

# HOSPITALIZATIONS FOR RESPIRATORY INFECTIONS ASSOCIATED WITH ENVIRONMENTAL FACTORS

## Hospitalizações por infecção respiratória associada a fatores ambientais

### *Ingresos por infección respiratoria asociada a factores ambientales*

Original Article

#### ABSTRACT

**Objective:** To evaluate the relationship between the meteorological variables and respiratory diseases by age. **Methods:** This is an ecological time-series study, for the period comprised between 2008 and 2011. First, admissions were analyzed by age group and then related to climate information: temperature, precipitation, relative air humidity, and wind speed, through dynamic climatology and statistical parameters using multiple regression analysis, chi-square test and normal distribution. **Results:** The results showed 12,067 records of hospital admissions for respiratory diseases according to the age group. The highest average number of hospitalizations was found in the age range from 1 to 4 years, with a mean of 42.09% (5079), and over 60 years, with a mean of 27.14% (3274) for the study period. The highest prevalence was due to pneumonia, accounting for 81.0% (9,774) of admissions. The number of hospitalizations was lower in January and higher in June and July. **Conclusion:** Based on the investigations carried out, a significant correlation was observed between climate parameters and hospitalization for respiratory diseases.

**Descriptors:** Climate; Health; Respiratory Tract Diseases; Temperature.

#### RESUMO

**Objetivo:** Avaliar a relação entre variáveis meteorológicas e doenças respiratórias por faixa etária. **Métodos:** Trata-se de um estudo ecológico de séries temporais para o período compreendido entre 2008 e 2011. Primeiramente, as internações foram analisadas por grupo de faixa etária e, em seguida, relacionadas com informações climáticas, temperatura, precipitação, umidade relativa do ar e velocidade dos ventos, através da climatologia dinâmica e de parâmetros estatísticos, utilizando análise de regressão múltipla, teste qui-quadrado e distribuição normal. **Resultados:** Os resultados mostraram 12.067 registros de internações por doenças respiratórias e por faixa etária. As maiores médias de internação ocorreram na faixa etária de 1 a 4 anos, com média de 42,09%, (5.079) e acima de 60 anos, com média de 27,14% (3.274) para o período de estudo, sendo as pneumonias predominantes, com 81,0% (9.774) das internações. Verificou-se menor número de internações em janeiro e maior, em junho e julho. **Conclusão:** Com base nas investigações realizadas, observou-se correlação significativa entre os parâmetros climáticos e as internações por doenças respiratórias.

**Descritores:** Clima; Saúde; Doenças Respiratórias; Temperatura Ambiente.

#### RESUMEN

**Objetivo:** Evaluar la relación entre variables meteorológicas y enfermedades respiratorias por franja de edad. **Métodos:** Se trata de un estudio ecológico de series temporales en el período entre 2008 y 2011. En primer lugar, los ingresos fueron analizados por franja de edad y, en seguida, relacionados con las informaciones climáticas, temperatura, precipitación, humedad relativa del aire y la velocidad de los vientos a través de la climatología dinámica y parámetros estadísticos utilizándose del análisis de regresión múltiple, prueba del Chi-

Amaury de Souza<sup>(1)</sup>  
Flavio Aristone<sup>(1)</sup>  
Luciane Fernandes<sup>(1)</sup>  
Li Bai<sup>(2)</sup>  
Weiwei Yu<sup>(3)</sup>  
Débora Aparecida da Silva Santos<sup>(1)</sup>  
Ismail Sabba<sup>(4)</sup>

Federal University of Mato Grosso do Sul  
(Universidade Federal de Mato Grosso do Sul - UFMS) - Campo Grande (MS) - Brazil

Chinese Center for Disease Control and Prevention - Beijing 102206 - People's Republic of China

University of Queensland Herston - QLD  
- Australia

College of Health Sciences, the Public Authority for Applied Education and Training - Kuwait

Received on: 07/05/2013  
Revised on: 09/11/2013  
Accepted on: 08/11/2014

cuadrado y distribución normal. **Resultados:** Los resultados señalaron 12.067 registros de ingresos por enfermedades respiratorias y franja de edad. Las mayores medias de ingreso se dieron en la franja de edad de 1 a 4 años con media del 42,09%, (5.079) y por encima de los 60 años con media del 27,14% (3.274) en el período del estudio, siendo las neumonías las más predominantes en el 81,0% (9.774) de los ingresos. Se verificó menos ingresos en enero y más en junio y julio. **Conclusión:** Basado en las investigaciones realizadas, se observó correlación significativa entre los parámetros climáticos y los ingresos por enfermedades respiratorias.

**Descriptor:** Clima; Salud; Enfermedades Respiratorias; Temperatura Ambiental.

## INTRODUCTION

An understanding of the nature of the effects of weather conditions on health is essential for its protection. The weather-health relationship is associated between temperature and morbidity/mortality. Nonlinear relations (U, J or V shaped) of temperature and mortality are observed<sup>(1)</sup>. Apart from temperature, weather variables, such as humidity, barometric pressure and rain fall, are also found to be related to morbidity/mortality<sup>(2)</sup>. However, the combined impact of weather variables on morbidity/mortality is less widely examined<sup>(1,2)</sup>.

Furthermore, there is often a lag between mortality/morbidity and weather conditions in addition to the immediate impact of weather on health, because the effects of weather parameters can occur after some delay. However, this lag structure between weather and mortality has not been widely investigated<sup>(3)</sup>.

High rates of morbidity show the extent and the need for research on the respiratory system diseases (RSD), especially in children under the age of five and people over the age of 60. The incidence of RSD is similar all around the world in developed or developing countries; however, there is a difference in the tendency towards a higher frequency and severity of respiratory tract infections, particularly pneumonia. This leads to a 30 times increase in mortality rates in developing countries<sup>(4)</sup>.

Several factors are associated with RSD, such as malnutrition, passive smoking, maternal education and number of people living in the same house<sup>(5)</sup>.

Noteworthy are the environmental factors, such as air pollution and weather variables, as determinants of the increase in the number of cases and severity of RSD in children under the age of five. Sudden climate changes affect the quality of air inhaled, especially when the cold air

mass hinders the air currents and causes the precipitation of the particulate matter of the atmosphere in large cities. Thus, there is a significant increase in the number of cases of pneumonia, asthma and bronchitis<sup>(6,7)</sup>.

A study conducted with children in São Paulo on mortality from respiratory diseases and the relationship to humidity, temperature and environmental pollutants showed that there was a significant association and an increase of circa 20% in the emergency care of respiratory diseases<sup>(8)</sup>.

Based on the above, the present research aims to assess the relationship between weather variables and respiratory diseases by age.

## METHODS

This is an ecological time-series study conducted in the city of Campo Grande, Mato Grosso do Sul (MS), Brazil. The city of Campo Grande (S 20°26'16" W 54°32'16" - 677 meters above sea level) is located in the Central-West region of Brazil. It lies about 1,200 km south of the southern region of the Amazon Basin and about 150 km east of the *Pantanal*, the largest wetland area in the world. It is situated on the Maracaju plateau, the watershed between the drainage basins of the Paraná River and Paraguay River, and about 100 km east of the Andes<sup>(9)</sup>.

According to the Köppen-Geiger climate classification, the climate of Campo Grande region is classified as tropical, with a dry season, characterized by high temperatures (18°C to 28°C, with temperature range of 5°C to 7°C) and two well-defined seasons: a rainy season and a dry season. It presents high rainfall, circa 1500 mm/year, and the rainy season begins in October and lasts until April, and the dry period corresponds to the remaining months of the year<sup>(10)</sup>.

Data were collected in the *Secretaria Municipal de Saúde – SMS* (Municipal Health Secretariat) from outpatient records of municipal health facilities; the data refer to cases of respiratory diseases in the age group 0-80 years. The analysis comprised the period from January 2008 to December 2011. The databases of the Hospital Information System of the *Sistema Único de Saúde – SUS* (Brazil's Unified Health System) were used and coded according to the International Classification of Diseases (ICD) - 10th Revision (ICD10 J10 and J18). The data analyzed refer to Chapter X of ICD 10, which includes the respiratory system diseases (RSD).

Information about rainfall, air temperature, humidity and wind speed were obtained from the *Embrapa – Gado de Corte – Campo Grande* (MS).

The dependent variable (Y) was the coefficients for respiratory diseases; and the independent variable (X), the years of study. The transformation of the variable "year" into

the variable “centralized-year” (year minus the midpoint of the study period) was necessary as, in polynomial regression models, the equation terms are often highly correlated, and expressing the independent variable as a mean deviation substantially reduces the autocorrelation between them.

Trend analysis of time series has been carried out using a multiple linear regression model that best described the relationship between the independent variable X (rainfall, minimum and maximum temperature, relative humidity, wind speed) and the dependent variable Y (coefficients for hospitalizations for RSD) according to equation  $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + \varepsilon$ ; where k: number of variables;  $X_j$ : regressors;  $\beta_j$ : estimators;  $\varepsilon$ : standard error. The coefficient of determination ( $R^2$ ) was used as a measure of precision. Residual analysis confirmed the homoscedasticity assumption of the model<sup>(11)</sup>.

Chi-squared tests with 95% confidence interval for proportion differences were used to analyze the correlations between the covariates and the response variable. ANOVA test was used for continuous and parametric variables and Kruskal-Wallis test was used for nonparametric variables.

As the dependent variable for regression analysis, the total number of cases of RSD (number of hospitalizations) by age group were collected. Multiple linear regression models included all “response variables” (continuous) that were statistically associated with the severity of RSD. Statistically significant tests of association included p values below 0.05; Fisher-Snedecor distribution test with critical values of F, such that  $(F > F_c) = 0.05$ ; and coefficients of determination ( $R^2$ ) that did not include null values.

Normal distribution of the several variables was assessed using the Kolmogorov-Sminov method (K-S), and the heteroscedasticity and the absence of collinearity were verified through the use of graph plotting and appropriate statistical tests. At this stage, it was opted for the smoothing of variables due to the fact they have presented asymmetric distribution in the analyzed period. Thus, it was transformed into a binary variable, presence/absence (1/0) type, allowing its use in modeling the multiple linear regression. It was also performed the modeling of categories through the transformation into “dummy” variables, using their respective quartiles, in an attempt to find cut-off points that could better explain the model.

To verify the absence of autocorrelation between RSD severity score and consequent assumption of independence of errors, it was used the Studentized graphic residual analysis because the use of the Durbin-Watson method tests the hypothesis that indicates the absence of zero residual autocorrelation, compromised by the small size of the study series.

As for residual analysis, there was a normal distribution of residuals that was close to a horizontal dispersion pattern of the mean, which was equal to zero (0.0). The heteroscedasticity and the linearity could also be checked by plotting residual plots with random distribution, without a cyclical behavior or defined trend, which would hinder the regression model.

Finally, in an attempt to find models that best demonstrate the relationship between environmental variables and hospitalization for RSD, the behavior of associations were explored by the curvilinear transformation of the response variables, with consequent regression. However, there was no significant difference between the significance levels and determination coefficients that would prevent the use of linear regression, since the conditions for its implementation have been satisfied after the adjustments mentioned above.

Utilization of the Mean Squared Error (MSE) to assess the skill of the model:

$$EQM = \sqrt{\frac{1}{n} \{ \sum_{i=1}^n (p_i - O_i)^2 \}}$$

Where:  $P_i$  is the estimated value and  $O_i$  the observed value. In all the analyses the significance level was set at 5%.

## RESULTS

There were 12,067 hospitalizations for respiratory diseases in the period of the present research. Considering the number of hospitalizations for respiratory diseases by age, the higher averages of hospitalizations occurred in the age group from 1-4 years, with a mean of 42.09% (5,079), and in people over 60 years old, with a mean of 27.14% (3,275); pneumonias were the most prevalent diseases, accounting for 81.0% (9,774) of hospitalizations. Hospitalizations were less frequent in January and more intense in June and July.

Table 1 shows the values of the risks related to the model 1-4 years and > 60 years and the b coefficients assuming positive and negative values, depending on the variable, confirming that the number of hospitalizations decreases when these values increase; that is, the lower the human thermal comfort index, the greater the number of people with respiratory system diseases or vice versa, with a higher risk related to the 95% confidence interval, which involves temperature, relative humidity, rainfall and wind speed<sup>(12)</sup>.

In the final model of multiple linear regression, it was verified that the linear function, selected for the regression model, presented random distribution around the zero line and there were no “outliers” in its residual distribution,

which featured a variance homogeneity in the adjustment, validating, therefore, the final analysis.

In this group of statistical models, the dependent variable (number of hospitalizations) is a counting process, i.e., it is a discrete quantitative variable, and the independent variables are candidates variables that could explain the behavior of the series over time. The independent variables were the weather variables (maximum (lag of 2 days) and minimum (lag of 4 days) temperatures), humidity (lag of 4

days), wind speed (lag of 2 days) and rainfall (lag of 1 day). the variable “weekday” and “holiday” were used to control the short-term seasonality. The variable “year” was used to control the long-term seasonality.

The analysis of the present research, which used multiple linear regression, shows that there is a persistent influence of RSD in the age group 1-4 years, with rainfall with a correlation of (-0.89), minimum temperature with a correlation of (-0.79), maximum temperature with a

Table I - Coefficients of regression, mean squared error, relative risk and correlation coefficient for the 95% confidence intervals for the age groups assessed. Campo Grande, MS, 2008-2011.

Age group (years)	I	$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	MSE	RR	R <sup>2</sup>
		lag 1 day	lag 2 days	lag 4 days	lag 4 days	lag 2 days			
0 - 4	603	-0.617	-31.4	29.3	13.1	-3.07	13	1.98	88.10
5 - 9	56	-0.053	-8.25	8.93	12.3	-0.68	3.98	0.96	78.90
10 - 14	-4.5	-0.0048	-0.46	0.08	3.65	0.195	1.25	0.30	81.50
15 - 19	-49.4	0.0167	3.03	-3.47	2.11	0.629	1.21	0.19	70.20
20 - 24	24.7	-0.0006	-1.21	0.95	0.782	-0.043	1.22	0.17	34.20
25 - 29	-1.1	-0.0131	-0.31	0.52	0.914	0.122	1.05	0.19	49.00
30 - 34	-9.6	-0.0041	0.57	-0.49	0.546	0.187	1.05	0.33	29.10
35 - 39	48.7	-0.0408	-4.08	4.94	0.758	-0.517	1.09	0.39	51.30
40 - 44	-52.1	0.0099	3.19	-3.27	1.39	0.615	0.71	0.26	78.50
45 - 49	-48.2	0.0151	2.86	-2.84	2.5	0.325	1.71	0.33	52.70
50 - 54	9.2	-0.0043	-1.01	0.97	1.67	0.0067	1.41	0.41	47.00
55 - 59	-19	-0.001	0.92	-0.9	2.72	0.126	1.8	0.62	53.40
> 60	89	-0.118	-3.1	2.2	5.16	1.41	5.66	1.18	77.40

I-intercept;  $\beta_1$ -rainfall;  $\beta_2$ -maximum temperature;  $\beta_3$ -minimum temperature;  $\beta_4$ -wind speed;  $\beta_5$ -relative humidity; MSE- mean squared error; RR-relative risk; correlation coefficient R<sup>2</sup>.

correlation of (-0.72) and wind speed with a correlation of (0.50), which is associated with the severity of the RSD. As for the ages older than 60 years, the correlations are significant for the maximum temperature (-0.41) and humidity (0.44). It must be said that the coefficient of determination of the model was 88.1% for 0-4 years and greater than 77.4% for individuals over age 60, as shown in Table 1. For other age groups, the maximum temperature (10-14 years; 20-24 years -0.45; -0.42) and wind speed (5-9; 10-14; 15-19; 40-44; 45-49; 55-59 years; 0.82; 0.82; 0.61; 0.43; 0.68 and 0.70) were significant. Even after smoothing of irregularities and conducting curvilinear regression, better determination coefficients or statistical significances could be found. On the other hand, it is known

that individual exposure measurements or even certain endemic seasonality and possibilities of irregular variations such as epidemics could explain the other 12 and 23% of unexplained variability in the model.

## DISCUSSION

Positive associations were found in this study between the weather variables and age groups by respiratory diseases in Campo Grande-MS. These effects are similar to those found in other cities of Brazil, especially to those observed in São Paulo<sup>(13)</sup>, both in the diversity of variability of associated meteorological values and the magnitude of the estimated effects. The increase in hospitalizations for

respiratory diseases in the colder times of the year is caused by the low temperatures, which shows that the relative risks of hospitalization for respiratory diseases are associated with age groups 0-4 years and > 60 years.

Regarding the analysis of data collected in the present study, the results show a striking frequency of RSD in children under the age of four during the years of the study given that almost half (42.09%) of the consultations provided to this age is due to children with signs and symptoms resulting from a diagnosis of RSD, leaving all other age groups with the other half. This is twice the rate found in another study<sup>(13)</sup>, which assessed children of the same age in the emergency department of a pediatrics service and found a prevalence of 25.6%<sup>(13)</sup>.

It is believed that the temperature affects blood pressure and blood viscosity<sup>(14,15)</sup>. The blood pressure increases with lower temperatures, although the temperature may rise at night<sup>(16)</sup>. The low temperature also increases blood viscosity and heart rate<sup>(14)</sup> and can trigger cardiovascular diseases.

In general, the minimum temperature can cause respiratory diseases and bronchoconstriction, increasing the susceptibility to pulmonary infection induced by cold air inhalation. During heat exposure, the blood is forced into the periphery to promote heat loss and thus blood pressure is increased because the blood vessels near the body core are constricted<sup>(17)</sup>. In addition, blood viscosity may increase with higher temperature<sup>(18)</sup>, and these increases will interact with atrial fibrillation resulting in blood clot. In addition to gender differences in thermoregulatory responses to heat, the lower tolerance time in heat, due to excessive body heat storage<sup>(19)</sup>, contributes to the greater susceptibility to respiratory disease.

The weather-morbidity is associated with the age group  $\geq 60$  and ascertains that the elderly are more susceptible to weather stress. This weather-morbidity relationship is evident due to the failure of homeostatic defense mechanism with advancing age, which in turn would cause breathing difficulties or other diseases<sup>(20)</sup>.

The RSD is one of the leading causes for seeking medical consultations, accounting for over a third of them and a large number of hospitalizations in children and adults in many countries<sup>(21)</sup>. The age group with the highest incidence of RSD is between six months and four years and individuals over the age of 60 in both developed and developing countries. The RSD morbidity difference between rich and developing countries is that the latter has the most serious cases, particularly pneumonia, which often come with life-threatening complications. It is well described that the RSD mortality rate is higher in countries with lower quality of life of its inhabitants<sup>(21)</sup>.

Another indicator of the severity of the RSD is the rate of hospitalization in a given service. It is known that complications of RSD usually require hospital care, and infections of the lower airways, especially pneumonia and bronchopneumonia, which require more hospitalization due to its severity can lead to death. Comparing all hospitalizations of children under five years for any diagnosis, PAHO/WHO data<sup>(22)</sup> show that pneumonia accounts for 20% to 40% of hospitalizations in developing countries, and frequent hospitalizations could be attributed to forms that could be effectively treated on an outpatient basis. In the present study, in Campo Grande-MS, pneumonia in infants, children and adults accounted for 81% of the number of hospitalizations for RSD. The high number of severe cases may be related to the higher prevalence of different associated factors that aggravate the RSD, such as malnutrition, early weaning, delayed consultation and inadequate assessment and classification of cases by health personnel at the first visit.

It is known that environmental factors influence the prevalence and severity profile of RSD with increased outpatient demand in the winter months, especially benign cases of upper airway infections. However, pneumonia and bronchiolitis have a significant proportional increase, a fact that reinforces the hospital demand<sup>(7)</sup>.

During the dry season in Campo Grande-MS, the relative humidity may reach levels incompatible with the integrity of the airways<sup>(10)</sup>. It is known that, for the proper functioning of the airways, there is a need for some level of humidity, which shall not be less than 60%<sup>(23)</sup>. The airways make great effort to try to maintain internal homeostasis with the quality of the air inhaled, as the minimum relative humidity is very low, around 19% to 27% during the dry season<sup>(23)</sup>.

The results presented in this study represent a quantitative approach to the impact of climate data on population health. It is important to highlight that the outcome studied here - hospitalization - is just one of the many effects caused by meteorological data. Effects such as the onset of symptoms, use of medication, social conditions, reduced physical activity, among others, were not assessed in this study. These effects, which are considered less harmful to the individual's health, are of great importance to public health due to the high frequency with which they occur and due to the negative impact on quality of life and negative economic consequences, including school and work absenteeism.

The World Health Organization (WHO) and the United Nations Environment Programme (UNEP) estimate that the thermal comfort conditions will affect thousands

of people, since they are related to the climate and form of appropriation and interaction with local and/or regional spaces. In general, poor people suffer more from excessive heat and have difficulties in adapting to new conditions because of the lack of financial resources and, consequently, living conditions. Furthermore, urban areas are more affected than rural areas, mainly because of the abundance of surfaces that retain heat. Thus, the increase and/or decrease in temperature affect the human health in various ways and in different proportions. According to the IPCC (Intergovernmental Panel on Climate Change), in addition to deaths directly caused by the occurrence of an extreme event and the impact of this event on the local infrastructure and natural resources, climate changes can lead to an increase in malnutrition, the spread of diseases transmitted by water or other vectors, the increased frequency of cardio-respiratory diseases from air pollution, the reduced productivity of the population affected and an increased spending on medicines and health care. Over the last three decades, social problems, in addition to changes in temperature, humidity and biodiversity, have altered the balance between predators, competitors and preys, preventing pests and pathogens to be under control and hence contributing to the resurgence of infectious diseases<sup>(24)</sup>.

Estimating the risk to the health of the population due to weather variables is a first step in the planning and implementation of actions aimed at a healthier environment. The production of technically well-grounded data is critical to the formulation of public policies and decision-making to promote socioeconomic development and take into account environmental issues and quality of life of people. The results presented here indicate, in quantitative terms, the risk for an increase in the number of hospitalizations of children under the age of 4 and individuals over the age of 60, according to an increase or a decrease in temperature, humidity, rainfall and wind speed in the city of Campo Grande-MS. The data presented here are expected to serve as tools for a better understanding of the impact of weather variables on people's health, contributing to the monitoring and sanitation of this issue in Campo Grande-MS and other cities.

## CONCLUSION

This study aimed to build a predictive model that could estimate the number of hospitalizations for respiratory diseases by age group and demonstrate the association between this outcome and the main weather variables in Campo Grande-MS, taking into account the relevance of knowing the epidemiological characteristics of the disease and the climate peculiarities of the region. The use of multiple

linear regression was satisfactory for demonstrating the association between hospitalization for respiratory system diseases (RSD) by age group and the study variables. Based on the investigations carried out, it can be concluded that there is a significant correlation between weather variables and hospitalizations for respiratory diseases.

## REFERENCES

1. Baccine M, Biggeri A, Accetta G, Kosatsky T, Katsouyanni K, Analitis A, et al. Heat effects on mortality in 15 European cities. *Epidemiology*. 2008;19(5):711-9.
2. Jimenez-conde J, Ois A, Rodriguez-campello A, Cuadrado-godia E, Subirana I, ROQUER J: Weather as a trigger of stroke. *Cerebrovasc Dis*. 2008;26(4):348-54.
3. Souza A, Guo Y, Pavão HG, Fernandes WA. Effects of Air Pollution on Disease Respiratory: Structures Lag. *Health*. 2014;6(12):1333-9.
4. Oliveira BRG, Viera CS, Furtado MC, Mello DF, Lima RAG. Perfil de morbidade de crianças hospitalizadas em um hospital público: implicações para a Enfermagem. *Rev Bras Enferm*. 2012;65(4):586-93.
5. Islam F, Sarma R, Debroy A, Kar S, Pal R. Profiling Acute Respiratory Tract Infections in Children from Assam, India. *J Glob Infect Dis*. 2013;5(1):8-14.
6. Rosa AM, Ignotti E, Botelho C, Castro HA de, Hacon SS. Doença respiratória e sazonalidade climática em menores de 15 anos em um município da Amazônia brasileira. *J Pediatr (Rio J)*. 2008;84(6):543-9.
7. Silva Júnior JL, Padilha TF, Rezende JE, Rabelo EC, Ferreira AC, Rabahi MF. Effect of seasonality on the occurrence of respiratory symptoms in a Brazilian city with a tropical climate. *J Bras Pneumol*. 2011;37(6):759-67.
8. Arbex MA, Santos UP, Martins LC, Saldiva PHN, Pereira LAA, Braga ALF. A poluição do ar e o sistema respiratório. *J Bras Pneumol*. 2012;38(5):643-655.
9. Souza A, Aristone F, Pavão HG, Fernandes WA. Development of a Short-Term Ozone Prediction Tool in Campo Grande-MS-Brazil Area Based on Meteorological Variables. *OJAP*. 2014;3(2):42-51.
10. Souza A, Pavao HG, Lastoria G, Gabas SG, Paranhos Filho AC, Cavazzana GH. Distribuição espacial da relação precipitação/número de dias de chuvas em Campo Grande-MS. *Seminário de recursos hídricos da bacia hidrográfica do Paraíba do Sul*. Taubaté; 2009.

11. Latorre MRDO, Cardoso MRA. Análise de séries temporais em epidemiologia: uma introdução sobre aspectos metodológicos. *Rev Bras Epidemiol.* 2001;4(3):145-52.
12. Souza A, Schujmann E, Fachel JMG, Fernandes, WA. Indicadores ambientais e doenças respiratórias em crianças. *Mercator.* 2013;12(27):101-9.
13. Silva AMC, Matos IE, Freitas SR, Longo KM, Hacon SS. “Material particulado (PM2. 5) de queima de biomassa e doenças respiratórias no sul da Amazônia brasileira; Particulate matter (PM2. 5) of biomass burning emissions and respiratory diseases in the south of the Brazilian Amazon.” *Rev Bras Epidemiol.* 2010;13(2):337-51.
14. Rosa AM, Ignotti E, Botelho C, Castro HA, Hacon SS. Respiratory disease and climatic seasonality in children under 15 years old in a town in the Brazilian Amazon. *J Pediatr (Rio J).* 2008;84(6):543-9.
15. Kunst AE, Looman CW, Mackenbach JP. Outdoor air temperature and mortality in the Netherlands: a time series analysis. *Am J Epidemiol.* 1993;137(3):331-41.
16. Mercer JB, Osterud B, Tveita T. The effect of short-term mild cold exposure on risk factors for cardiovascular disease. *Thromb Res.* 1999;95(2):93-104.
17. Jehn M, Appel LJ, Sacks FM, Miller ER. The effect of ambient temperature and barometric pressure on ambulatory blood pressure variability. *Am J Hypertens.* 2002; 15(11):941-5.
18. Burse RL: Sex differences in human thermoregulatory response to heat and cold stress. *Human factors.* 1979;21(6):687-699.
19. Keatinge WR, Cloeshaw SRK, Easton JC, Cotter F, Mattock MB, Chelliah R. Increased platelet and red cell counts, blood viscosity and plasma cholesterol level during heat stress and mortality from coronary and cerebral thrombosis. *Am J Med.* 1986; 81(5):795-800.
20. Shirreffs SM: Heat stress, thermoregulation and fluid balance in women. *Br J Sports Med.* 1999;33(4):225.
21. Pan WH, Li LA, Tsai MJ. Temperature extremes and mortality from coronary heart disease and cerebral infarction in elderly Chinese. *Lancet.* 1995;345(8946):353-5.
22. Niobey FML, Duchiate MP, Vasconcelos AGG, Carvalho ML, Leal MC, Valente JC. Fatores de risco para morte por pneumonia em menores de um ano em região metropolitana do Sudeste do Brasil. Um estudo de tipo caso-controle. *Rev Saúde Pública.* 1992;26(4):229-38 .
23. Organización Panamericana de la Salud, Organización Mundial de la Salud. Investigaciones operativas prioritarias para evaluar el impacto de las acciones de control de las infecciones respiratorias agudas. Ginebra: OPS/OMS; 1992.
24. Hungria H, Palombini BC, Pereira AP. Vias respiratórias superiores e inferiores – Correlações fisiopatológicas e clínicas. In: Bethlem N, organizador. *Pneumologia.* 4ª ed. São Paulo: Atheneu; 1996. p. 69-76.
25. Intergovernmental Panel on Climate Change - IPCC. Summary for policymakers. In: Solomon D, Qin M, Manning Z, Chen M, Marquis KB, Averyt M, editors. *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press, 2007. [2014 Feb 03]. Available in: [http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1\\_Print\\_SPM.pdf](http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_SPM.pdf)

**Mailing address:**

Universidade Federal de Mato Grosso do Sul  
Departamento de Física  
Cidade Universitaria, s/nº  
Bairro: Universitário  
CEP: 79070-900 - Campo Grande - MS - Brasil  
E-mail: amaury.de@uol.com.br