as coughing, dyspnea and wheezing, especially in children.¹

In the municipality of Piracicaba, SP, in addition to pollutants emitted by burning fossil fuels, sugar cane is burnt between April and November, releasing particulate matter and gases into the atmosphere. According to Cançado et al,³ pioneers in studies in that city, burning the cane fields in the pre-harvest increases atmospheric pollution in the region. Ignotti et al,⁵ assessing atmospheric pollution from burning biomass in the Amazonian region of Brazil, showed a positive association between exposure to $PM_{2.5}$ and the occurrence of respiratory disease, especially in the most vulnerable age groups (the elderly and children < 5 years old).

Application of Sao Paulo law no. 11.241/02,^f which deals with the gradual elimination of the practice of burning sugar cane, was not evaluated, nor were its possible social implications.

This study observed a negative correlation between hospitalization and apparent temperature, which takes into consideration physiological experience of exposure combined with humidity and temperature. This enables the effect of these variables on the individual's health to be evaluated more effectively.²

Motor vehicles can contribute to the release of pollutants. These, together with pollutants released from burning can sugar, contribute to increasing hospitalization in the winter, when there is lower humidity and temperatures. This affects the dispersion of atmospheric pollution.

^fSão Paulo. Lei nº 11.241, de 19 de setembro de 2002. Dispõe sobre a eliminação gradativa da queima da palha da cana-de-açúcar e dá providências correlatas. *Diário Oficial Estado São Paulo*. 22 set 2002 [cited 2013 Jan 18]. Available from: www.cgpp.sp.gov.br/gt_licitacoes/legislacao/lei_11241_02.htm

A limitation of this study could be the fact that the CATT-BRAMS measurements are estimated at an altitude of 40m and not closer to the ground, where concentrations may be different.

To conclude, exposure to particulate matter smaller than 2.5 microns in diameter (PM_{2.5}) was associated with hospitalizations for respiratory disease in children.

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