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THE INFLUENCE OF METEOROLOGICAL VARIABLES AND AIR POLLUTANTS ON THE OCCURRENCE OF RESPIRATORY DISEASES IN THE CITY OF MANAUS/AM

***[1]Emília dos Santos Magalhães, [1]Luis Miguel Gonçalves Figueiredo da Silva, [1,2]Alexandra Amaro de Lima, [1]Gleide Solange Silva Dutra, [2]Igor Felipe Oliveira Bezerra and [3]Patrícia dos Santos Costa**

[1]University FAMETRO (Ceuni-FAMETRO), Manaus, Amazonas, Brazil
[2]Research Department, Institute of Technology and Education Galileo of the Amazon (ITEGAM), Manaus, Brazil
[3]Amazonas State University – UEA, Manaus, Brazil

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ABSTRACT

The objective of this work was to show data on how there is an association of climatic factors and air pollution influence hospitalizations due to respiratory diseases in individuals in the city of Manaus. An ecological study of indicators, hospitalization and deaths was conducted during a few months from 2013 to 2015. It was observed that precipitation has a strong influence on the number of hospitalizations. The data presented are expected to be used to assess the impact of meteorological variables and air pollutants on the city's human health.

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INTRODUCTION

In recent decades air pollution has been pointed out as one of the evil grids of the century, which can cause public health problems, in addition to directly impacting human lives. The increase in problems related to air pollution follow the period since world war II and industrial revolution. An example of these impacts can be verified in Saldiva and Coelho (2013), where the authors showed that in the mid-1930s, the exponential increase in steel mills, carvoarias, cement industries, gunpowder plant among others, which were responsible deaths caused by emissions of pollutants emitted into atmosphere. The burning of fossil fuels and industrial processes are the main responsible for air pollution. Some substances such as sulphur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), ozone (O_3), photochemical oxidants, heavy metals and particulate matter of different dimensions are of great influence, and cause a great impact human health (DANIEL, 2013). Thus, these pollutants emitted come from the combustion of motor vehicles, industries and fires caused in forests that alter air temperature, visibility and radiation levels (CARVALHO *et al*., 2003; MORAES *et al*., 2019). Air pollution has now been one of the biggest influences for increased hospitalizations and deaths from respiratory diseases (BRAGA *et al*., 2007). This is the way modern society currently lives. However, children and the elderly are the most likely to have complications due to vulnerability and immune fragility (GOUVEIA, 2003). In the Amazon region at sometimes of the year, it is normal to occur periods of prolonged drought, in which fires are susceptible in the region. Also, in the city of Manaus, the period of heavy rains or strong convective activity are during the months of November to February, on the other hand, the dry season takes place between the months of May to September (FISCH, 1998). In addition, there is a strong aggravating factor in the region for the increase in drought-related diseases, which due to the lack of rain further intensify the concentration of pollutants (ARTAXO *et al*., 2001). This

****Corresponding author:*** **Emília dos Santos Magalhães,**
University FAMETRO (Ceuni-FAMETRO), Manaus, Amazonas, Brazil

work shows an analysis of respiratory diseases in the city of Manaus-AM, through the panorama of emissions of particulate matter and the concentration of Ozone in the atmosphere. For a better approach to the theme, some meteorological variables were also analyzed during the Goamazon experiment period.

MATERIALS AND METHODS

The study used aims to relate the most common pollutants present in the atmosphere and the individuals exposed for a certain period of time. In addition, verifying the results of a number of different clinical adversities (LOPES and HERRINGTON, 2015). To develop the analysis, information was used on the monthly hospitalizations (residence) of patients who entered the hospitals in the city of Manaus, due to respiratory diseases. Diseases are classified according to the 10th revision of the International Classification of Diseases ICD - 10 (J00-J99), which were obtained through the DATASUS platform. This platform is maintained by the Brazilian Federal Government and updated by the Ministry of Health (MS), for the period from January 2013 to December 2015. The city of Manaus is located in the northern end of the country, occupying an area of 11,401 km², and from this territorial space, approximately 592.19 km² belongs to the urban area. According to the population census of 2019, 54% of the population of the state of Amazonas, this concentrated in the capital that has on average 3,350,773 inhabitants. Also, according to data from the National Register of Health Establishment (CNES), the municipality has 17 general hospitals, seven from the public sector and ten from the private sector.

Data on the concentration of pollutants during the years 2013/2015 were obtained through the GoAmazon project platform. From this project, data from Particulate Matter (PM10) and Ozone (O3) were used. Some data were not computed due to possible failures in the pollutant measurement apparatus. All data regarding pollutants and environmental factors were calculated as independent variables (BRAGA *et al*., 2007). These are quantitative variables that analyzed together are determinant for the association of respiratory diseases and air pollution (TADANO *et al*., 2009). In addition, the climate in Manaus is a relevant factor in this study, as it can intensify the effects of aggravating air pollution. Thus, climatological means of precipitation were used. Estimates of precipitation rates were obtained from the database available to the public on the website of the National Institute of Meteorology (INMET). Thus, this information was analyzed qualitatively with the objective of finding direct relationships between the concentrations of pollutants present in the atmosphere, and the number of hospital admissions during the rainy season.

RESULTS

During the period 2013/2014, from October to April as shown in Figure 1. It can be observed that in the months of low precipitation, it presents as the months of higher concentration of Particulate Matter suspended in the atmosphere. Although some works show that the Amazon region is characterized by a rainy season during the months of December to March (Figueroa and Nobre, 1990; Marengo *et al*. 2004; Marengo, 2004, 2005 and 2006; Vera *et al*., 2006; Correia *et al*., 2007), the results of Figure 1 show that the years analyzed are atypical. Subsequently, it was verified that due to the low rainfall indexes in February, they contributed to the higher concentration of particulate matter. High concentrations of MP10 can provide an increase in respiratory and cardiovascular diseases (WORDLEY, *et al*.,1997), and high rainfall rates, in addition to decreasing concentration in the atmosphere, help maintain a moist soil reducing the amount of suspended particles (FREITAS AND SOLCI, 2009). On the other hand, the reverse occurs in March where there is a considerable increase in precipitation and a decrease in the concentration of PM_{10}.

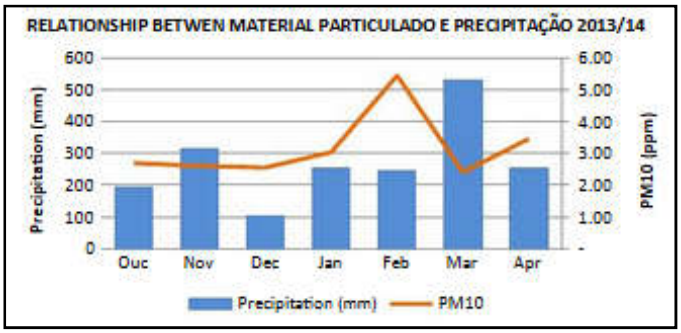

Figure 1. Relationship between Particulate Matter and Precipitation, 2013/2014

Regarding hospitalizations, it is perceived that even in the face of the large concentration of PM10 in February, the number of hospitalizations is not as high as it is seen in March, where there was a lot of rain and a low concentration of particulate matter. It is possible to affirm that hospitalizations occurred after the period most exposed to pollutant and not in the same month of exposure as presented in Table 1. Knowing that air quality is a very important aspect for society, because its concentrations reflect a lot on the state and quality of life of the pollutant. Respiratory problems represent an important cause of morbidity in the distribution of diseases in the city of Manaus. In the years of 2013/14/15 there were 118 deaths and 2,061 cases of hospitalizations in the city, as is the case in Table 1. In a study addressing the concentration of hospitalization pollutants, Roseiro (2002) showed that 1,936,444 patients were admitted to hospitals in the Brazilian public network in 2000 due to lung problems, and of all 275,769 (14.24%) happened in the state of São Paulo. The higher concentration of pollutants and the major common consequences indicate hospitalizations and deaths occurs after exposure, i.e., the number of hospitalizations and deaths did not follow the increasing concentration of pollutants in less rainy periods, as ANDRADE, BOTELHO, *et al*., (2015) describes. When precipitation levels are high, pollutant concentrations end up getting low due to the high amount of rain that prevents particles from being dispersed in the air.

Table 1. Manaus/AM: Hospitalizations and deaths due to Respiratory Diseases, 2013/2014

Month	Hospitalizations	Death
October	94	2
November	55	0
December	10	4
Janvier	49	1
Febrier	43	5
Mars	50	7
April	73	3
Total	374	22

Source: Ministério da Saúde, DATASUS, 2013/2014.

The Figure 2 shows the relationship of ozone concentration and precipitation, referring to the year 2013/14 in the months of October to April. It was found that unlike PM10, the highest concentration of Ozone (O_3) occurred in December, the month of which the lowest rainfall indices were verified. Associated with these low rainfall indexes, hospitalizations showed a progressive increase from October to December (Table 1). Allied to this increase in hospitalizations, those obtained due to respiratory diseases occurs in December, possibly a consequence of the exposure of previous months (October and November). On the other hand, in the study by Souza et. al., (2013) pollutant O_3 was positively correlated with hospitalizations for respiratory diseases.

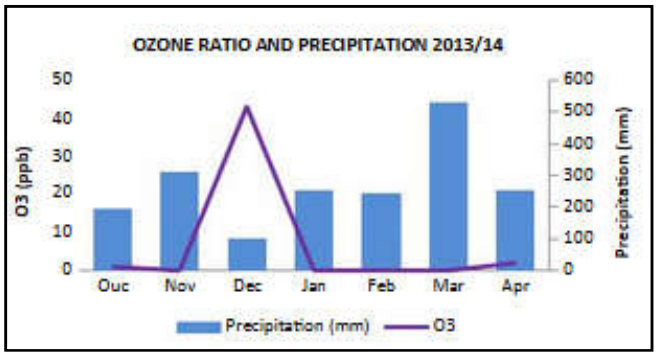

Figure 2. Relationship between Ozone and Precipitation, 2013/2014

During the humid months of 2014/2015, it is noticed that precipitation from October to December did not exceed 200 mm in each of the months. At the same time, a peak of the concentration of Particulate Matter is perceived, which is related to. In January and February 2015 there was an increase in precipitation causing the pollutant rate to be the lowest during the period studied, as expected.

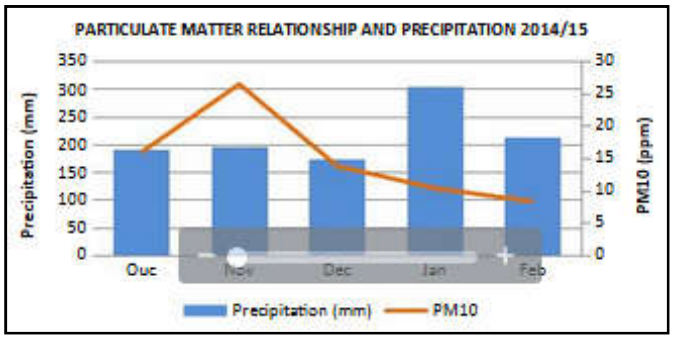

Figure 3. Relationship between Particulate Matter and Precipitation, 2013/2014

Regarding hospitalizations for the years 2014/15, we can observe that there was an increase in the number of hospitalized only in the wettest period and in the preceding months these numbers were lower than that is not expected for the months of higher concentration of pollutant, as shown the table 2 below:

For the pollutant Ozone, only the months of November and December 2014 one could detect a concentration of the pollutant, with a number much below what is determined by who. With this, it is unlikely to determine whether there were hospitalizations due to the concentration of the pollutant mentioned above.

Table 2. Manaus/AM: Hospitalizations and deaths due to Respiratory Diseases, 2014/2015

Month	Hospitalizations	Death
October	73	1
November	52	1
December	11	3
Janvier	90	2
Febrier	80	2
Mars	55	5
April	100	6
Total	371	20

Source: Ministério da Saúde, DATASUS, 2014/2015.

Individuals exposed to high concentration of Particulate Matter tend to have serious problems in the upper and lower portion of the airway. The smaller the size of the particles, the greater the effect on health, causing consequences in people with lung disease, asthma and bronchitis, increased hospital care and premature deaths. The MP is the most efficient conveyor of air pollutants inside the body. Chronic exposure to Particulate Matter has been associated with increased bronchitis and respiratory diseases rates, with decreased lung function and increased risk of contracting lung cancer.

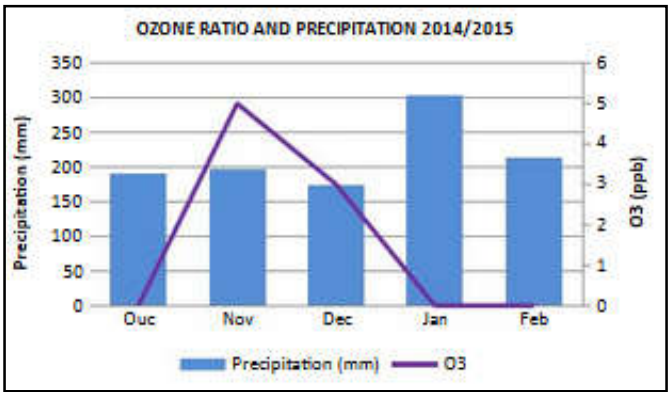

Figure 4. Relationship between Ozone and Precipitation, 2014/2015

Based on the results found, it can be said that air pollution levels in Manaus, although not as high or even when they do not exceed the air quality standard, as in the case of NO2 and O_3, interfere in the profile of respiratory morbidity of the population. It is expected that the results and the entire set of information found will be useful, as they allow measuring the risks to which individuals are exposed and provide subsidies for the development of measures aimed at minimizing these risks, also contributing to the environmental or urban health planning and the improvement of public policies. The concentrations of particulate matter and ozone found in the city of São Paulo reached 54.5 ug/m³ of MP10 and 45 ppb of ozone, as the author says (NEGRISOLI, 2013), numbers that were higher those identified in the City of Manaus. On the other hand, despite this superiority, in Manaus there were a greater number of hospitalizations and deaths due to respiratory diseases. However, ozone can cause irritable symptoms in the upper and lower airways, increase the bronchial response to allergy, increase the number of hospitalizations for asthma and respiratory diseases. O_3-induced diseases are conjunctivitis, upper airway irritation, cough, shortness of breath, decreased respiratory volume, nausea, malaise and headache. When investigating nasal inflammation in schoolchildren and its subsequent environmental adaptation after exposure to ozone, it was

observed that acute inflammation occurs in the nasal mucosa after the first increase in O_3 levels that occurs in spring, however, a possible adaptation of the nasal mucosa occurs in summer, regardless of the constant elevation in the levels of this pollutant (ROSEIRO, 2003).

Conclusion

The results presented in this article concluded that precipitation is directly linked with the number of hospitalizations due to respiratory diseases, but also the same influence for softening in the concentration of pollutants such as particulate matter. Ozone on the other hand is a pollutant that occurs with incidence of sun rays and influence the increase of respiratory infections and inflammatory reactions in the lungs, due to oxidizing substances that reduce lung defenses. It is hoped that the results presented here can serve as a warning to the health administration of the city of Manaus, in order to direct attention and promote new incentives to research by improving new methods of softening the effects of rains on these Individuals. It is noteworthy that such actions and measures would have consequent positive reflections regarding the number of hospitalizations, which will consequently reduce expenses with the care provided, with medicines and other services.

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