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# Evaluation of the Influence of Air Pollution on Hospitalizations for Respiratory Diseases in Divinópolis, Brazil

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**Abstract:** With the increasing urbanization and industrialization of developing countries, there is an imminent need for pollution control in its various sources. The present study aims to evaluate the interference of air pollution in the number of hospitalizations due to respiratory problems in the city of Divinópolis, Minas Gerais. This municipality is located in southeastern Brazil, with about 230 thousand inhabitants, of which 97.42% live in the urban area, according to IBGE data. Secondary data on the concentration of suspended particulate matter (monitored in five Hi-Vol volume devices, maintained by the municipal public power and distributed in the urban area), were used in this study, climatologic data such as humidity, temperature and wind speed (from the municipal airport station) and hospital admissions (obtained from the DATASUS system, electronic website of the Unified Health System). Hospital admission data were categorized into the following categories: total admissions, for asthma and bronchitis. All data obtained, with monthly frequency, were included between January 2000 and December 2014, totaling 180 months of evaluation. The data were submitted to statistical analysis of Pearson correlation, using SPSS software 20 (Statistical Package for Social Studies). The correlation between hospitalizations and particulate matter was moderate (0.353) as well as between admissions and temperature and humidity (0.329). At the end of this research, we intend to obtain the relation between these several parameters through the Generalized Linear Model, integrating all the variables that obtain the moderate or high Pearson correlation.

**Key words:** respiratory diseases, air pollution, particulate matter

## 1. Introduction

Recently many epidemiological studies have discussed the correlation between particulate matter and its diverse effects on human health. The particulate matter is subdivided into groups categorized by the size of their particles, which determine their polluting potential on exposed organisms [1]. Studies have shown that particulate matter suspended in the atmosphere can cause various health damages, causing respiratory and circulatory system morbidities, the main ones being people with preexisting diseases, the elderly and children [2, 3]. The World Health Organization has stated that there are no safe levels of exposure to particulate matter, and their presence is hazardous in any concentration [2].

In Brazil, the level of urbanization has increased considerably, reaching 86.53% of the national population living in the cities and only 13.47% living in the rural area [4]. As is well known, the urban environment has a large potential for pollution, due to the presence of industries, which emit gaseous effluents and other waste in the atmosphere, traffic, which contributes to the emission of suspended particles, and eventually soil and dust suspended due to the presence of roads [3, 5].

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The present study provides an analysis of the correlation between air pollution (in the form of suspended particulate matter and inhalable particles) and hospitalizations of children (individuals under 14 years of age) in the public health system in the city of Divinópolis, Brazil.

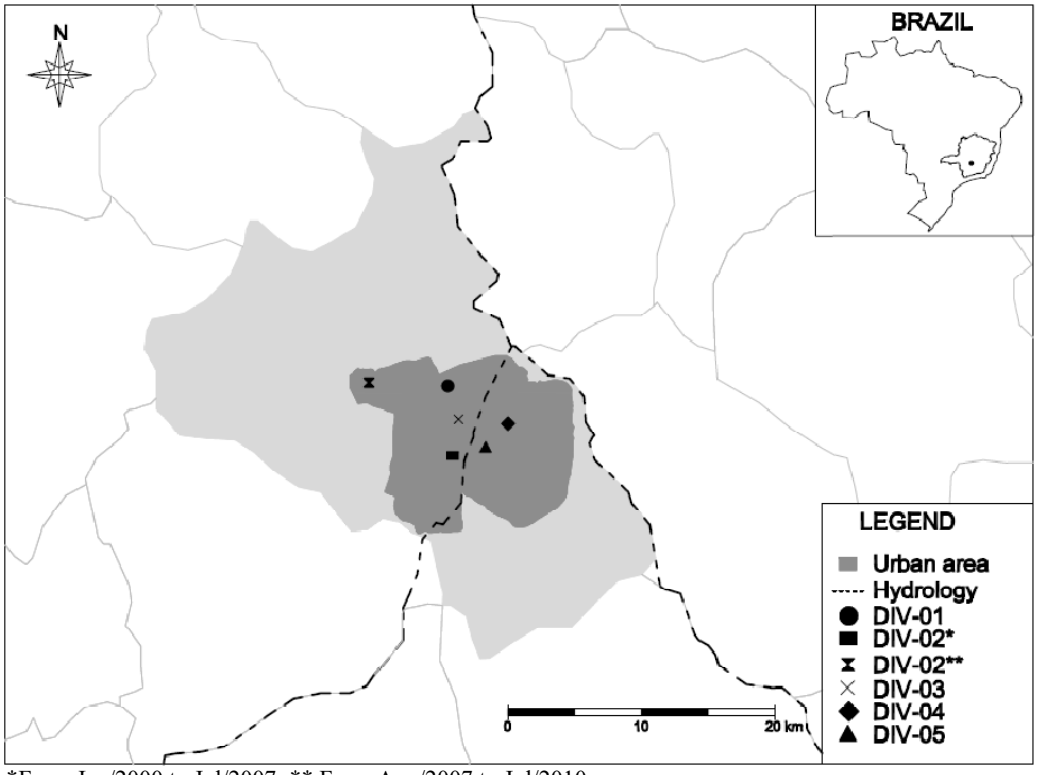
The analyzed municipality is located in southeastern Brazil, with about 213 thousand inhabitants, of which 97.42% are in the urban zone [4] and has a very diversified economic activity, but has in the steel industry its main source of collection and volume related services. The exhaust system of the steelworks and the traffic of the municipality, with about 53,000 vehicles in total [6], are potential sources of pollution in the region.

According to epidemiological studies, urban vehicle traffic is correlated to TSP release into the atmosphere, generated mainly by abrasion in vehicle braking time [7-9]. The fine particles can be generated from a variety of sources, including, as mentioned earlier, by the steel mill chimneys. As described in some authors, TSP and IP10 may be associated with various breathing problems, such as bronchitis and asthma [10]. These same studies also show that the child population is more susceptible to the effects of this form of pollution since the rate of air absorption of their lung bronchi is bigger because they are in a physical growth period.

The objective of this paper is to provide a case study where it is possible to correlate data from a wide period of analysis on total suspended particles (TSP) and inhalable particles (IP10) with respiratory system related morbidities in children (0-14 years) residing in the municipality.

## 2. Materials and Methods

PTS sampling was carried out in four different city points (Fig. 1) every week from January 2000 to July 2014, in samplers belonging to the secretariat through municipal environment. In July 2007, the station named DIV-02 was transferred to the northwest urban area for administrative reasons.




*From Jan/2000 to Jul/2007; ** From Aug/2007 to Jul/2010

**Fig. 1 Location of samplers in the city of Divinópolis, Brazil.**

Already sampling IP10 was carried out in the southeast of the urban area, site of intense industrial activity. The measurements were performed in 24-hour periods at all points for both parameters (TSP and IP10), and geometric means were used to determine the mean weekly and monthly concentration.

The PTS's samples were obtained using samplers large volume model AGVMP101 (Energética Air Quality Inc.) common filter 203 mm × 254 mm made of glass fiber, and flow controllers 1.13 $m^3.min^{-1}$ giving a precision of 1 $ug.m^{-3}$ in a period of 24 h. Since IP10 was measured by a continuous sampler model FH62C14 particles of Thermo Fisher Scientific Inc., which analyzes particles between 10 and 1 $\mu m$ in diameter. It works by attenuating beta rays in a glass fiber filter tape at a flow rate of 1 $m^3.h^{-1}$.

Data on hospital admissions were collected in the national database of the single health system (DATASUS) maintained by the Brazilian Ministry of Health. This system is composed of data sent from health posts and hospitals about hospitalizations registered in the SUS, the Brazilian public health system. These data are categorized according to the International Classification of Diseases (ICD-10) and in this study we considered hospitalizations of children (0-14 years) in the municipality, who presented worsening of symptoms of asthma, acute bronchitis, chronic sinusitis and hospitalizations due to general respiratory problems, for the data collected are only validated between January 2000 and December 2014, totalling 180 months of data in order to guarantee analyzes with relative statistical significance.

The municipality has a weather station managed by the local public authority, which was responsible for providing data together with the INMET (National Meteorological Institute, 2018) [11] website; maximum and minimum temperature, relative humidity, isolation, average wind speed and precipitation in the period analyzed by this research, which were used for the correlation with hospital admissions together with atmospheric pollution.

For the elaboration of a statistical correlation, it was necessary to assign different weights for each region influenced by a particulate sampler. This is justified by the different demographic densities in each region of the city.

Statistical analyses of the data were performed by two tests: bivariate correlation and a generalized linear model according to previous studies by Tabaku [12] and Moshammer [13]. The statistical treatment of data, as well as the application of a linear additive model, was performed using the SPSS 20 (Statistical Package for Social Studies).

Through SPSS was further performed on the Pearson correlation [14] for the external variables therethrough are determined to be the most relevant agents for the creation of the algorithm.

The logarithm was created following the linear log of Poisson, which was done according to previous studies and previous studies in order to reveal the most important factor when crossing the data between the number of hospitalizations, external variables and the amount of IP10 and TSP found in the samplers.

The analysis of the variables by linear Poisson log showed a relation that follows the model defined by Eq. (1):

$$\log G = \beta 0 + \beta 1\, Z1 + \beta 2\, Z2 + \beta 3\, Z3 = + \beta 4\, Z4 \quad (1)$$

At where:

G: Number of hospitalizations for respiratory diseases;

$\beta 0$: Intercept;

$\beta 1, \beta 2, \beta 3, \beta 4$: Prediction values for interaction with the dependent variable (G);

$Z1$: Categorical variable that represents the concentration of Total Suspended Particles;

$Z2$: Categorical variable that represents the concentration of Inhalable Particles;

$Z3$: Categorical variable that represents the Relative Humidity of the Monthly Average Air;

$Z4$: Categorical variable that represents the Minimum Average Monthly Temperature.

## 3. Results and Discussion

### *3.1 TSP and IP10*

The concentration distribution along the analysis period is arranged in the graph of Fig. 2, besides the statistical boxplot described in Fig. 3. A short period of data was not obtained due to maintenance problems. It is possible to visualize the increase in concentration in the winter and autumn seasons (cold and dry in the region) that occur between March and September in the southern hemisphere. These low concentrations can be justified by the low volume of rainfall during these periods, which makes it difficult to remove the particles from the atmosphere.

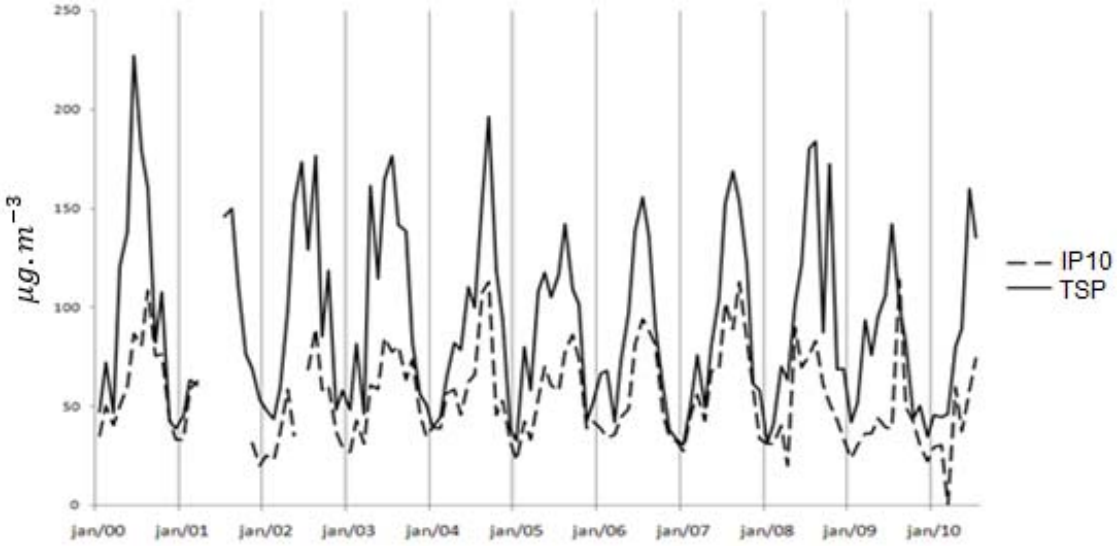
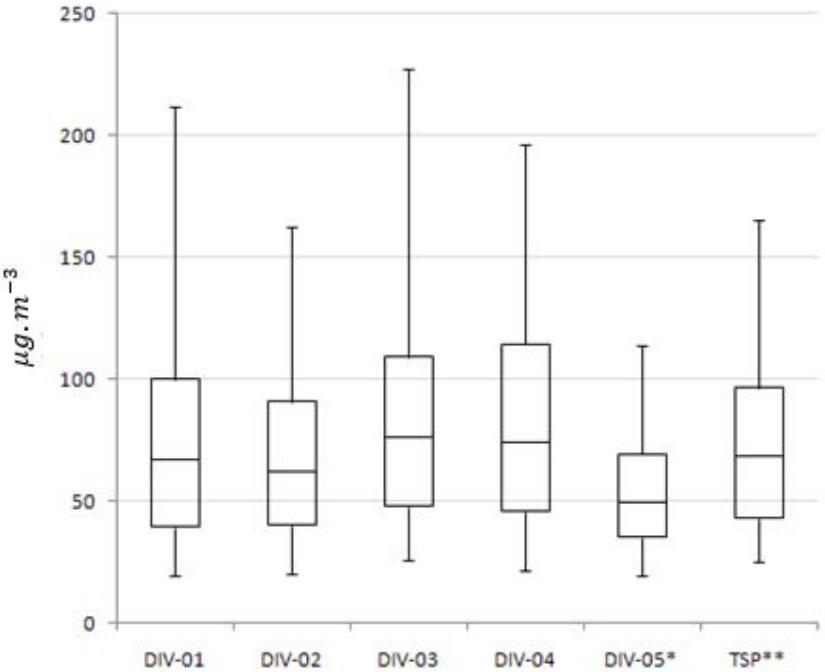



**Fig. 2 Temporal distribution of concentrations of TSP and IP10.**




*IP10 sampler, **Geometric media of the seasons DIV-01, DIV-02, DIV-03 and DIV-04

**Fig. 3 Box-Plot representation of the distribution of IP10 and TSP.**

According to Brazilian legislation on the subject, the average concentration over 24 hours does not exceed 240 $\mu g.m^{-3}$ for the primary standard and 150 $\mu g.m^{-3}$ for the secondary standard. In the graph of Fig. 2 it is observed that the secondary pattern is exceeded in the dry (winter) seasons and the primary standard is not reached during the analysis period.

Analyzing the single graphic shown in Fig. 3 has the geometric mean concentration in the samplers presenting a great variation, with an upper and lower limit very far from the quartiles and the median that is around 70 $\mu g.m^{-3}$ in the average of the 4 samplers of TSP. It is evident that the concentration undergoes a high degree of variability, for example in the DIV-03 sampler, that the upper limit reaches 240 $\mu g.m^{-3}$ and the lower 30 $\mu g.m^{-3}$.

It is noteworthy that some samplers such as DIV 02 are located in areas farthest from the center of the city analyzed, in neighborhoods with low demographic density resulting in low concentration of TSP at the event.

Fig. 4 shows the distribution of the number of hospitalizations in each year due to bronchitis, asthma and respiratory diseases in general. These data were collected in the national database of the single health system (DATASUS) maintained by the Ministry of Health of Brazil, with the number of hospitalizations only of public hospitals. Correlating Figs. 1 and 4, it is evident that the concentration of TSP and IP10 directly affects the number of hospitalizations due to respiratory diseases.

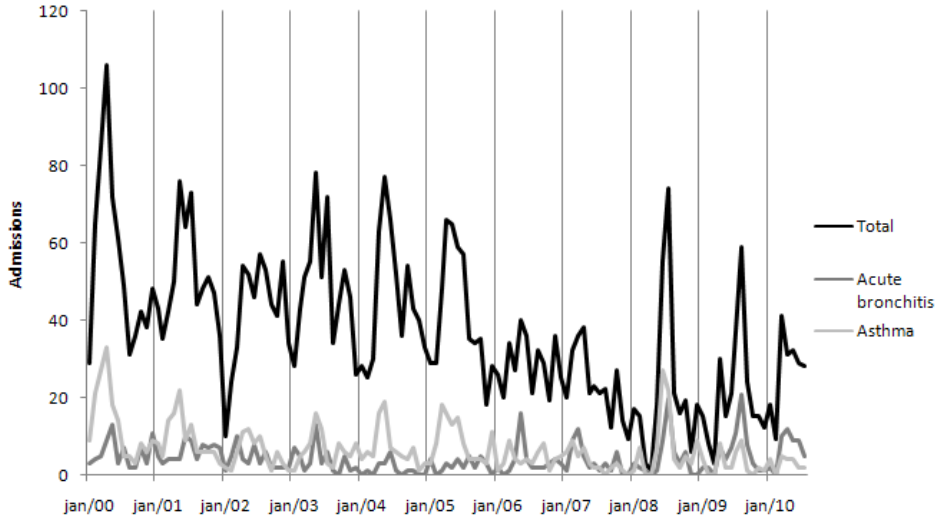



**Fig. 4 The distribution of the number of hospitalizations in each year.**

### *3.2 Pearson Correlation*

The Pearson correlation shows the relationship between hospital admissions due to respiratory diseases. If the direction of this correlation is positive, the correlation is directly proportional, and if negative, inversely proportional. The closer to 1 the stronger the correlation, and the closer to 0 the more independent they are from each other.

As can be observed in Table 1, the correlation showed that the indexes of higher correlation inversely proportional to the number of hospitalizations from respiratory diseases are the temperature and humidity of the air.

### *3.3 Multivariate Regression*

When applying multivariate regression, it was obtained the following values for the intercept and prediction values of the variables as seen in Table 2.

It can be observed that the parameters of the suspended particles showed a direct correlation with the number of hospitalizations, being most significant for fine particles, taken in Iijima [7] as more impacting

to the health of the exposed population. In the case of climatological parameters of relative humidity and mean minimum temperature, its inversely variable correlation can be analyzed as expected, since, in cold and dry periods, the occurrence of pulmonary morbidities is frequently observed [13].

**Table 1 Pearson correlation of the analyzed parameters.**

| | DIV-05 IP10 | TSP | TH | AB | A | P | H | TMax | TMin | AV (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|
| IP | 1 | .770** | .216* | .126 | .076 | -.668** | -.773** | -.195* | -.692** | -.017 |
| TSP | .770** | 1 | .353** | .210* | .165 | -.729** | -.727** | -.298** | -.805** | -.107 |
| TH | .216* | .353** | 1 | .521** | .646** | -.361** | -.170 | -.301** | -.389** | -.263** |
| AB | .126 | .210* | .521** | 1 | .296** | -.292** | -.163 | -.198* | -.334** | -.231** |
| A | .076 | .165 | .646** | .296** | 1 | -.181* | .052 | -.216* | -.181* | -.119 |
| P | -.668** | -.729** | -.361** | -.292** | -.181* | 1 | .661** | .220* | .717** | .202* |
| H | -.773** | -.727** | -.170 | -.163 | .052 | .661** | 1 | -.183* | .488** | -.111 |
| TMax | -.195* | -.298** | -.301** | -.198* | -.216* | .220* | -.183* | 1 | .697** | .203* |
| TMin | -.692** | -.805** | -.389** | -.334** | -.181* | .717** | .488** | .697** | 1 | .229* |
| AV | -.017 | -.107 | -.263** | -.231** | -.119 | .202* | -.111 | .203* | .229* | 1 |

*Correlação significante ao nível de 95%; **Correlação significante ao nível de 99%
IP: Inhalable Particles
TSP: Total Suspended Particles
TH: Total Hospitalizations (respiratory diseases)
AB: Acute Bronchite
A: Ashtma
P: Precipitation
H: Relative Humidity of the air
Tmax: Maximum temperature average (°C)
Tmin: Minimum temperature average (°C)
AV: Average wind speed (m/s)

**Table 2 Prediction Values for the Parameters Analyzed.**

| Parameter | β | Confidence interval |
|---|---|---|
| Intercept | 3,465 | 95% |
| Total suspended particles | 0.002 | 95% |
| Inhalable particles | 0.003 | 95% |
| Relative humidity | -0.007 | 95% |
| Minimum average temperature | -0.031 | 95% |

## 4. Conclusions

As can be seen, the number of hospital admissions resulting from pulmonary diseases has a strong correlation with the concentration of particulate material found in the atmosphere, besides the relative air humidity. However, the concentration of inhalable particles in the atmosphere (IP10) is evidenced as a parameter of greater interference in hospitalizations, considering its polluting potential observed in the bibliographies used in this research. These results reinforce the urgent need and public policies at the regional level that guides the mitigating measures of this form of pollution.

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