Effect of seasonality on the occurrence of respiratory symptoms in a Brazilian city with a tropical climate*

Efeito da sazonalidade climática na ocorrência de sintomas respiratórios em uma cidade de clima tropical*

José Laerte Rodrigues da Silva Júnior, Thiago Fintelman Padilha, Jordana Eduardo Rezende, Eliane Consuelo Alves Rabelo, Anna Carolina Galvão Ferreira, Marcelo Fouad Rabahi

Resumo

Objetivo: Avaliar o efeito da sazonalidade climática na ocorrência de sintomas respiratórios em uma cidade de clima tropical no Brasil. **Métodos:** Estudo de corte transversal relacionando dados de indivíduos que procuraram assistência médica em uma Unidade Básica de Saúde na cidade de Goiânia (GO) com dados meteorológicos coletados diariamente. No intervalo de um ano, todos os pacientes que preenchiam os critérios de inclusão foram entrevistados em 44 dias distintos (11 em cada estação) escolhidos aleatoriamente. ANOVA foi usada para a comparação das médias das variáveis dependentes por estação. Correlação foi conduzida entre as variáveis dependentes e cada variável meteorológica. Os efeitos das variáveis meteorológicas foram analisados com um modelo de *AutoRegressive Moving Average with eXogenous input* (ARMAX, média móvel autorregressiva com entrada exógena). **Resultados:** Dos 3.354 participantes, 494 (14,6%) apresentavam sintomas respiratórios. A variação de temperatura não foi suficiente para provocar mudanças no número de indivíduos com sintomas respiratórios; porém, houve aumento desse número com baixos níveis de umidade no inverno, com diferença estatisticamente significativa entre as estações (p < 0,01). Foi observado que a média da umidade relativa mínima dos três dias que antecederam as observações correlacionou-se negativamente com o número de indivíduos com sintomas respiratórios (p = 0,04), e um modelo ARMAX incluindo a mesma variável apresentou um coeficiente estatisticamente significativo (p < 0,0001). **Conclusões:** Nesta amostra, o número de indivíduos com sintomas respiratórios aumentou significativamente com a redução da umidade relativa do ar, e esse aumento pôde ser previsto a partir de dados meteorológicos.

Descritores: Estações do ano; Clima tropical/efeitos adversos; Sinais e sintomas respiratórios; Modelos logísticos.

Abstract

Objective: To evaluate the effect that seasonality has on the occurrence of respiratory symptoms in a Brazilian city with a tropical climate. **Methods:** This was a cross-sectional study, in which data related to subjects who sought outpatient treatment at a primary health care clinic in the city of Goiânia, Brazil, were correlated with daily meteorological data. Over a one-year period, all the patients who met the inclusion criteria were interviewed on 44 distinct, randomly selected days (11 days per season). We used ANOVA in order to compare the means of the dependent variables by season. Correlations were drawn between each dependent variable and each meteorological variable. The effects of the meteorological variables were analyzed with an AutoRegressive Moving Average with eXogenous input (ARMAX) model. **Results:** Of the 3,354 participants, 494 (14.6%) had respiratory symptoms. Although temperature variation alone had no effect on the number of individuals with respiratory symptoms, the low levels of humidity during winter resulted in a statistically significant difference among the seasons (p < 0.01). The mean minimum relative humidity on the three days prior to the interviews correlated negatively with the number of subjects with respiratory symptoms (p = 0.04). An ARMAX model including the same variable showed a statistically significant coefficient (p < 0.0001). **Conclusions:** In this sample, the number of subjects with respiratory symptoms increased significantly when the relative humidity dropped, and this increase could be predicted using meteorological data.

Keywords: Seasons; Tropical climate/adverse effects; Signs and symptoms, respiratory; Logistic models.

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Introduction

Seasonality has been researched because of potential risks to human health, especially in relation to the respiratory system.[1] Health risks include those directly related to climate and those occurring indirectly, because of sensitive biological systems, such as vector-borne infections, food-contaminating pathogens, aeroallergen production, and waterborne diseases.[2] The World Health Organization (WHO) states that climate plays an important role in the transmission of various infectious diseases that are among the leading causes of morbidity and mortality in developing countries.[3]

Although several effects of seasonality on public health in areas with a temperate-subtropical climate have been documented,[4-8] the relationships between health and climate have yet to be understood.[9] Some studies have found a connection between temperature or humidity and the increase in the proportion of respiratory diseases, however, those studies were based on secondary data, which are subject to biases, and this causes concern about their methodological validity and reliability.[10-17]

Because the interaction between climate and health is specific to geographic location,[10] the objective of the present study was to evaluate the effect that seasonality has on the occurrence of respiratory symptoms in subjects who sought outpatient treatment at a primary health care (PHC) clinic in a Brazilian city with a tropical climate, using primary data.

Methods

The study was carried out at a PHC clinic, the *Cais Novo Horizonte* Clinic, located in the city of Goiânia, Brazil. This clinic serves approximately 40 neighborhoods, which have a total of 170,000 inhabitants. The city of Goiânia has a semi-humid tropical climate, with a dry season (from May to September) and a wet season (from October to April).

In this study, 44 cross-sectional observations were performed between January 8 and December 17, 2009, 11 in each season. All patients who sought outpatient treatment at the PHC clinic were invited to participate in a survey evaluating the occurrence of respiratory symptoms. Climate data were obtained from meteorological instruments at the Central Station of the Meteorology and Hydrology System of the state of Goiás. The meteorological instruments used were under automatic operation and were located in the urban area of Goiânia, thereby reflecting the climatic conditions in the city.

The days of cross-sectional observation were randomly selected, occurring on weekdays and weekends, and each observation lasted 12 hours (from 7:00 a.m. to 7:00 p.m.) All subjects over 5 years of age who sought treatment at the PHC clinic for any reason were interviewed with six closed-ended questions in order to gather the following information: name; gender; age; presence of cough; presence of breathlessness, and presence of noisy breathing. The data were collected by medical students, who used specific data collection instruments and were specifically trained for this purpose. In order to ensure that all subjects who sought treatment at the PHC clinic would be interviewed, the data collection team was positioned near the counter at the main entrance to the clinic. Subjects who did not complete the interview were excluded. All participants gave written informed consent.

In this study, we used the following definitions:

- subjects with respiratory symptoms—subjects with cough, breathlessness, or noisy breathing, or any combination of the three
- subjects without respiratory symptoms—subjects without cough, breathlessness, or noisy breathing
- maximum temperature—highest temperature recorded on a given day
- minimum temperature—lowest temperature recorded on a given day
- mean temperature—mean of the 24 temperature values recorded at equidistant intervals over a 24-h period
- previous minimum temperature—mean of the minimum temperature values recorded on the last three days
- temperature variation (Δt)—difference between the maximum and minimum temperatures recorded on a given day
- maximum relative humidity—highest relative humidity on a given day
- minimum relative humidity—lowest relative humidity on a given day

- mean relative humidity—mean of the 24 relative humidity values recorded at equidistant intervals over a 24-h period
- previous minimum relative humidity—mean of the minimum relative humidity values recorded on the last three days
- wind velocity—velocity measured in m/s
- precipitation—accumulated rainfall depth (in mm) over a given 24-h period
- accumulated precipitation—total precipitation in the month preceding the day of analysis

The dependent variables of the study were the number of subjects with respiratory symptoms and the proportion of subjects with respiratory symptoms in relation to the total number of subjects who sought outpatient treatment at the PHC clinic on each observation day. To investigate a possible late effect of the meteorological variables, we generated variables for minimum temperature and relative humidity that described the patterns observed one to five days prior to each day of cross-sectional observation. The variables “previous minimum temperature” and “previous minimum relative humidity”, both created on the basis of the mean minimum humidity or minimum temperature values recorded three days prior to the days of cross-sectional observation, were selected for use because they correlate better with the dependent variables. The chi-square test was used for the analysis of dichotomous variables. Fisher’s exact test was used for the validation of the random distribution of the cross-sectional observations in relation to weekdays and weekends, and ANOVA was used for the comparison of the means of the dependent variables in each season. Pairwise correlation analysis was performed between each dependent variable and each meteorological variable. The effects of the meteorological variables were analyzed with a Poisson multivariate regression model, with logarithm as link function, and with an AutoRegressive Moving Average with eXogenous input (ARMAX) model. To analyze trends, we used LOcally WEighted Scatterplot Smoothing (LOWESS) regression with a standard bandwidth of 30%. The results were analyzed with the STATA program, version 11.0 (Stata Corp, College Station, TX, USA). For all tests, values of $p < 0.05$ were considered statistically significant. The study was approved by the Human and Animal Research Ethics Committee of the Federal University of Goiás *Hospital das Clínicas* (Protocol no. 142/2008). An explanation of the statistical method used in the present study is described in detail in the online supplement of the journal (www.jornaldepneumologia/xxx).

Results

During the study period, 3,396 subjects were interviewed (an average of 76 interviews per day in the 44 observations). Of those, 42 (1.2%) were excluded because they either did not complete the interview or did not meet the age criterion. Of the 3,354 subjects who were included in the study, 494 (14.6%) presented to the PHC clinic with respiratory symptoms (Table 1).

The most common symptom was cough, present in 439 subjects (88.9%), followed by breathlessness, in 281 (56.9%), and noisy breathing, in 185 (37.5%). Female patients predominated (56.4%), with no statistically significant differences among seasons. There were statistically significant differences in the age distribution among seasons when the subjects were divided as follows: children (5-9 years of age); adolescents (10-19 years of age); adults (20-64 years of age); and elderly subjects (≥ 65 years; $p = 0.007$). The age distribution showed a predominance of children in winter and a reduced number of elderly subjects in spring. There were statistically significant differences in the presence or absence of respiratory symptoms among seasons ($p < 0.0001$). Respiratory symptoms were more common in winter and less common in spring. The median precipitation, the median relative humidity, and the median minimum temperature were lower in winter, whereas the median wind velocity was higher in winter. The median maximum temperature, the median mean temperature, and the median previous minimum temperature were lower in autumn. The Δt was higher in winter (Table 2). Fisher’s exact test was used for the validation of the random distribution of the cross-sectional observations in relation to weekdays and weekends. The test revealed that there were no statistically significant differences when the observations were arranged in a contingency table by day of the week (Monday through Sunday) in relation to the four seasons of the year ($p = 0.14$).

Table 1 – Descriptive statistics of dependent and meteorological variables between January 8 and December 17, 2009, Goiânia, Brazil.

Variable	n (%)	Mean ± SD	Median	Range	Days
Total number of subjects, n	3,354 (100.0)	76.2 ± 47.7	60	19-209	44
Subjects without respiratory symptoms, n (%)	2,860 (85.4)	65.0 ± 41.8	52	15-185	44
Subjects with respiratory symptoms, n (%)	494 (14.6)	11.2 ± 10.3	7.5	0-45	44
Precipitation, mm		3.9 ± 9.7	0	0-89	344
Accumulated precipitation, mm		51 ± 63	24	0-276	344
Wind velocity, m/s		1.4 ± 0.4	1.3	0.7-3.2	344
Maximum relative humidity, %		84.4 ± 12.9	88	43-100	344
Minimum relative humidity, %		44.8 ± 12.8	46	18-91	344
Mean relative humidity, %		63.1 ± 15.4	64.8	27.0-95.7	328
Previous mean relative humidity, %		44.5 ± 13.0	44.8	18.7-73.7	344
Maximum temperature, °C		28.8 ± 2.2	28.9	21.3-34.3	344
Minimum temperature, °C		19.7 ± 1.8	19.9	10.3-26.0	344
Previous minimum temperature, %		19.6 ± 1.9	20.0	13.9-24.3	344
Mean temperature, °C		23.7 ± 1.8	23.6	15.7-28.3	331
Δtemperature, °C		9.1 ± 1.9	9.1	2.9-14.5	344

Days: number of observation days.

The relationship between the meteorological variables and the number of subjects with and without respiratory symptoms can be seen in Figure 1. Visual inspection of the LOWESS regression curves identified a possible association of low relative humidity levels, lower temperatures, and low precipitation levels with an increase in the number of subjects with respiratory symptoms in winter (Figure 1). An increase in wind velocity was also recorded in winter. However, a similar pattern of increase in velocity was also seen in spring and it was not associated with an increase in the number of subjects with respiratory symptoms (Figure 1).

Table 2 – Demographic characteristics, presence of symptoms, and meteorological variables by season.

Variable	Season				Total	p*
	Summer	Autumn	Winter	Spring		
Gender, n (%)						
Male	332 (43.0)	388 (43.1)	405 (43.7)	336 (44.4)	1,461 (43.6)	0.9
Female	440 (57.0)	512 (56.9)	521 (56.3)	420 (55.6)	1,893 (56.4)	
Age, n (%)						
≤ 9 years	41 (5.3)	55 (6.1)	83 (9.0)**	45 (6.0)	224 (6.8)	0.007
10-19 years	115 (14.9)	147 (16.3)	145 (15.7)	137 (18.1)	544 (16.2)	
20-64 years	515 (66.7)	579 (64.4)	579 (62.4)	506 (66.9)	2,179 (64.9)	
≥ 65 years	101 (13.1)	119 (13.2)	119 (12.9)	68 (9.0)**	407 (12.1)	
Respiratory symptoms, n (%)						
Absent	667 (87.6)**	784 (87.1)	713 (77.0)**	687 (90.9)**	2,860 (85.3)	< 0.0001
Present	96 (12.4)**	116 (12.9)	213 (23.0)**	69 (9.1)**	494 (14.7)	
Total precipitation, mm	343.3	314.6	69.4	779		
Relative humidity,[a] %						
Minimum	49.0	46.0	30.5	50.5		
Mean	62.5	65.5	44.7	77.5		
Maximum	92.0	89.0	69.0	93.5		
Previous[b]	52.0	41.3	28.0	52.0		
Wind velocity,[a] m/s	1.3	1.3	1.5	1.4		
Temperature,[a] °C						
Minimum	20.7	19.1	18.8	20.4		
Mean	24.4	22.9	23.4	24.2		
Maximum	29.6	27.8	29.1	29.4		
Previous[c]	20.4	18.8	19.3	20.6		
Δtemperature	9.1	8.9	10.2	8.5		

*Chi-square test. **Significant adjusted residual (cut-off value = 1.96). [a]Values expressed as median. [b]Mean minimum relative humidity three days prior to each observation. [c]Mean minimum temperature three days prior to each observation.

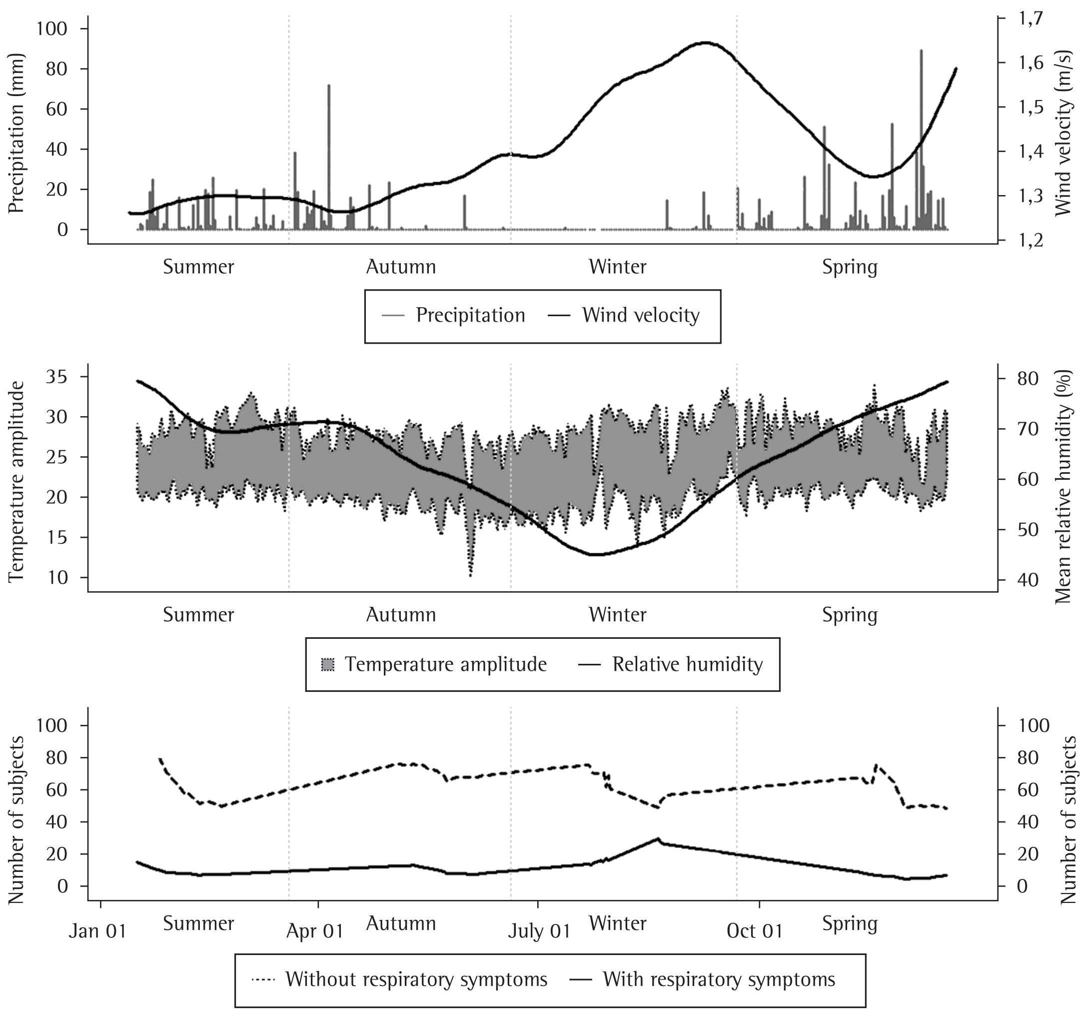

Figure 1 - Time series of meteorological variables and number of subjects with and without respiratory symptoms at a primary health care clinic in the city of Goiânia, Brazil, in 2009. The temperature area represents the amplitude of daily temperatures. The other data are presented by LOcally WEighted Scatterplot Smoothing curves with a bandwidth of 30%.

A statistically significant difference was found by ANOVA ($p < 0.01$) only for the subjects with respiratory symptoms (Bartlett's test; $p = 0.08$). The Tukey-Kramer test showed that the mean number of subjects with respiratory symptoms was significantly higher in winter than in other seasons (Figure 2). There were statistically significant differences in the comparison of the mean number of subjects with respiratory symptoms by season in all age groups (ANOVA; $p = 0.02$, $p = 0.02$, and $p = 0.03$ in children, adolescents, and adults, respectively), except in the group of elderly subjects ($p = 0.20$). The post-ANOVA Tukey-Kramer test showed that the mean number of children with respiratory symptoms was significantly higher in winter than in other seasons ($p = 0.04$); regarding adolescents and adults, although the mean number of subjects with respiratory symptoms was higher in winter than in other seasons, the difference was significant for summer and spring but not for autumn ($p < 0.05$).

In the initial analysis, there were statistically significant correlations between the number of subjects with respiratory symptoms and four meteorological variables: minimum relative humidity (coefficient, −0.32; $p = 0.04$); minimum temperature (coefficient, −0.30; $p < 0.05$);

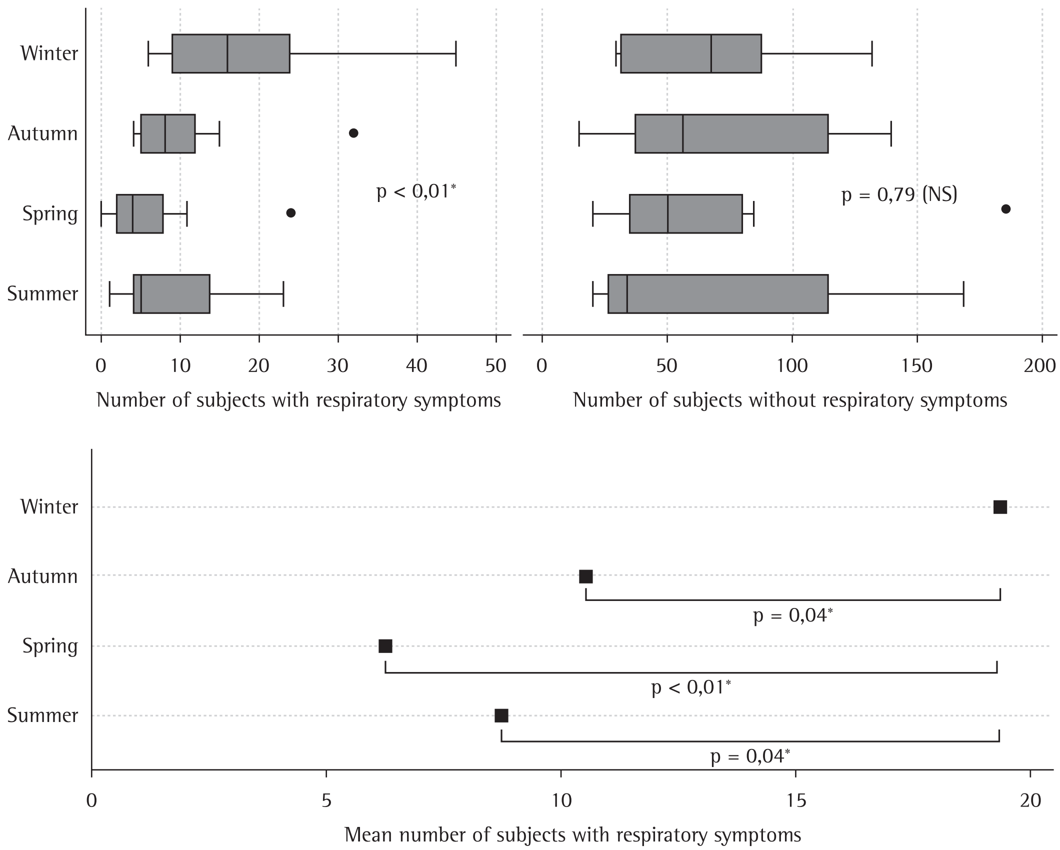

Figure 2 - Subjects with and without respiratory symptoms by season. The upper graphs show box-whisker plots and ANOVA results. The lower graph shows the post-ANOVA analysis with the Tukey-Kramer test. NS: Not significant. *p < 0.05.

previous minimum relative humidity (coefficient, −0.46; p = 0.002); and Δt (coefficient, +0.30; p < 0.05). The Bonferroni adjustment of significance levels ensured the negative correlation of the variable "previous minimum relative humidity" (p = 0.04) and discarded the remaining variables.

The Poisson regression model, with previous minimum relative humidity as an exposure variable and minimum temperature and Δt as independent variables, was statistically significant (p < 0.00001). However, the fit was poor (pseudo-R^2 = 0.17), and the goodness-of-fit test revealed that the predictions differed significantly from the observed counts (p < 0.00001).

The Phillips-Perron test confirmed that only the variable "proportion of subjects with respiratory symptoms" met the requirement of stationarity of an AutoRegressive Integrated Moving Average (ARIMA) model (p < 0.0001). For an ARMAX model, the variable "previous minimum relative humidity" was included as an exogenous variable in order to improve prediction accuracy. All coefficients were statistically significant: autoregressive coefficient (coefficient, 0.59; 95% CI: 0.22-0.96; p < 0.0001); previous minimum relative humidity (coefficient, −0.37; 95% CI: −0.61 to −0.12; p = 0.003); constant (coefficient, 30.37; 95% CI: 18.69-42.77; p < 0.0001); and sigma (coefficient, 6.8; 95% CI: 4.2-9.3; p < 0.0001). The Portmanteau test for white noise showed that there was no statistically significant autocorrelation between residuals (p = 0.9). The model fit is graphically shown in Figure 3.

Discussion

The population who sought treatment at the PHC clinic was found to be female-predominant (56.4%). This finding has been described in a large multi-center study conducted by the WHO

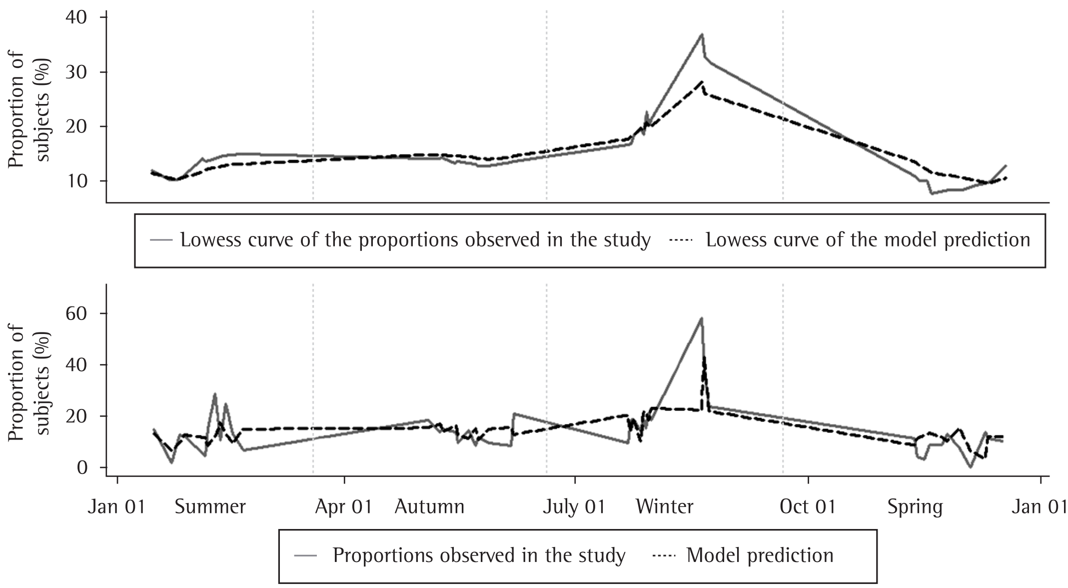

Figure 3 – AutoRegressive Moving Average with eXogenous input model showing the observed proportion of subjects with respiratory symptoms and the model prediction. In the lower graph, untreated data. In the upper graph, LOcally WEighted Scatterplot Smoothing (LOWESS) curves with a bandwidth of 30%.

in nine developing countries: 50-60% of the subjects who sought treatment at PHC clinics were female.[18] It has been suggested that women are more aware that they should seek medical attention when necessary, as well as being in a more constrained financial situation to seek medical attention outside the public health care system than are men.[19] The proportion of subjects with respiratory symptoms found in the present study (15%) is in accordance with the mean value reported by the WHO (18%).[18]

Low relative humidity is considered a risk to the integrity of the airway because it alters the balance of the respiratory tract.[1] The increase in the number of subjects who had respiratory symptoms in winter was associated with a significant reduction in humidity as a result of low rainfall. This finding has not been reported in studies based on secondary data conducted in Brazil.[1,15-17] Those studies found an increase in the number of patients in the period of high humidity,[1,17] they found no association[16] or reported ambiguous associations (an increase in the number of outpatients in the period of high humidity and an increase in the number of hospitalizations for respiratory disease in the period of low humidity).[15] The present study, however, uses primary data, which are less subject to biases and are therefore more apt to produce reliable data.

The difference in the mean number of subjects with respiratory symptoms among the seasons of the year was not caused by a more susceptible age group (children), because statistically significant differences among the means remained in nearly all of the age groups (children, adolescents, and adults), which corresponded to 88% of the subjects evaluated. The number of subjects with respiratory symptoms was significantly higher in winter than in other seasons in the analysis by age group, except for the group of subjects over 65 years of age. Because of the higher prevalence of chronic diseases in this age group, there might have been a proneness to seek medical attention, caused by decompensation and respiratory symptoms, also in other seasons, bringing the means obtained for these seasons closer to that obtained for winter. Regarding the group of adolescents and adults, the lack of a statistically significant difference between the mean number of subjects with respiratory symptoms in winter and in autumn could be explained by the sample size (494 subjects with respiratory symptoms). It is likely that, in a larger sample, the observed difference in the means would be statistically significant.

The decrease in temperature was not significantly associated with the increase in the number of subjects with respiratory symptoms, as might be expected. In tropical areas, the seasonal changes in temperature over the year are not of great magnitude. The mean annual temperature recorded was 23.7°C, whereas the annual minimum temperature was 19.7°C, a difference of only 4°C. Similar findings have been described in studies assessing the effects of temperature conducted in Brazil.[1,15-17]

Pairwise correlation analysis revealed a strong connection between the number of subjects with respiratory symptoms and a variable that describes a pattern of previous days rather than a daily pattern. This might represent a late effect of climate on health,[10] or it could be explained by a delay in seeking medical attention, a situation that is common in Brazil.[20,21]

The ARMAX model fit in the present study reflects the significant effect of the variable "previous minimum relative humidity". Because this variable yielded a good prediction of the proportion of subjects with respiratory symptoms who sought treatment at the PHC clinic over the year, it is important to consider these results in public health. Because most of Brazil has a semi-humid tropical climate, with well-defined wet and dry seasons and small temperature variations, the major meteorological variable related to respiratory symptoms is relative humidity. In order to mitigate the deleterious effects of this seasonal variable, health education policies, aimed at instructing the population and reducing the effects of low humidity on the airway, should be reinforced in the dry season. In addition, since climatic conditions can be predicted, the increase in the demand on the health care system in relation to respiratory diseases can be anticipated, this being in agreement with the WHO recommendation, which stimulates the development of models that can predict an increase in diseases, because, if these models show good accuracy, they can be invaluable in fighting and preventing epidemics.[3]

The major limitation of the present study is the fact that air pollution was not investigated, because there is no systematic air quality monitoring in the city of Goiânia. Despite the fact that the increase in wind velocity in winter affects the dispersion of pollutants and particulate matter, leading to a reduction of their levels in the air,[22] in addition to the fact that the location of the PHC clinic (which is approximately 10 km from the city center and serves a population who lives in areas that have a smoother flow of vehicles, are not industrialized, and have low buildings) mitigates the effects of pollution,[23] pollution per se could explain the results or it could be associated with low humidity. Further studies, with records of humidity and particulate matter levels, could be performed in order to elucidate the findings of the present study.

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References

1. 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.
2. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ; Comparative Risk Assessment Collaborating Group. Selected major risk factors and global and regional burden of disease. Lancet. 2002;360(9343):1347-60.
3. Global Partnership to Roll Back Malaria. Using climate to predict infectious disease outbreaks: a review. Geneva: World Health Organization; 2004.
4. Zanolin ME, Pattaro C, Corsico A, Bugiani M, Carrozzi L, Casali L, al al. The role of climate on the geographic variability of asthma, allergic rhinitis and respiratory symptoms: results from the Italian study of asthma in young adults. Allergy. 2004;59(3):306-14.
5. Moyes CD, Waldon J, Ramadas D, Crane J, Pearce N. Respiratory symptoms and environmental factors in schoolchildren in the Bay of Plenty. N Z Med J. 1995;108(1007):358-61.
6. Lee YL, Shaw CK, Su HJ, Lai JS, Ko YC, Huang SL, al al. Climate, traffic-related air pollutants and allergic rhinitis prevalence in middle-school children in Taiwan. Eur Respir J. 2003;21(6):964-70.
7. Kotaniemi JT, Pallasaho P, Sovijärvi AR, Laitinen LA, Lundbäck B. Respiratory symptoms and asthma in relation to cold climate, inhaled allergens, and irritants: a comparison between northern and southern Finland. J Asthma. 2002;39(7):649-58.
8. Gosai A, Salinger J, Dirks K. Climate and respiratory disease in Auckland, New Zealand. Aust N Z J Public Health. 2009;33(6):521-6.
9. McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. Lancet. 2006;367(9513):859-69.
10. Kendrovski VT. The impact of ambient temperature on mortality among the urban population in Skopje, Macedonia during the period 1996-2000. BMC Public Health. 2006;6:44.

11. Liang WM, Liu WP, Kuo HW. Diurnal temperature range and emergency room admissions for chronic obstructive pulmonary disease in Taiwan. Int J Biometeorol. 2009;53(1):17-23.
12. Green RS, Basu R, Malig B, Broadwin R, Kim JJ, Ostro B. The effect of temperature on hospital admissions in nine California counties. Int J Public Health. 2010;55(2):113-21.
13. O'Neill MS, Hajat S, Zanobetti A, Ramirez-Aguilar M, Schwartz J. Impact of control for air pollution and respiratory epidemics on the estimated associations of temperature and daily mortality. Int J Biometeorol. 2005;50(2):121-9.
14. Braga AL, Zanobetti A, Schwartz J. The effect of weather on respiratory and cardiovascular deaths in 12 U.S. cities. Environ Health Perspect. 2002;110(9):859-63.
15. Botelho C, Correia AL, da Silva AM, Macedo AG, Silva CO. Environmental factors and hospitalization of under-five children with acute respiratory infection [Article in Portuguese]. Cad Saude Publica. 2003;19(6):1771-80.
16. Façanha MC, Pinheiro AC. Distribution of acute respiratory diseases in Brazil from 1996 to 2001, Brazil [Article in Portuguese]. Rev Saude Publica. 2004;38(3):346-50.
17. Valença LM, Restivo PC, Nunes MS. Seasonal variations in emergency room visits for asthma attacks in Gama, Brazil. J Bras Pneumol. 2006;32(4):284-9.
18. World Health Organization. Respiratory care in primary care services: a survey in 9 countries. Geneva: World Health Organization; 2004.
19. Aït-Khaled N, Enarson D, Bousquet J. Chronic respiratory diseases in developing countries: the burden and strategies for prevention and management. Bull World Health Organ. 2001;79(10):971-9.
20. Job JR, Prado PE, Vranjac S, Duarte PC. Comparison of epidemiological data on pulmonary tuberculosis in Sorocaba, São Paulo, Brazil, (1986-1996) [Article in Portuguese]. Rev Saude Publica. 1998;32(6):596-7.
21. Pelaquin MH, Souza e Silva R, Ribeiro SA. Factors associated with death by tuberculosis in the eastern part of São Paulo city, 2001. J Bras Pneumol. 2007;33(3):311-7.
22. Colls J. Meteorology and Modelling. In: Colls J, editor. Air pollution. New York: Spon Press; 2002. p. 267-9.
23. Marcilio I, Gouveia N. Quantifying the impact of air pollution on the urban population of Brazil. Cad Saude Publica. 2007;23 Suppl 4:S529-36.

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