Association between concentrations of air pollutants and mean time of hospitalization due to pneumonia in children

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ABSTRACT

A time-series ecological study was developed to estimate the role of air pollutants in the mean daily duration of hospitalization for pneumonia in children under one year old and living in São José dos Campos, SP, between January 1, 2009 and December 31, 2009. Air pollutants PM_{10}, SO_2 and O_3, and climatic variables were measured by the Environmental Company of the State of São Paulo (Cetesb). The duration of each hospitalization was obtained from the Datasus site. The values of air pollutants and climatic variables were analyzed using multiple linear regression in lags of zero to five days; the dependent variable was the mean duration of hospitalization and the independent variables were the pollutants. We obtained R^2 and alpha = 0.05 was the significance level of the model. There were 559 children under one year of age admitted during the study period; the mean hospital stay was 3.81 days (SD = 4.06). The PM_{10} was associated with length of stay in concurrent days and lags four and five (P <0.001, R^2 = 0.08); a 15 $\mu g.m^{-3}$ increase in concentration of this pollutant implies an increase of approximately one day of mean time of hospitalization for lags of 0, 4 and 5 days. It was therefore possible to identify the role of particulate matter in the duration of pneumonia hospitalizations in children.

Keywords: particulate matter, pneumonia, air pollution, air pollutants, child health, public health.

Associação entre concentrações de poluentes do ar e tempo médio de internação por pneumonia em crianças

RESUMO

Foi desenvolvido um estudo ecológico de series temporais sobre internações por pneumonia em crianças com até um ano de idade residentes em São José dos Campos, SP, entre 01 de janeiro e 31 de dezembro de 2009, para estimar o papel de poluentes do ar na duração da internação hospitalar. Os dados dos poluentes analisados PM_{10}, SO_2 e O_3 e variáveis climáticas foram obtidos da CETESB. Os dados sobre internação foram obtidos do DATASUS. A análise estatística utilizou a regressão linear múltipla e defasagens de zero a cinco dias; a variável dependente foi o tempo médio de internação e as variáveis

independentes foram as concentrações dos poluentes do ar ajustadas pela temperatura e umidade. Foi calculado R^2 e a significância estatística adotada foi alfa = 0.05. Foram internadas 559 crianças no período de estudo com duração media de internação de 3,81 dias (dp = 4,06). PM_{10} esteve associado com a duração da internação no mesmo dia da exposição e quarto e quinto dias após a exposição (P <0.001, R^2 = 0.08); com aumento de 15 µg.m^{-3} na concentração de PM_{10}, houve aumento médio de um dia na duração da internação no mesmo dia da exposição e também quatro e cinco dias após a exposição. Assim foi possível mostrar o papel de poluentes do ar na duração da internação por pneumonia em crianças com até um ano de idade.

Palavras-chave: material particulado, pneumonia, poluição do ar, poluentes do ar, saúde da criança, saúde pública.

1. INTRODUCTION

Pneumonia is a multifactorial disease; cited among these factors are a lack of breastfeeding, the presence of smokers in the home, low birth weight, and low socioeconomic status (Nascimento et al., 2004; Nascimento-Carvalho et al., 2002)

As it is known that the components of anthropogenic air pollution predominantly affect the body via inhalation, it is expected that its main effects manifest themselves in the respiratory tract. (American Thoracic Society, 1996) Thus, exposure to air pollutants is recognized as an important risk factor for the occurrence of hospitalizations in children (Amâncio e Nascimento, 2012; Nascimento et al., 2006) school absenteeism (Park et al., 2002), and also for low birth weight (Nascimento e Moreira, 2009)

Among the pollutants associated with these outcomes, we highlight sulfur dioxide (SO_2), ozone (O_3) and particulate matter with an aerodynamic diameter less than 10 micra (PM_{10}). Sulfur dioxide is a known respiratory irritant absorbed in the upper airway and deposited in the inferior airway and in the lung parenchyma (American Thoracic Society, 1996). Industries that use coal and oil products and motor vehicles that use fossil fuels are the main sources of this pollutant.,. Ozone near the Earth's surface is the result of photochemical reactions of pollutants with solar radiation. Ozone reaches the deepest portions of the lungs and can cause inflammation and decreased lung function (American Thoracic Society, 1996). Particulate matter, originating mainly from burning fossil fuels, may have a half-life of a few days to years. It is associated with increased symptoms and respiratory diseases in children and an increase and worsening of asthma symptoms (Amâncio e Nascimento, 2012; Nascimento et al., 2006; Moura et al., 2009; Jasinski et al., 2011).

Several studies assessing air pollution and respiratory diseases were conducted in large urban centers in Brazil (Bakonyi et al., 2004; Braga et al., 2001; Castro et al., 2009; Moura et al., 2008); few studies have been conducted in medium-sized cities (4.5) and, in general, these studies employ Poisson regression models, where the dependent variable is the number of daily hospitalizations. Is there an association between levels of air pollutants, especially particulate matter, and the average daily hospitalization? The objective of this work is to investigate the association between exposure to air pollutants and childhood respiratory morbidity, represented by the average length of hospitalization for pneumonia.

2. METHODS

The study was conducted in São José dos Campos, a medium-sized city; this city has intense industrial activity and is crossed by the Via Dutra, the most important Brazilian highway with an impressive traffic flow (about 130 thousand per day, mainly heavy vehicles and buses). It is located in southeastern Brazil (latitude 23° 11' S and longitude 45° 53' W),

about 80 km from São Paulo, and has a population of approximately 650,000, occupying an area of 1,142 km^2 (urban area approximate 360 km^2).

A time-series ecological study was developed to estimate the role of air pollutants in the mean daily duration of hospitalization for pneumonia in children under one year old (ICD-10: J12-J18) and living in São José dos Campos, SP, between January 1, 2009 and December 31, 2009. These data were obtained from the Department of Informatics of Health System (Datasus). For the consolidation of hospitalization data, the first three months of 2010 were reviewed in order to obtain any information regarding admissions through December 31, 2009. These data were analyzed in relation to exposure to air pollutants that were measured by the Environmental Company of the State of São Paulo (Cetesb), which has a metering station in São José dos Campos. Particulate matter, SO_2 and O_3 were the estimated pollutants, beyond the climatic variables of relative humidity and minimum temperature. The duration of each hospitalization, in days, was obtained from the Datasus.

The values of air pollutants and climatic variables were analyzed continuously and formed the block of independent variables; the dependent variable was the mean duration of hospital admissions in days considered; so if the day included three hospitalizations lasting 4, 5 and 9 days each, the average length of hospital stay was (4 +5 +9) / 3, i.e. 6 days.

Models were built using multiple linear regression, with the average daily duration of hospitalization for pneumonia associated with exposure to PM_{10}, according lags (lags) of zero to five days, controlled by other air pollutants and the climatic variables.

To identify the robustness of the models, we used the methods of Durbin-Watson reports on the independence of errors and the inflation factor to identify collinearity among the variables; we obtained the values of R^2 and significance of the final model (p-value). Descriptive analyzes were performed for all variables and the correlations between those of interest were estimated by means of Pearson correlation coefficients.

Figure was built with the length of hospitalization considering an increase in PM_{10} concentration of 15 µg m^{-3}, with confidence intervals of 95% for lags 0-5 days.

3. RESULTS

559 children under one year of age were admitted during the study period; the daily average values of hospitalization and length of hospital stay and their standard deviations were 1.53 cases (sd = 1.67) and 3.81 days (sd = 4.06). Mean values, standard deviations, minimum and maximum of the variables are shown in Table 1. A large number of hospital stays of significant duration can be observed.

Table 1. Mean, minimum and maximum (Min – Max) values, and standard deviation (sd) of the study variables, São José dos Campos, Brazil, 2009.

	Mean (sd)	Min-Max
hospitalization	1,53 (1,67)	0 – 8
Average hospitalization time (days)	3,81 (4,06)	0 – 30,0
PM_{10} (µg/m^3)	20,77 (8,65)	7 – 57
SO_2 (µg/m^3)	2,68 (1,76)	0,8 – 15,0
O_3 (µg/m^3)	83,17 (31,58)	16 – 196
Relative humidity (%)	87,04 (6,92)	62,9 – 100,0
temperatue (^{0}C)	16,42 (7,58)	7,58 – 20,96

The Pearson correlation coefficients for the variables are shown in Table 2. A significant correlation can be observed between the mean duration of hospitalization and PM_{10} and SO_2, as well as minimum temperature.

Table 2. Matrix of the Pearson correlation coefficients of the study variables, São José dos Campos, Brazil, 2009.

	AHT [@]	PM$_{10}$ (µg m^{-3})	SO$_2$ (µg m^{-3})	O$_3$ (µg m^{-3})	RH [*] (%)	Temp [**] (^{0}C)
AHT [@]	1					
PM$_{10}$ (µg m^{-3})	0,20[#]	1				
SO$_2$ (µg m^{-3})	0,17[#]	0,47[#]	1			
O$_3$ (µg m^{-3})	-0,63	0,31[#]	0,17[#]	1		
RH [*] (%)	-0,08	-0,37[#]	-0,15[#]	-0,35[#]	1	
Temp [**] (^{0}C)	-0,23[#]	-0,37[#]	-0,47[#]	0,14[#]	0,21[#]	1

* Relative Humidity
** temperature
[@] Average hospitalization time
# p<0,05

The coefficients obtained by linear regression for each pollutant-adjusted minimum temperature and humidity, and according lags 0-5 days, are shown in Table 3. The only pollutant that proved significant was the competitor and PM$_{10}$ on lags of four and five days before admission.

Table 3. Coefficients of pollutants with the respective standard deviation (sd) obtained by linear regression, values from the Durbin-Watson test and value of inflation, according to the lags 0-5 days, São José dos Campos, Brazil, 2009.

	PM$_{10}$ Coefficient (sd)	SO$_2$ Coefficient (sd)	O$_3$ Coefficient (sd)	D-W[#]	VIF[@]
LAG 0	**0,069 (0,030)***	0,171 (0,149)	-0,014 (0,008)	1,96	1,51
LAG 1	0,061 (0,032)	0,247 (0,159)	-0,008 (0,008)	1,93	1,51
LAG 2	0,040 (0,033)	0,112 (0,161)	0,005 (0,008)	2,03	1,54
LAG 3	0,019 (0,033)	0,215 (0,160)	0,007 (0,008)	2,02	1,53
LAG 4	**0,079 (0,033)***	0,184 (0,162)	-0,011 (0,009)	2,04	1,52
LAG 5	**0,078 (0,033)***	0,131 (0,161)	-0,014 (0,008)	2,05	1,51

Durbin-Watson test for the model
[@] value of inflation in respect to PM$_{10}$
*the values in bold have P < 0.05

The resulting F test F = 5.13 (p <0.001) and the coefficient of determination R^2 was equal to 0.08.

The results of the Durbin-Watson analysis are close to the value 2 showing independence of errors and the amount of inflation (VIF) is close to the unit value and does not show collinearity.

The coefficients for the particulate material can be used to estimate that with the increase in concentration of 15 µg m^{-3} of this pollutant, the average time of hospitalization is increased by approximately a day for lags 0, 4, and 5 days (Figure 1).
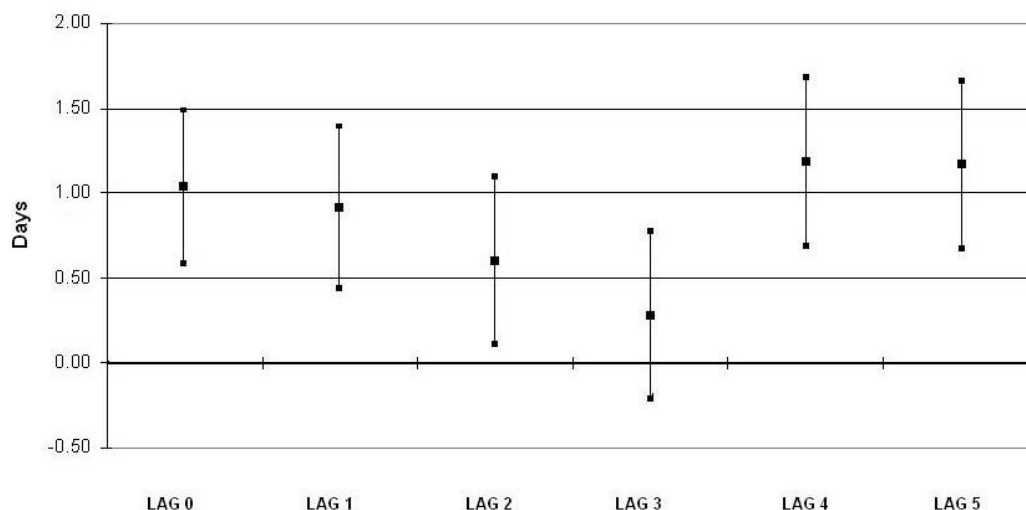
Figure 1. Increase in the length of hospitalization in days, due to the increase in the concentration of 15 μg m^{-3} of PM$_{10}$ in lags 0-5 days, São José dos Campos, Brazil, 2009.

4. DISCUSSION

This is the first study, to our knowledge, that examines the role of concentrations of pollutants in the length of hospitalization for respiratory disease in children.

The concentrations of pollutants are lower than those found in national studies conducted in large centers (Bakonyi et al., 2004; Braga et al., 2001; Castro et al., 2009; Moura et al., 2008), and this situation can be explained by the fact that this study was performed in a medium-sized city (650,000 inhabitants with a vehicle fleet of approximately 300 000 vehicles).

Even so, a positive association between exposure to particulate matter and length of hospitalization can be demonstrated; exposure to this pollutant is associated with hospitalization for pneumonia in children under 10 years of age, in a previous study (Nascimento et al., 2006).

In a study conducted in the Brazilian Amazon, exposure to particulate matter less than 2.5 microns in aerodynamic diameter (PM$_{2,5}$), generated by biomass burning, was strongly associated with hospitalization for respiratory illness in children aged less than 5 years (Ignotti et al., 2010). Moreover, Moura et al. (2008) found no association between levels of PM$_{10}$ and acute respiratory disorders in children in a study conducted in Rio de Janeiro. In a study conducted in medium-sized city, exposure to PM$_{10}$ was associated with hospitalizations for asthma on same day of exposure and with lags of two and three days of exposure (Amâncio e Nascimento, 2012)

Even within acceptable levels for most of the period, air pollution, especially PM$_{10}$ and NO$_2$, was associated with decreased lung function in children living in Rio de Janeiro (Castro et al., 2009). In a study conducted in Ribeirão Preto, exposure to PM$_{10}$ was associated with greater number of inhalation and nebulization procedures , but the authors point out that these findings should be treated with caution in view of possible confounding factors (Carneseca et al., 2012). In Cubatão, with average values of PM$_{10}$ in the order of 64 μg m^{-3}, increases in the concentration of 50 μg m^{-3} had a risk of hospitalization by nearly 10%. (Moura et al., 2009).

Hansen et al. (2012) identified an association between PM$_{10}$ and admissions for respiratory diseases in Australia, even with relatively low average concentrations (20 μg m^{-3}), this study used a case-crossover analysis.

A recent study published in Brazil draws attention to the role of particulate matter in the genesis of respiratory diseases (Arbex et al., 2012).

The comparison of our results with those of other studies is difficult, because the approach of the mean length of stay is not a usual way to analyze the effects of exposure to air pollutants and pneumonia in children.

It should be considered that the findings of this study suggest an association between exposure to PM_{10} and admissions, but not necessarily a causal effect. Another point to consider is that other pollutants, also important, such as nitrogen oxides, volatile organic compounds and CO are not estimated by station São José dos Campos. It is important to remember the possibility of errors in coding of diagnoses and that hospitalizations might not be counted for those who used private health plans and health insurance. The source of the data analyzed in this study, Datasus, is an official source, having been used in other national studies mentioned before, despite this source have important accounting purposes.

Anyway, even with concentrations of PM_{10} at levels lower than those found in other studies, it was possible to identify its association with the length of hospitalizations in children under one year of age, in a medium-sized city. These results can be extended to other cities with similar characteristics to those of São José dos Campos, such as a major industrial park, a considerable vehicular fleet, and transected by roads with heavy traffic such as trucks and buses.

5. ACKNOWLEDGEMENT

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