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Air Pollution and Outpatient Treatment and Hospital Admissions for Respiratory Diseases in Children in Southeast Region of Brazil

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1. Introduction

The harmful effects of air pollution on human health have been observed in both overall mortality[1-9] and mortality from specific causes such as cardiovascular disease[10-16] or respiratory diseases[13,17-19]. Effects on morbidity have also been observed and include increases in respiratory symptoms in children, decreases in lung function[21-23], increase respiratory diseases[24,25], or simply an increase in school absenteeism[26,27]. More recently, several studies have used the number of hospitalizations as an indicator of the effects of pollution on health[28-34].

Considering the amount of research that have been produced in many countries, various issues, however, deserve further elucidation, for example, which pollutants would be more associated with the effects investigated or which individuals more susceptible to these hazardous exposures. A recent study that uses data from several cities showed that daily exposure to volatile pollutants appears to be associated with respiratory hospital admissions than exposure to particulate matter with a diameter of up to 10 microns (PM_{10})[35].

The effects of air pollutants seem to relate differently between men and women. Kotesovec and colleagues (2000)[36], observed a significant increase in daily mortality associated with increased levels of Total Solid Particulate (TSP) and SO_2 in men until 65 and not among women of similar age, while that for the population over 65 years the mortality significantly increased only among women. Zanobetti and Schwartz (2000)[37] showed that the effect of PM_{10} on mortality could be modified by gender, the curve of deaths among women 1/3 higher than that of men.

In relation to cancer, and more specifically to lung cancer, several studies have shown differences in the occurrence of this disease between urban and rural areas[38]. It is assumed that this difference can be attributed to different carcinogens in environmental pollutants, but the difficulty of confirming this hypothesis is due to the presence of other risk factors that also are implicated in the etiology of disease, including active and passive smoking and occupational exposures.

Dean (1966)[39] showed that the highest rates observed in urban areas remained even after controlling for age and the start of smoking. Several studies have compared the coefficients of lung cancer between areas with different pollution levels showed a slight increase in those most polluted.[38]

In Brazil, some studies showed the effects of air pollution on health, Pena and Dulchiade (1991)[40] comparing annual averages of particulate matter at the rates of infant mortality from pneumonia in several areas of the city of Rio de Janeiro and found a statistically significant association. In Sao Paulo, Saldiva and colleagues conducted two important studies [41.42] using time series, and have shown associations between mortality from respiratory diseases and levels of nitrogen oxides (NO_X) and mortality in the elderly and levels of particulate matter. More recently, the same group showed evidence of an association between intrauterine mortality and air pollution[43].

Regarding morbidity, Sobral (1989)[44], using a cross-sectional study compared the proportions of children with respiratory symptoms in two areas of Greater Sao Paulo with different levels of pollution and found a positive correlation. Cubatão differences were observed in lung function of children living in areas with varying levels of pollution [45]. Rumel and colleagues (1993)[46] studied the occurrence of visits to emergency services for acute myocardial infarction and found an association with levels of carbon monoxide (CO) and ambient temperature. In an experimental study, Reymão and colleagues (1997)[47] suggest that air pollution may facilitate the formation of certain types of lung cancer in rats.

However, the ecological character of some these studies, the lack of specificity regarding the age groups most susceptible and the various health effects, the short period of investigation (usually one year), which hampers control of temporal trends and the short careful control of meteorological variables, among other issues, prevented a better assessment of the effects of air pollution on health in the Brazilian context. Moreover, none of previous studies investigated the effects of pollution on hospital admissions, or tried to define the most vulnerable population subgroups.

Encouraged by these results, a series study covering a longer period of time (three years) was conducted with data from the city of Sao Paulo[48.49]. In these studies, special attention was given to the control of meteorological variables, and an investigation of different causes of death as well as in different age groups was made. Also, was first investigated the effect of pollution on morbidity of children through the examination of hospital admissions. An enhancement of 3.4% in the number of deaths from all causes (excluding violent deaths) and cardiovascular causes, compared to an increase in pollution levels from 10th to 90th percentile. For respiratory causes of the increase was 6%. Furthermore, it was observed that the effects of pollution on mortality alone were more prominent from age 65, having no effect on mortality for children or young adults. Moreover, hospital admissions for respiratory diseases in children under 5 years age group only investigated with regard to hospitalization, also showed an association with increases in daily levels of pollutants.

The aim of this study was to assess the association between exposure to daily records on air pollution concentrations emitted from the industrial and car emissions and the daily numbers of children outpatient and hospital admissions due to respiratory diseases under 6 years in public hospitals and the Universal Healthcare System in the urban area of Vitoria from 2001 to 2003, in individuals of the age groups considered most susceptible to air pollution in the city of Vitoria in Espirito Santo.

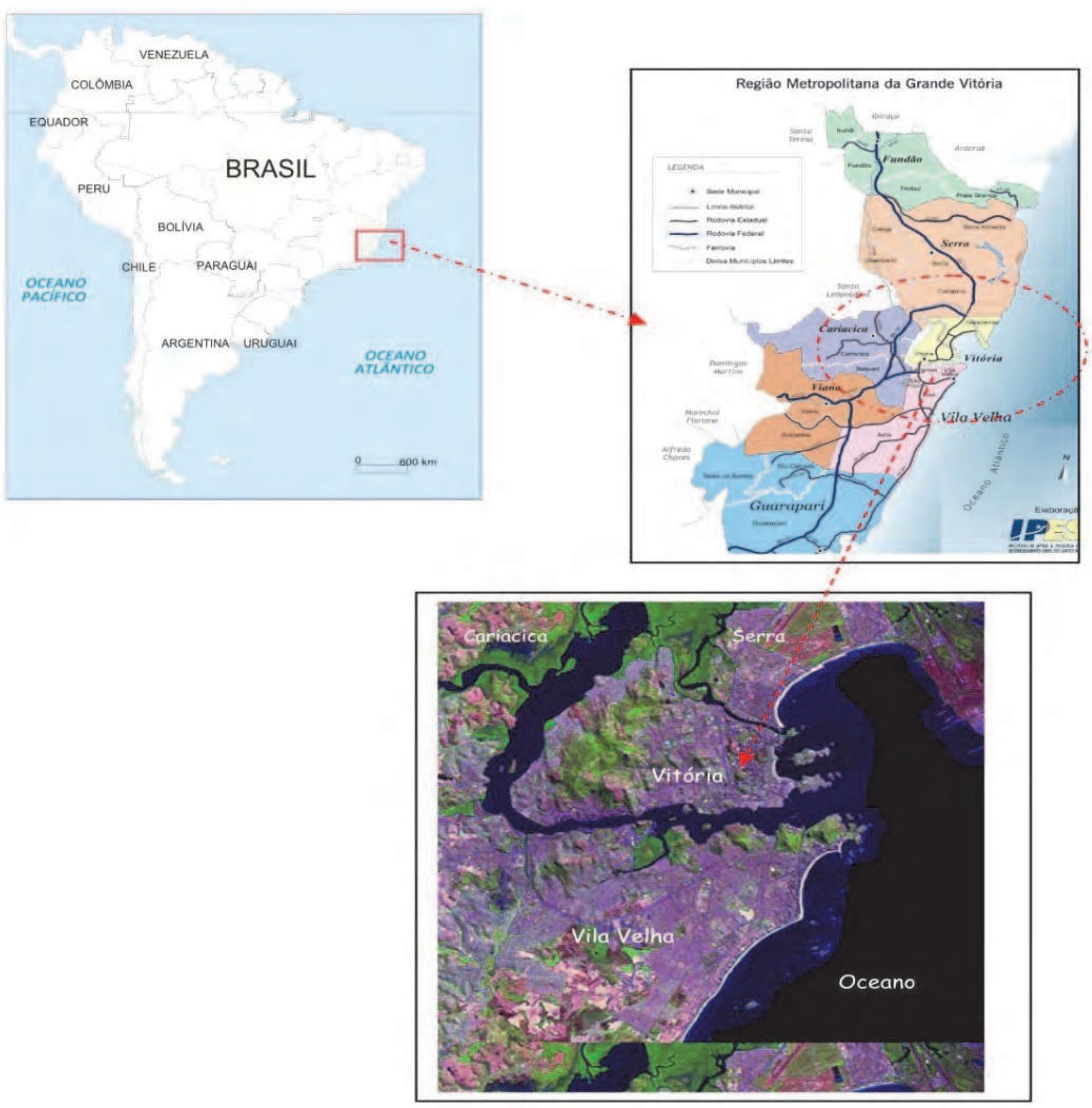
2. Methodology

2.1 Area and period of the study

Vitoria is located at latitude South 20°19′9″ and longitude West 40°20′50″ and borders on the cities of Serra to the North, Vila Velha to the South, Cariacica to the West, and the Atlantic Ocean to the East. It is an extension of continental land consisting of a mountainous island with the same name and several mangrove and salt marsh areas[50], resulting from the retreat of ocean levels.

There were 293,305 inhabitants in an area of 93km^2, corresponding to 3,154 inhabitants per square kilometer, with the highest population density in the State of Espirito Santo and some 50% of the State's entire industrial activity[51]

Vitoria has the second highest annual per capita income of all the Brazilian State capitals, with R$1,588.00, and a human development index (HDI) of 0.856.[52]



Source: Brazilian Institute of Geography and Statistics – IBGE. 2005

Fig. 1. Location of study area. City of Vitoria, Espirito Santo State, Brazil.

The daily records from the air quality monitoring program were provided by the State Environmental Secretariat (SEAMA) and State Environmental Institute (IEMA), and outpatient records on respiratory diseases were furnished by the Municipal Health Secretariat. Daily records on respiratory diseases were obtained from the Unified Productivity Bulletin (UPB), a registry used by 27 primary health units in the municipality of Vitoria, which is the only municipality that uses this kind of outpatient registry. Both data sets referred to January 1, 2001, to December 31, 2003. The UPB was established in the early 1990s with the aim of providing information related to population morbidity at outpatient services. This type of registry presents individual data on treatment in the primary health system. The information available contained date of consultation, patient's name, sex, date of birth, age, place of residence, and main diagnosis. The study analyzed respiratory diseases in general (J00-J99), pneumonia (J12-J18), and asthma (J45) for children under 6 years of age, based on the International Classification of Diseases, 10th Revision (ICD-10).
Despite the low frequency of missing observations in environmental databases, we used an imputation procedure. The purpose of the imputation was to minimize the loss of statistical precision of estimates of effects.
The air quality program is managed by the IEMA, which is responsible for five automatic monitoring stations that provided daily records of CO (8-hour averages), SO_2 (24-hour averages); particulate matter with an aerodynamic profile ≤ 10µg (PM10 – 24-hour averages); and O_3 and NO_2 (one-hour means), for Greater Vitoria. The IEMA also provides daily records on minimum, average, and maximum daily temperatures and relative humidity.
The daily air pollutant concentrations measured in Vitoria were compared to the National Environmental Council (CONAMA) standard 1990 [9] and WHO air quality guidelines for PM_{10}, SO_2, NO_2, and O^3 from 2005 [10].

2.2 Statistical analysis

Data analysis techniques were used usual time series analysis. For each outcome a model was estimated using semi-parametric class of generalized additive models (GAM)[53]. These models that allow both linear and nonlinear structures are introduced in the model. The implementation of the application GAM S-Plus was used. Each outcome was modeled initially took as its basic assumption that the distribution of counts of health events (visits, procedures or hospital admissions) follow a Poisson distribution.
The problem of over dispersion, a phenomenon in which the observed variance is larger than expected for the Poisson distribution, was treated using the quasi-likelihood estimation[54]. In analyzing the series of procedures nebulizer, the residual autocorrelation after adjustment for potential confounding factors available were modeled using Poisson regression for auto correlated data[55]. Robust regression was used to deal with too high or too low for the series of outcome[53].
The analysis strategy was to deal with seasonality and trend series using *splines* of the index of time, ie, the number of days elapsed since the series began. These smooth functions are flexible and are estimated from the data. We included indicator variables to control the effects of schedule - weekdays and holidays, which may modify the association between the pollutant and the response variable (outcome). It was also included in the model the effect of interactions of day of the weekend with an indicator variable for each quarter. This approach was employed because the heterogeneity of the occurrence of health events on

weekends in different seasons. Once it expects an increase in the number of hospitalizations due to influenza epidemics, the daily number of visits for *influenza* was introduced in a linear model.

The meteorological confounding factors were controlled through functions *splines* of temperature and humidity. Also introduced is a variable number of daily visits for all causes except respiratory and external causes, in order to control the residual variability in outcome due to series of problems that prevented the population's access to health services not covered by other variables[56].

Finally, add to the model of the baseline or *core model* terms corresponding to the studied pollutants (PM_{10}, SO_2, NO_2, CO and O_3) in a linear fashion. To construct the *core model*, after inclusion of each covariate were performed analysis of model fit via the periodogram or spectral analysis (to verify the presence of seasonal effects of medium and long term remaining), the autocorrelation function and partial autocorrelation function of the residual, testing normality of residuals (qq-plot) and eventually the Akaike information criterion (parsimony of the model) to decide between two or more models with similar diagnostic pictures.

3. Results

The biological manifestations of the effects of pollution on health appear to exhibit behavior that shows a lag in relation to the individual's exposure to pollutants. That is, events that occur on a given day may be associated with pollution levels that day and / or previous days. Thus, the daily values were tested for pollutants, lags of up to seven days and the average of two to seven days before the event as an indicator of cumulative exposure.

The results presented here represent the variations percentage in emergency procedures, mist or hospitalizations related to variations of 10 $\mu g / m^3$ in the levels of pollutants (except CO for which we calculated the percentage change in respect of 10 $\mu g/m^3$). The respective relative risks using the same convention are also presented. The adopted significance level of 5% in all analysis.

3.1 Descriptive analysis

3.1.1 Health events

Unified Productivity Bulletin-UPB

Table 1 presents the mean, standard deviation and percentiles for all outcomes analyzed. It is observed that the average child attended. There were no missing data for outcomes, but the first two days were excluded because there is no environmental data available. The number of valid observation was 1093.

	mean	SD	min	p5	p10	p25	p50	p75	p90	p95	max
DAR6	126.15	72.09	5.00	39.00	47.00	71.00	119.00	167.00	203.80	224.40	582.00
ASMA6	18.75	11.33	0.00	5.00	7.00	12.00	17.00	23.00	31.00	36.00	96.00
NEB6	80.67	46.54	0.00	20.00	25.20	43.00	74.00	111.00	146.00	166.40	237.00

Table 1. Descriptive statistics of health data BUP

The Figure 2 in Figure 3 show the temporal trends of the daily number of emergency visits for asthma (ASMA6) and respiratory diseases (DAR6) in children, respectively.

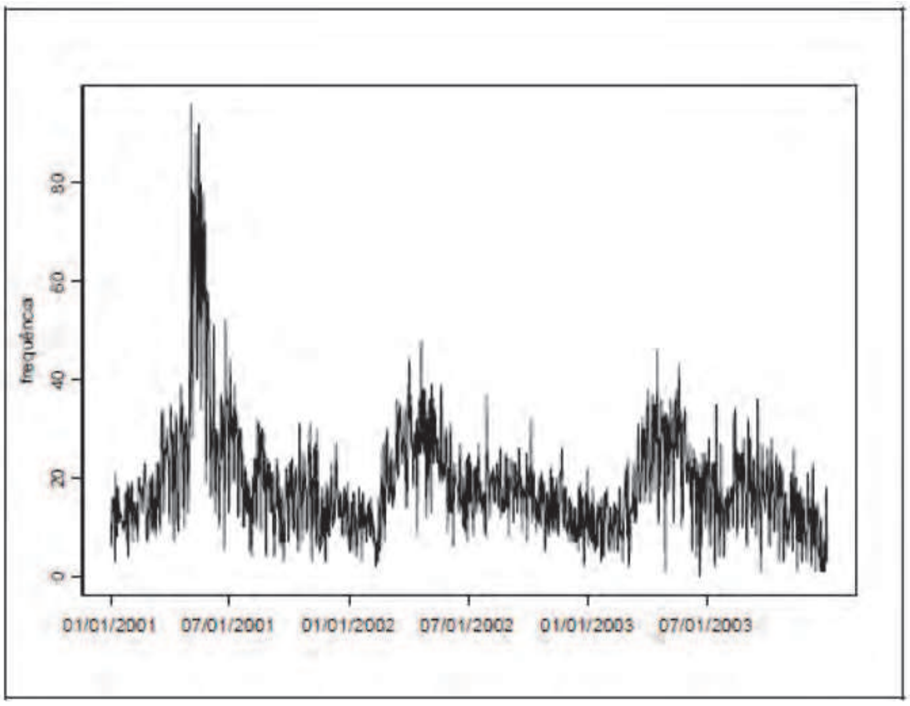


Fig. 2. Counts of daily visits for asthma in children under 6 years

The Figure 3 show the temporal evolution of the daily number of procedures performed in children nebulizer (NEB6).

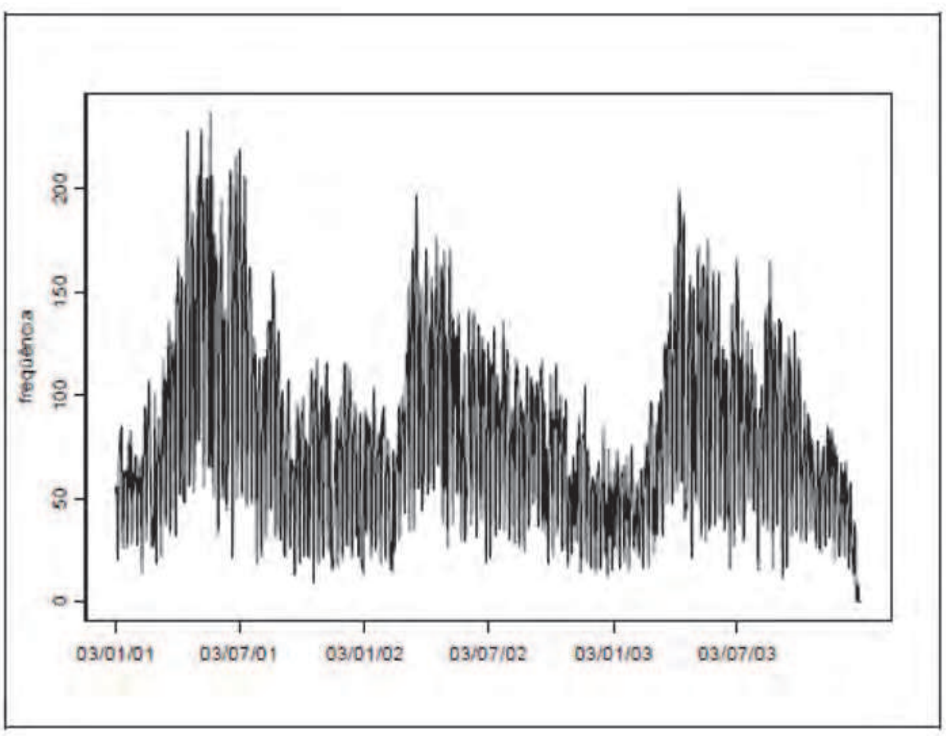


Fig. 3. Counts of daily procedures nebulization in children under 6 years

AIH

Table 2 shows the mean, standard deviation and percentiles for the number of daily hospital admissions for respiratory diseases in children (AIHDAR6), in the city of Victoria. The number of valid observations is 1093.

	mean	SD	min	p5	p10	p25	p50	p75	p90	p95	max
AIHDAR6	2.59	1.83	0.00	0.00	0.00	1.00	2.00	4.00	5.00	6.00	10.00

Table 2. Descriptive statistics of health data AIH

The Figure 4 show the temporal trends of the number of daily hospital admissions for respiratory diseases in children (AIHDAR6).

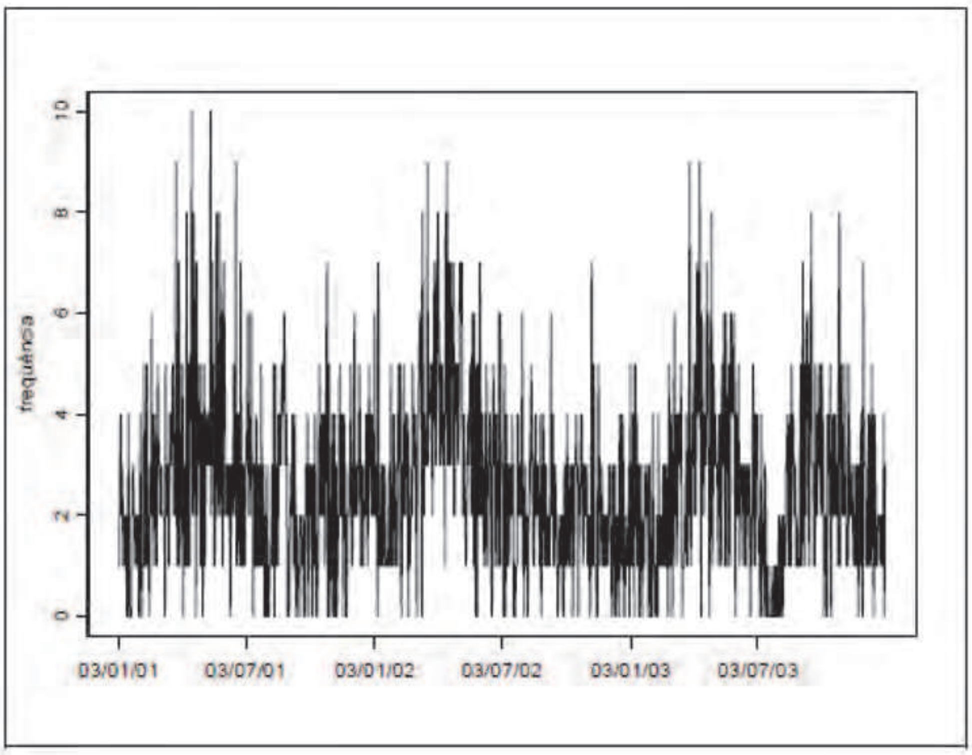


Fig. 4. Counts of daily admissions for respiratory diseases in children under 6 years

Meteorology

Table 3 shows the mean, standard deviation and percentiles for the meteorological variables: minimum temperature, average and maximum (degrees Celsius) and relative humidity (%). The number of valid observations is 1093.

	mean	SD	min	p5	p10	p25	p50	p75	p90	p95	max
Maximum temperature	28.47	3.12	19.65	23.15	24.35	26.05	28.70	30.85	32.55	33.25	35.60
Average temperature	24.17	2.35	17.91	20.41	21.07	22.19	24.28	26.15	27.28	27.66	28.84
Minimum temperature	20.88	2.31	15.00	16.80	17.70	19.00	21.10	22.85	23.70	24.05	25.75
Relative Humidity	77.36	6.01	57.98	68.58	70.26	72.98	77.00	81.45	85.87	88.33	95.63

Table 3. Descriptive statistics of meteorological data

The Figure 5 show the temporal trends of the average daily mean temperature and relative humidity. Each indicator is constructed by averaging the monitors in the city of Victoria.

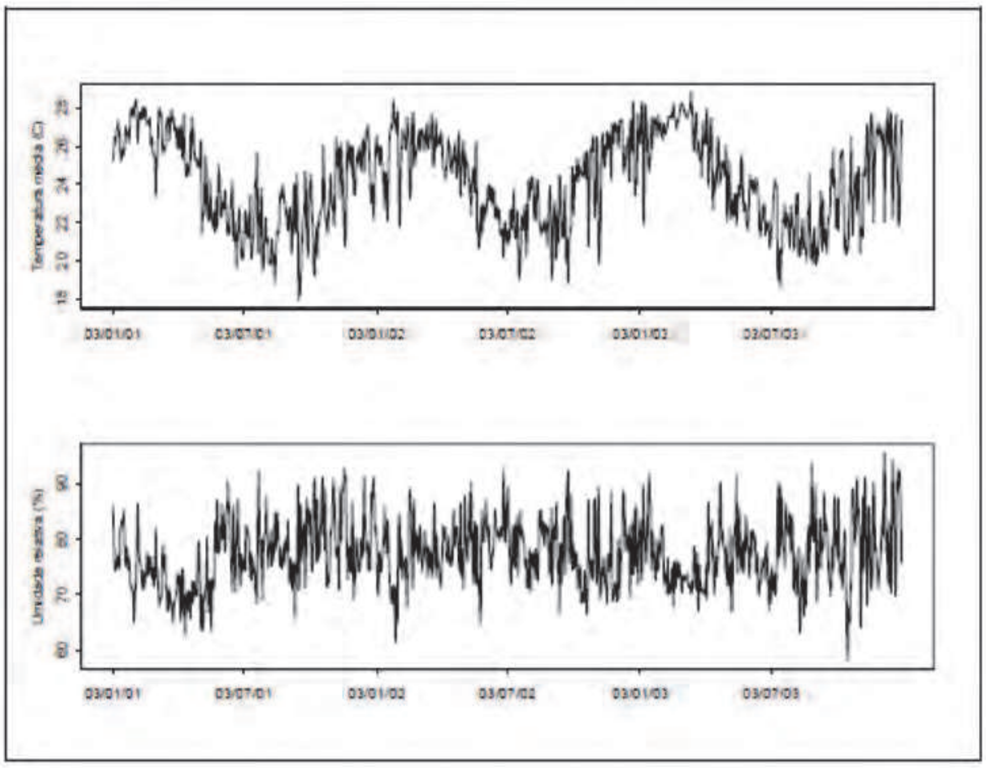


Fig. 5. Mean temperature and daily mean relative humidity for the period 2001- 2003

Pollutants

Table 4 shows the mean, standard deviation and percentiles of the concentrations of PM_{10}, SO_2, NO_2, CO and O_3, in g/m³. Following imputation, the number of observations used in the analysis was 1093.

	mean	SD	min	p5	p10	p25	p50	p75	p90	p95	max
PM	27.09	6.97	6.50	16.54	18.98	22.65	26.44	30.81	35.31	39.40	60.65
SO2	15.02	6.04	4.10	7.23	8.43	10.50	14.10	18.40	22.91	26.16	47.46
NO2	21.50	7.51	6.54	10.72	12.63	15.96	20.71	26.30	31.84	34.79	53.16
CO	1024.41	381.10	357.63	546.50	620.50	756.00	944.25	1223.75	1496.61	1710.63	3157.00
O3	38.89	13.58	10.25	21.35	23.53	28.50	37.00	46.75	57.25	64.23	97.50

Table 4. Descriptive statistics of the pollution data in the City of Vitoria.

The Figure 6, Figure 7, Figure 8, Figure 9 and Figure 10 show the temporal trends of daily concentrations of PM_{10}, SO_2, NO_2, CO and O_3, respectively. The average concentrations of these pollutants in the city of Victoria was not violated in any day primary or secondary standards for air pollution established by Brazilian CONAMA Resolution 003/90[55].

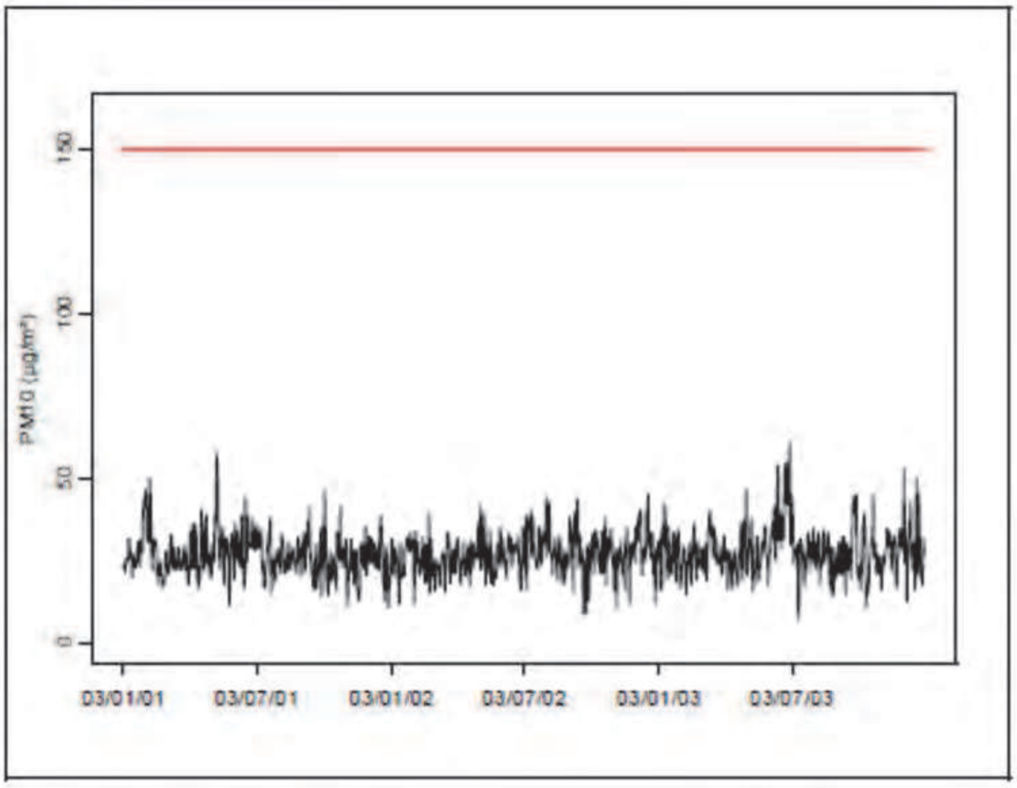


Fig. 6. Daily average concentrations of PM10 in the city of Victoria

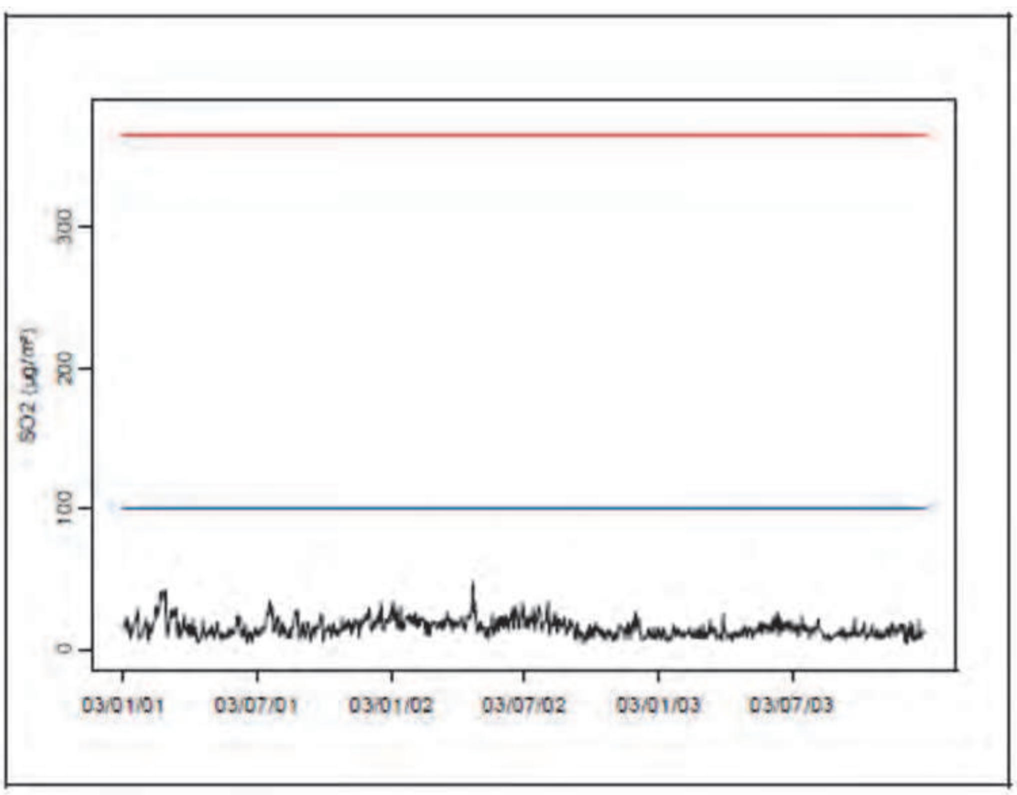


Fig. 7. Daily average concentrations of SO_2 in the city of Victoria

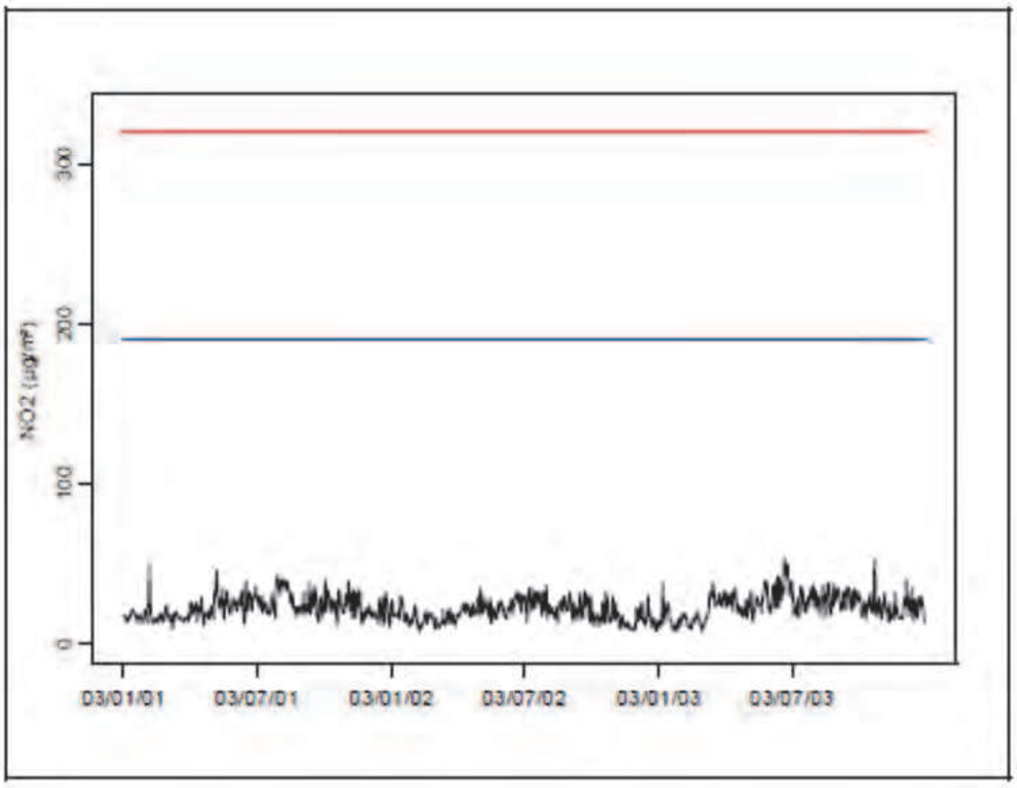


Fig. 8. Daily average concentrations of NO_2 in the city of Victoria

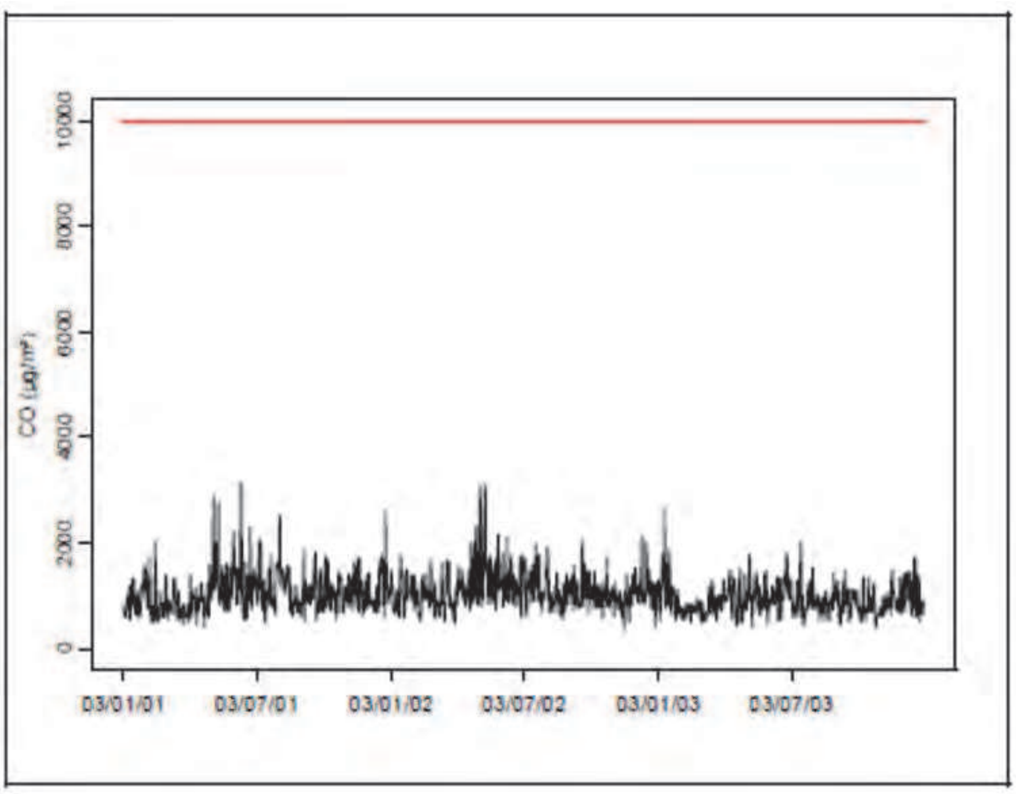


Fig. 9. Daily average concentrations of CO

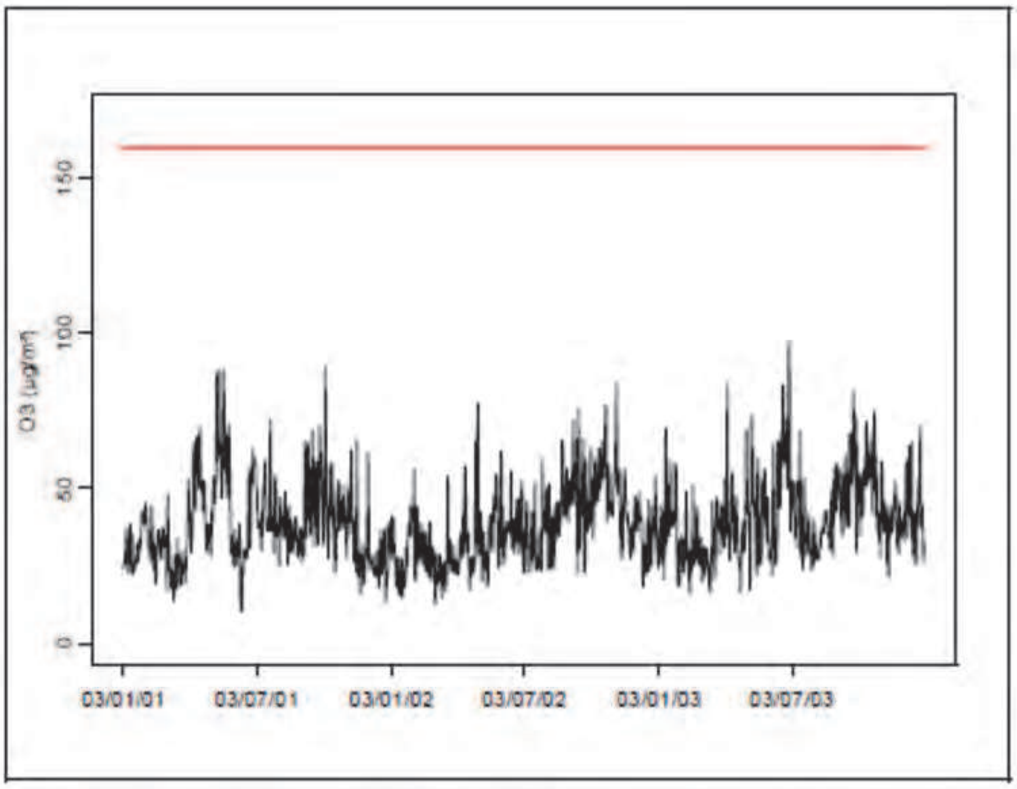


Fig. 10. Daily average concentrations of O_3

3.2 Effects of pollutants

3.2.1 Respiratory diseases

In Table 5 are shown the percentage changes and relative risks with confidence intervals of 95% for the outcome of respiratory diseases in children. We estimated a 2.1% increase in average daily number of outpatients increased to 10 µg / m³ PM_{10} exposure in a cumulative average of 7 days. NO_2 was estimated for a 2.6% increase in the number of attendances outpatients referring to an increase of 10 µg/m³. For O_3 was estimated to increase 1.4% for the exposure with a lag of 3 days and from 1.14% to 1.21% cumulative average exposure for 4-6 days.

Exposição a PM10	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.48	-0.821; 1.792	1.00	0.992; 1.018	0.473
lag of 1 day	0.44	-0.839; 1.740	1.00	0.992; 1.017	0.501
lag of 2 days	0.46	-0.859; 1.800	1.00	0.991; 1.018	0.495
lag of 3 days	0.17	-1.106; 1.471	1.00	0.989; 1.015	0.791
average of 2 days	0.66	-0.834; 2.174	1.01	0.992; 1.022	0.389
average of 3 days	0.85	-0.809; 2.544	1.01	0.992; 1.025	0.317
average of 4 days	0.85	-0.926; 2.650	1.01	0.991; 1.027	0.352
average of 5 days	1.22	-0.651; 3.121	1.01	0.993; 1.031	0.203
average of 6 days	1.77	-0.185; 3.769	1.02	0.998; 1.038	0.076
average of 7 days	2.09	0.050; 4.172	1.02	1.001; 1.042	0.045

Exposição a SO2	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	-0.98	-2.429; 0.483	0.99	0.976; 1.005	0.188
lag of 1 day	-0.15	-1.593; 1.313	1.00	0.984; 1.013	0.840
lag of 2 days	-0.08	-1.541; 1.398	1.00	0.985; 1.014	0.912
lag of 3 days	-1.08	-2.568; 0.430	0.99	0.974; 1.004	0.160
average of 2 days	-0.73	-2.298; 0.859	0.99	0.977; 1.009	0.365
average of 3 days	-0.63	-2.295; 1.053	0.99	0.977; 1.011	0.459
average of 4 days	-1.07	-2.813; 0.711	0.99	0.972; 1.007	0.238
average of 5 days	-0.95	-2.765; 0.906	0.99	0.972; 1.009	0.314
average of 6 days	-0.72	-2.602; 1.191	0.99	0.974; 1.012	0.456
average of 7 days	-0.98	-2.900; 0.978	0.99	0.971; 1.010	0.324
Exposição a NO2	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.78	-0.528; 2.097	1.01	0.995; 1.021	0.245
lag of 1 day	-0.16	-1.503; 1.207	1.00	0.985; 1.012	0.820
lag of 2 days	0.54	-0.924; 2.023	1.01	0.991; 1.020	0.473
lag of 3 days	0.72	-0.726; 2.185	1.01	0.993; 1.022	0.331
average of 2 days	0.44	-1.031; 1.936	1.00	0.990; 1.019	0.559
average of 3 days	0.67	-0.977; 2.347	1.01	0.990; 1.023	0.427
average of 4 days	0.99	-0.794; 2.807	1.01	0.992; 1.028	0.279
average of 5 days	1.44	-0.439; 3.352	1.01	0.996; 1.034	0.134
average of 6 days	1.92	-0.020; 3.900	1.02	1.000; 1.039	0.053
average of 7 days	2.64	0.645; 4.680	1.03	1.006; 1.047	0.009
Exposição a CO	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.00	-0.025; 0.023	1.00	0.975; 1.023	0.935
lag of 1 day	0.01	-0.019; 0.030	1.01	0.981; 1.030	0.669
lag of 2 days	-0.03	-0.049; - 0.004	0.97	0.952; 0.996	0.020
lag of 3 days	-0.02	-0.042; 0.005	0.98	0.959; 1.005	0.119
average of 2 days	0.00	-0.027; 0.033	1.00	0.974; 1.034	0.829
average of 3 days	-0.02	-0.054; 0.014	0.98	0.947; 1.014	0.243
average of 4 days	-0.03	-0.072; 0.003	0.97	0.930; 1.003	0.071
average of 5 days	-0.05	-0.090; - 0.010	0.95	0.914; 0.990	0.015
average of 6 days	-0.06	-0.098; - 0.014	0.95	0.906; 0.986	0.009
average of 7 days	-0.04	-0.085; 0.003	0.96	0.919; 1.003	0.070
Exposição O3	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.22	-0.500; 0.953	1.00	0.995; 1.010	0.546
lag of 1 day	0.22	-0.485; 0.926	1.00	0.995; 1.009	0.544
lag of 2 days	0.31	-0.398; 1.032	1.00	0.996; 1.010	0.388
lag of 3 days	1.44	0.740; 2.150	1.01	1.007; 1.022	0.000
average of 2 days	0.32	-0.497; 1.146	1.00	0.995; 1.011	0.442
average of 3 days	0.47	-0.420; 1.363	1.00	0.996; 1.014	0.303
average of 4 days	1.21	0.270; 2.151	1.01	1.003; 1.022	0.012
average of 5 days	1.18	0.212; 2.150	1.01	1.002; 1.022	0.017
average of 6 days	1.14	0.161; 2.128	1.01	1.002; 1.021	0.023
average of 7 days	0.94	-0.052; 1.937	1.01	0.999; 1.019	0.064

Table 5. Percentage change and relative risks for care per DAR6

Asthma

In Table 6, the estimated effects for the outcome of asthma in children. Estimated to increase from 3.9% to 6.1% in the average daily number of outpatients increased to 10 μg / m³ PM10 in an average cumulative exposure ranging from 4 to 7 days. NO2 was estimated for a 2.9% increase in the number of outpatient visits related to an increase of 10 μg / m³ exposure lagged 3 days and 3.7% to 5.8% for the cumulative exposure of 3 to 7 days. The effect of CO is less than 0.1%, very small although statistically significant. For O3 was estimated to increase 1.8% for the exhibition on the same day and from 2% to 3.5% cumulative average exposure for 2-7 days.

Exposição a PM10	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.57	-2.027; 3.235	1.01	0.980; 1.032	0.670
lag of 1 day	2.51	-0.078; 5.158	1.03	0.999; 1.052	0.058
lag of 2 days	2.06	-0.486; 4.673	1.02	0.995; 1.047	0.114
lag of 3 days	2.10	-0.462; 4.720	1.02	0.995; 1.047	0.109
average of 2 days	2.22	-0.786; 5.325	1.02	0.992; 1.053	0.149
average of 3 days	3.10	-0.195; 6.511	1.03	0.998; 1.065	0.066
average of 4 days	3.89	0.346; 7.550	1.04	1.003; 1.076	0.031
average of 5 days	4.98	1.213; 8.884	1.05	1.012; 1.089	0.009
average of 6 days	6.10	2.139; 10.219	1.06	1.021; 1.102	0.002
average of 7 days	5.92	1.797; 10.206	1.06	1.018; 1.102	0.005
Exposição a SO2	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	-2.33	-5.123; 0.551	0.98	0.949; 1.006	0.112
lag of 1 day	-1.55	-4.373; 1.365	0.98	0.956; 1.014	0.295
lag of 2 days	-3.33	-6.129; - 0.442	0.97	0.939; 0.996	0.024
lag of 3 days	-5.02	-7.824; - 2.122	0.95	0.922; 0.979	0.001
average of 2 days	-2.47	-5.492; 0.653	0.98	0.945; 1.007	0.120
average of 3 days	-3.66	-6.842; - 0.379	0.96	0.932; 0.996	0.029
average of 4 days	-5.32	-8.603; - 1.927	0.95	0.914; 0.981	0.002
average of 5 days	-6.13	-9.512; - 2.632	0.94	0.905; 0.974	0.001
average of 6 days	-6.37	-9.828; - 2.777	0.94	0.902; 0.972	0.001
average of 7 days	-7.28	-10.794; - 3.625	0.93	0.892; 0.964	0.000
Exposição a NO2	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	1.94	-0.947; 4.915	1.02	0.991; 1.049	0.190
lag of 1 day	2.64	-0.330; 5.694	1.03	0.997; 1.057	0.082
lag of 2 days	1.71	-1.102; 4.599	1.02	0.989; 1.046	0.236
lag of 3 days	2.90	0.143; 5.739	1.03	1.001; 1.057	0.039
average of 2 days	3.27	-0.069; 6.711	1.03	0.999; 1.067	0.055
average of 3 days	3.71	0.118; 7.428	1.04	1.001; 1.074	0.043
average of 4 days	4.86	1.067; 8.788	1.05	1.011; 1.088	0.012
average of 5 days	4.82	0.928; 8.871	1.05	1.009; 1.089	0.015
average of 6 days	5.07	1.079; 9.217	1.05	1.011; 1.092	0.012
average of 7 days	5.78	1.689; 10.031	1.06	1.017; 1.100	0.005

Exposição a CO	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.03	-0.020; 0.074	1.03	0.981; 1.076	0.256
lag of 1 day	0.06	0.018; 0.111	1.07	1.018; 1.117	0.007
lag of 2 days	-0.01	-0.058; 0.028	0.99	0.943; 1.029	0.502
lag of 3 days	0.01	-0.035; 0.052	1.01	0.966; 1.054	0.691
average of 2 days	0.08	0.020; 0.137	1.08	1.020; 1.147	0.009
average of 3 days	0.06	-0.010; 0.121	1.06	0.990; 1.129	0.097
average of 4 days	0.06	-0.011; 0.133	1.06	0.989; 1.143	0.099
average of 5 days	0.05	-0.026; 0.129	1.05	0.974; 1.138	0.196
average of 6 days	0.02	-0.060; 0.104	1.02	0.941; 1.110	0.602
average of 7 days	0.07	-0.018; 0.155	1.07	0.982; 1.167	0.120
Exposição O3	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	1.76	0.331; 3.205	1.02	1.003; 1.032	0.016
lag of 1 day	1.07	-0.321; 2.479	1.01	0.997; 1.025	0.132
lag of 2 days	1.02	-0.324; 2.384	1.01	0.997; 1.024	0.138
lag of 3 days	2.56	1.222; 3.912	1.03	1.012; 1.039	0.000
average of 2 days	2.00	0.389; 3.643	1.02	1.004; 1.036	0.015
average of 3 days	2.20	0.491; 3.944	1.02	1.005; 1.039	0.012
average of 4 days	3.21	1.426; 5.034	1.03	1.014; 1.050	0.000
average of 5 days	3.45	1.610; 5.321	1.03	1.016; 1.053	0.000
average of 6 days	3.34	1.470; 5.244	1.03	1.015; 1.052	0.000
average of 7 days	3.20	1.305; 5.130	1.03	1.013; 1.051	0.001

Table 6. Percentage change and relative risks for care per ASMA6

Table 7 Estimated effects for the outcome nebulization in children. We estimated an increase of 2% and 2.3% for the exhibition on the same day and with a lag of 3 days respectively, and 3.1% to 3.6% for the cumulative exposure from 4 to 7 days in the average number daily for an increase of 10 µg/m³ PM_{10}. For NO_2 was estimated to increase from 2.9% to the cumulative exposure of 7 days. For O_3 was estimated to increase from 1.8% to the exposure with a lag of 2 days and 1.4% cumulative average exposure for 4 days.

Exposição a PM10	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	1.98	0.043; 3.957	1.02	1.000; 1.040	0.045
lag of 1 day	0.21	-1.713; 2.173	1.00	0.983; 1.022	0.831
lag of 2 days	1.46	-0.435; 3.401	1.01	0.996; 1.034	0.132
lag of 3 days	2.31	0.426; 4.236	1.02	1.004; 1.042	0.016
average of 2 days	1.50	-0.750; 3.792	1.01	0.993; 1.038	0.194
average of 3 days	2.11	-0.342; 4.625	1.02	0.997; 1.046	0.093
average of 4 days	3.14	0.515; 5.826	1.03	1.005; 1.058	0.019
average of 5 days	3.59	0.823; 6.430	1.04	1.008; 1.064	0.011
average of 6 days	3.63	0.742; 6.607	1.04	1.007; 1.066	0.014
average of 7 days	3.36	0.354; 6.452	1.03	1.004; 1.065	0.028

Exposição a SO2	RR	IC (95%)	RR	IC (95%)	p-valor
current day	-0.57	-2.673; 1.585	0.99	0.973; 1.016	0.603
lag of 1 day	-0.92	-3.000; 1.203	0.99	0.970; 1.012	0.393
lag of 2 days	-0.60	-2.691; 1.530	0.99	0.973; 1.015	0.577
lag of 3 days	-0.35	-2.487; 1.831	1.00	0.975; 1.018	0.750
average of 2 days	-0.96	-3.226; 1.349	0.99	0.968; 1.013	0.411
average of 3 days	-1.09	-3.478; 1.348	0.99	0.965; 1.013	0.377
average of 4 days	-1.11	-3.608; 1.445	0.99	0.964; 1.014	0.390
average of 5 days	-1.38	-3.956; 1.269	0.99	0.960; 1.013	0.305
average of 6 days	-2.07	-4.717; 0.641	0.98	0.953; 1.006	0.133
average of 7 days	-2.77	-5.462; - 0.011	0.97	0.945; 1.000	0.049
Exposição a NO2	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.82	-1.258; 2.932	1.01	0.987; 1.029	0.444
lag of 1 day	1.59	-0.549; 3.772	1.02	0.995; 1.038	0.147
lag of 2 days	1.71	-0.342; 3.808	1.02	0.997; 1.038	0.103
lag of 3 days	1.63	-0.370; 3.663	1.02	0.996; 1.037	0.111
average of 2 days	1.62	-0.751; 4.042	1.02	0.992; 1.040	0.183
average of 3 days	2.38	-0.177; 4.996	1.02	0.998; 1.050	0.069
average of 4 days	2.93	0.247; 5.684	1.03	1.002; 1.057	0.032
average of 5 days	2.60	-0.155; 5.427	1.03	0.998; 1.054	0.065
average of 6 days	2.57	-0.262; 5.476	1.03	0.997; 1.055	0.076
average of 7 days	2.36	-0.529; 5.340	1.02	0.995; 1.053	0.111
Exposição a CO	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.00	-0.030; 0.040	1.00	0.971; 1.040	0.781
lag of 1 day	0.00	-0.036; 0.036	1.00	0.964; 1.037	0.990
lag of 2 days	0.02	-0.018; 0.050	1.02	0.982; 1.051	0.356
lag of 3 days	-0.03	-0.063; 0.003	0.97	0.939; 1.003	0.079
average of 2 days	0.00	-0.040; 0.048	1.00	0.961; 1.049	0.860
average of 3 days	0.02	-0.034; 0.066	1.02	0.966; 1.069	0.529
average of 4 days	-0.01	-0.061; 0.049	0.99	0.941; 1.051	0.837
average of 5 days	0.00	-0.057; 0.062	1.00	0.945; 1.064	0.937
average of 6 days	-0.01	-0.069; 0.056	0.99	0.934; 1.058	0.844
average of 7 days	-0.02	-0.082; 0.046	0.98	0.921; 1.047	0.584
Exposição O3	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.38	-0.670; 1.432	1.00	0.993; 1.014	0.483
lag of 1 day	-0.44	-1.502; 0.642	1.00	0.985; 1.006	0.427
lag of 2 days	1.82	0.803; 2.842	1.02	1.008; 1.028	0.000
lag of 3 days	0.99	-0.003; 1.990	1.01	1.000; 1.020	0.051
average of 2 days	-0.05	-1.252; 1.174	1.00	0.987; 1.012	0.940
average of 3 days	1.05	-0.234; 2.358	1.01	0.998; 1.024	0.110
average of 4 days	1.40	0.071; 2.755	1.01	1.001; 1.028	0.039
average of 5 days	1.06	-0.299; 2.434	1.01	0.997; 1.024	0.127
average of 6 days	0.92	-0.451; 2.307	1.01	0.995; 1.023	0.190
average of 7 days	0.87	-0.515; 2.281	1.01	0.995; 1.023	0.219

Table 7. Percentage change and risks relating to procedures NEB6

Hospitalizations

Table 8 Estimated effects presented for the outcome of hospital admissions of children. Statistically significant effect was found only for O_3. Estimated to increase by 3.2% and 4% for exposure lagged by 1 and 3 days, respectively, and 4.3% to 7.9% average cumulative exposure for 2-7 days, referring to an increase of 10 μg/m³ of O_3. Despite the impact of high frequency of occurrence of this outcome in the population is low.

Exposição a PM10	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	1.06	-4.675; 7.133	1.01	0.953; 1.071	0.724
lag of 1 day	3.14	-2.755; 9.390	1.03	0.972; 1.094	0.303
lag of 2 days	1.00	-4.845; 7.208	1.01	0.952; 1.072	0.743
lag of 3 days	1.32	-4.410; 7.388	1.01	0.956; 1.074	0.659
average of 2 days	3.00	-3.793; 10.263	1.03	0.962; 1.103	0.396
average of 3 days	3.13	-4.398; 11.259	1.03	0.956; 1.113	0.425
average of 4 days	3.44	-4.569; 12.121	1.03	0.954; 1.121	0.411
average of 5 days	3.90	-4.539; 13.076	1.04	0.955; 1.131	0.377
average of 6 days	5.46	-3.481; 15.219	1.05	0.965; 1.152	0.240
average of 7 days	6.00	-3.351; 16.262	1.06	0.966; 1.163	0.216
Exposição a SO2	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	2.09	-4.161; 8.739	1.02	0.958; 1.087	0.522
lag of 1 day	1.33	-4.870; 7.928	1.01	0.951; 1.079	0.682
lag of 2 days	3.27	-3.026; 9.975	1.03	0.970; 1.100	0.316
lag of 3 days	-2.76	-8.797; 3.667	0.97	0.912; 1.037	0.391
average of 2 days	2.16	-4.583; 9.384	1.02	0.954; 1.094	0.540
average of 3 days	3.37	-3.795; 11.069	1.03	0.962; 1.111	0.366
average of 4 days	1.69	-5.663; 9.609	1.02	0.943; 1.096	0.662
average of 5 days	1.31	-6.257; 9.498	1.01	0.937; 1.095	0.742
average of 6 days	-0.32	-8.006; 8.000	1.00	0.920; 1.080	0.937
average of 7 days	-0.96	-8.780; 7.536	0.99	0.912; 1.075	0.819
Exposição a NO2	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	0.26	-5.870; 6.780	1.00	0.941; 1.068	0.937
lag of 1 day	5.53	-0.834; 12.299	1.06	0.992; 1.123	0.090
lag of 2 days	0.45	-5.609; 6.888	1.00	0.944; 1.069	0.889
lag of 3 days	2.28	-3.649; 8.584	1.02	0.964; 1.086	0.459
average of 2 days	3.86	-3.184; 11.408	1.04	0.968; 1.114	0.291
average of 3 days	3.39	-4.088; 11.454	1.03	0.959; 1.115	0.384
average of 4 days	4.09	-3.740; 12.563	1.04	0.963; 1.126	0.315
average of 5 days	2.87	-5.068; 11.474	1.03	0.949; 1.115	0.490
average of 6 days	3.28	-4.869; 12.118	1.03	0.951; 1.121	0.442
average of 7 days	3.22	-5.076; 12.247	1.03	0.949; 1.122	0.458

Exposição a CO	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	-0.06	-0.159; 0.044	0.94	0.853; 1.045	0.270
lag of 1 day	-0.02	-0.126; 0.076	0.98	0.882; 1.079	0.630
lag of 2 days	-0.02	-0.125; 0.083	0.98	0.883; 1.086	0.692
lag of 3 days	-0.09	-0.195; 0.013	0.91	0.823; 1.013	0.086
average of 2 days	-0.07	-0.189; 0.058	0.94	0.828; 1.060	0.300
average of 3 days	-0.08	-0.217; 0.066	0.93	0.804; 1.068	0.295
average of 4 days	-0.14	-0.298; 0.017	0.87	0.742; 1.017	0.081
average of 5 days	-0.19	-0.360; - 0.020	0.83	0.697; 0.981	0.029
average of 6 days	-0.20	-0.379; - 0.020	0.82	0.684; 0.980	0.030
average of 7 days	-0.17	-0.352; 0.020	0.85	0.703; 1.021	0.081
Exposição O3	%RR	IC (95%)	RR	IC (95%)	p-valor
current day	3.02	-0.010; 6.145	1.03	1.000; 1.061	0.051
lag of 1 day	3.22	0.159; 6.379	1.03	1.002; 1.064	0.039
lag of 2 days	2.99	-0.076; 6.154	1.03	0.999; 1.062	0.056
lag of 3 days	4.04	1.053; 7.124	1.04	1.011; 1.071	0.008
average of 2 days	4.35	0.864; 7.963	1.04	1.009; 1.080	0.014
average of 3 days	5.30	1.510; 9.233	1.05	1.015; 1.092	0.006
average of 4 days	6.55	2.580; 10.667	1.07	1.026; 1.107	0.001
average of 5 days	7.34	3.257; 11.594	1.07	1.033; 1.116	0.000
average of 6 days	7.94	3.783; 12.261	1.08	1.038; 1.123	0.000
average of 7 days	7.91	3.699; 12.294	1.08	1.037; 1.123	0.000

Table 8. Percentage change and relative risks for hospitalizations DAR6

4. Conclusion

Descriptive analysis of indicators of air pollution in the city of Victoria shows that, on average, these indicators did not exceed the primary standard or secondary air quality proposed by the World Health Organization (WHO) and by CONAMA 003/90[55]. However, even when the pollution levels are considered acceptable, it was possible to detect adverse health effects of some pollution indicators studied. These deleterious effects are observed on increasing the average daily number of outpatient procedures, hospitalizations in the mist and more susceptible populations, children residents in the city of Victoria.

The results of this study indicate the existence of statistical association between daily concentrations of air pollutants and daily average number of outpatient procedures, hospitalizations and mist in populations of children residents in the city of Victoria. This finding implies that some of these illnesses tracks stocks in the region may have been caused by air pollution. The pollutants whose effects were statistically significant were the PM_{10}, O_3 and NO_2.

The frequency of occurrence of hospital admissions in the population of the city of victory is very low, as shown in Table 2, and therefore, effects of great magnitude had low impact on the population.

The damage to the respiratory system due to exposure to air pollutants is the result of combined effects of all pollutants present in complex mix of air pollution. The results associated with PM_{10} and O_3 are consistent with the pathophysiology of these two pollutants. Both in an early act as primary irritant of the respiratory tract and may cause increased bronchial reactivity and symptoms of bronchospasm. Local inflammatory signs emerge that usually prevail over those of bronchospasm[61]. The combination of possible respiratory effects at two different times may explain a greater number of medical visits on the same day and some days after the increase in the levels of pollutants.

In studies whose outcome variable is the pediatric emergency medical care, considering lags of one or more days between exposure and demand for health services, several factors must be considered. One is the motivation of parents or guardians to seek pediatric clinics that depends, among other reasons, concern about the health of the child[57], the knowledge of the meanings and possible worsening of respiratory signs and symptoms and also the possibility to attend a health facility.

The clinical effects of environmental pollutants on the respiratory system vary according to factors related to the pollutants and exposed individuals. Children less sensitive when exposed to low environmental concentrations have mild symptoms and few clinical implications and do not require medical attention. It is reasonable to assume that the estimated effect is smaller than one would estimate that if these children had sought a health service. With low levels of air pollution observed was not expected a high number of severe cases, but a large number of milder cases.

The results of this study are consistent with those of studies conducted in other cities in the world using similar methodology. However, the health information system used, the Unified Productivity Bulletin (BUP) available in the city of Victoria, have not been fully validated. It is therefore necessary to consider that bias resulting from lack of validity of information may be operating in the study population. It is therefore reasonable to consider that the accuracy of this study is subject to a validation study of BUP.

5. Acknowledgments

This study received financial support from the Strategic Development Program at the Sergio Arouca National School of Public Health, Oswaldo Cruz Foundation (ENSP/FIOCRUZ), in partnership with the Vitória Municipal Health Secretaria. The State Environmental Secretariat (SEAMA) and State Environmental Institute (IEMA) provided the air quality database, with technical support from Nilson Castiglioni Júnior and José Gustavo da Costa. The authors wish to acknowledge the logistic field support provided by the State Health Secretariat through Maria de Fátima Bertollo Dettoni and Diana de Oliveira Frauches. The authors also acknowledge the collaboration and technical support from the Health Surveillance Secretariat of the Brazilian Ministry of Health.

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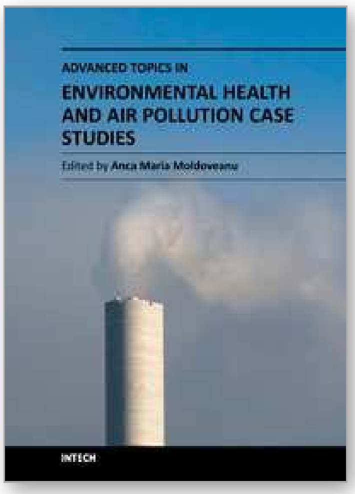

Advanced Topics in Environmental Health and Air Pollution Case Studies

Edited by Prof. Anca Moldoveanu

ISBN 978-953-307-525-9
Hard cover, 470 pages
Publisher InTech
Published online 29, August, 2011
Published in print edition August, 2011

The book describes the effects of air pollutants, from the indoor and outdoor spaces, on the human physiology. Air pollutants can influence inflammation biomarkers, can influence the pathogenesis of chronic cough, can influence reactive oxygen species (ROS) and can induce autonomic nervous system interactions that modulate cardiac oxidative stress and cardiac electrophysiological changes, can participate in the onset and exacerbation of upper respiratory and cardio-vascular diseases, can lead to the exacerbation of asthma and allergic diseases. The book also presents how the urban environment can influence and modify the impact of various pollutants on human health.

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