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ORIGINAL ARTICLE

Correlation between weather, population size and COVID-19 pandemic: a study of Brazilian capitals

Correlação entre clima, tamanho da população e pandemia da COVID-19:um estudo das capitais brasileiras

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Abstract

Objective: To analyze the correlation between weather, population size and cases of COVID-19 in the capitals of Brazil. **Methods**: All confirmed cases of COVID-19 infection, from the first confirmed case from February 26 until May 01, 2020 were included. For weather variables, average temperature (°C), dew point (°C), average humidity (%) and wind speed (m s-1) were extracted from the Instituto de Meteorologia database. The population size of each capital was used as a control variable, with data obtained from Instituto Brasileiro de Geografia e Estatística. Spearman rank correlation tests were utilized to examine the correlation between variables. **Results**: The analysis showed a significant and strong positive correlation between the total cases of COVID-19 and the population size (p<0,01). There was a significant positive correlation with the average humidity of the air and cumulative cases (p<0,05). There was no significant correlation with other climate variables. **Conclusion**: Our results confront some expectations commented around the world about a possible seasonality of COVID-19 during periods of low humidity and can assist government and health authorities in decision making to control the pandemic. Studies in other regions are important to strengthen the findings.

Keywords: : SARS-CoV-2. Weather. Temperature. Humidity. Population.

Resumo

Objetivo: Analisar a correlação entre clima, tamanho da população e casos de COVID-19 nas capitais do Brasil. **Métodos**: Foram incluídos todos os casos confirmados de infecção por COVID-19, do primeiro caso confirmado de 26 de fevereiro a 01 de maio de 2020. Para variáveis meteorológicas, temperatura média (° C), ponto de orvalho (° C), umidade média (%) e velocidade do vento (m s-1) foram extraídos da base de dados do Instituto de Meteorologia. O tamanho da população de cada capital foi utilizado como variável de controle, com dados obtidos no Instituto Brasileiro de Geografia e Estatística. Correlação de Spearman foi utilizado para verificar a correlação entre variáveis. **Resultados**: A análise mostrou uma correlação positiva significativa e forte entre o total de casos de COVID-19 e o tamanho da população (p <0,01). Houve correlação positiva significativa com a umidade média do ar e os casos acumulados (p <0,05). Não houve correlação significativa com outras variáveis climáticas. **Conclusão**: Os resultados confrontam algumas expectativas comentadas em todo o mundo sobre uma possível sazonalidade do COVID-19 durante períodos de baixa umidade e podem auxiliar autoridades governamentais e de saúde na tomada de decisões para controlar a pandemia. Estudos em outras regiões são importantes para fortalecer os resultados.

Palavras-chave: COVID-19. SARS-CoV-2. Clima. Temperatura. Umidade. População.

INTRODUCTION

In late December 2019, an outbreak of Severe Acute Respiratory Syndrome (SARS) caused by a new type of coronavirus (CoV-2) was described in China and soon spread around the world[1]. As of May 28, 2020, there were 3,419,184 of confirmed cases of disease resulting from SARS CoV-2, named COVID-19. The number of new cases in China has substantially reduced since the end of February. After, countries in Europe became the new world epicenter, followed by the United States. Current scenarios with the highest number of confirmed cases are the United States and Spain, which have a total of 1,127,712 and 216,582, respectively. The pandemic has already caused more than 243,600 deaths globally[2].

The epicenter of COVID-19 changes as the virus spreads between geographic spaces and depends largely on the speed of responses from government authorities to provide adequate support for patients and to interrupt transmission cycle[3,4], which occurs mainly through aspiration or contact with respiratory secretions of infected individuals[5]. However, in addition to the practices adopted in the communities, other factors related to the pathogen themselves, the host and the environment can influence the course of infectious diseases6. These observations are important to predict possible seasonality and guide more specific control measures.

Historically, climatic conditions have already been described as a factor that can influence the spread of respiratory viruses, such as coronaviruses from past epidemics, influenza and syncytial virus[7,8,9]. However, the weather influence for COVID-19 is not yet clear. Studies have already been carried out

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in countries located in the northern hemisphere or considering global climate data, with varying results[10,11,12,13,14,15]. Most of these published results suggest that environments with lower humidity and temperature are favorable for the spread of SARS-CoV-2. However, studies in specific regions and with varied climate data are necessary to strengthen or not this hypothesis. Here, we analyze the correlation of the climate with the cases of COVID-19 in the capitals of Brazil, a country characterized by being 90% within the tropical zone.

METHODS

Study area

Brazil is considered a country with continental dimensions, with a territorial extension of 8,514,876 km^2. Its area corresponds to about 1.6% of the entire surface of the planet and occupies 20.8% and 48% of the area of all of America and South America, respectively[16] (IBGE, 2020).

The spatial units of analysis of this study were all 27 capitals of Brazil. The main latitude and longitude of Brazil are 16º South and 55º West. Although 90% of the country is within the tropical zone, the climate of Brazil varies considerably from the zone crosses the country at the latitude of the city of São Paulo[16].

Data sources

The study included all confirmed cases of COVID-19 infection, from the first confirmed case until May 1, 2020. COVID-19 infection was defined as a case with a positive result for viral nucleic acid testing in respiratory specimens or with a positive serological test. This data was collected from the official website that reported the situation of COVID-19 infection in Brazil.
For weather variables, hourly data of average air temperature (°C), dew point temperature (ºC), average air humidity (%) and wind speed (m s^{-1}) were extracted from the Instituto Nacional de Meteorologia database – INMET (http://www.inmet.gov.br/) from Apr 18 to May 01, 2020. This period within 14 days was considered to assess whether fluctuations in weather records can influence correlations. The population size of each capital was used as a control variable, with data obtained from Instituto Brasileiro de Geografia e Estatística - IBGE (http://www.ibge.gov.br).

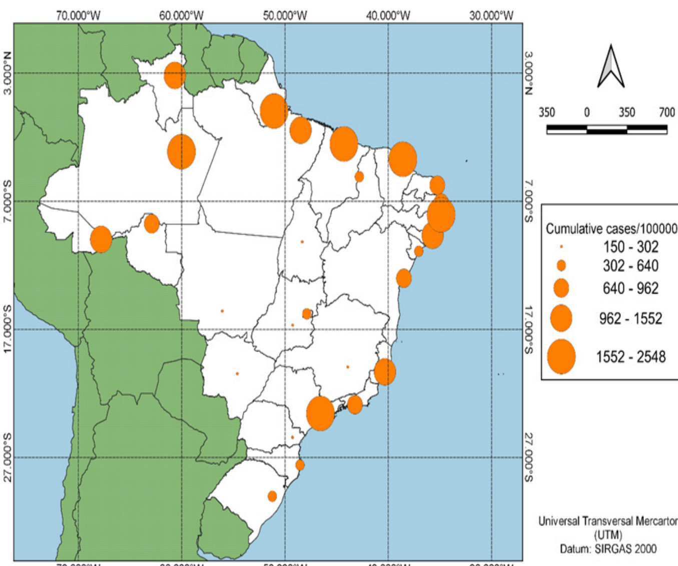
Data analysis

Data were organized in Microsoft Excel (Windows version 2016, Microsoft Corporation; Redmond, WA, USA) and incorporated into Jeffrey's Amazing Statistics Program (JASP®) software version 0.9.1. As the data was not normally distributed therefore Spearman rank correlation tests were utilized to examine the correlation between variables.

RESULTS

The first case of COVID-19 in Brazil was officially registered on February 26, 2020 in São Paulo, in an individual with a history of travel to Italy. As of May 1, 2020 there were already 92,596 cumulative cases in the country. Of these cases, 54,981 come from individuals residing in the capitals. São Paulo is the registered capital with the highest number of total cases (19,087) followed by Rio de Janeiro (6189) and Fortaleza (6082). São Luiz represents the capital with the highest rate of cumulative cases followed by Recife and Fortaleza (2278), with 2548, 2296 and 2278 cases per 1,000,000 inhabitants, respectively. All the last three capitals described are located in a single region of the country (northeast). Figure 1 shows the map of Brazil and the cumulative rates of COVID-19 for their respective capitals.

Figure 1. Cumulative cases of COVID-19 per one million inhabitants in Brazilian capitals



Regarding the climatic data of the analyzed capitals, Curitiba was the place that registered the lowest average temperature (17.4 ºC) during the study period and Boa Vista the highest medical temperature (28.7 ºC). The highest record of the dew point was found in Natal, with 24.2 ºC, while the lowest was in Curitiba (12.4 ºC). No results were obtained from the capitals Maceió, João Pessoa and Teresina for this variable. Average air humidity ranged from 89.34% in São Luiz to 53.9% in Campo Grande. The capitals Campo Grande and Belém registered the highest and lowest wind speed, with 2.83 m s-1 and 0.51 m s-1, respectively. Rio Branco and Porto Velho were the only capitals that did not present available climatological data for any of the studied variables. The detailed data are shown in Table 1.

The Spearman analysis showed a significant and strong positive correlation between the total cases of COVID-19 and the population size (p<0,01). There was a significant positive correlation with the average humidity of the air for the first seven days of recording cases (p<0,05). There was no significant correlation with other climate variables. The results are available in Table 2.

Table 1. Weather data for 25 Brazilian capitals, 2020.

City	Average Air Temperature (ºC)		Dew Point Temperature (ºC)		Average Air Humidity (%)		Wind speed (m s^{-1})	
	Mean	SD*	Mean	SD	Mean	SD	Mean	SD
São Paulo	19.64	1.38	13.24	0.77	68.34	3.54	1.80	0.48
Rio de Janeiro	23.39	0.92	18.95	0.60	76.73	4.49	1.88	0.67
Fortaleza	26.62	0.69	23.09	0.12	81.89	3.15	1.25	0.26
Recife	25.90	0.94	23.24	0.27	85.92	4.13	0.72	0.69
Manaus	26.89	1.14	23.41	0.54	81.96	3.72	1.19	0.30
São Luiz	26.01	0.41	24.06	0.29	89.34	2.21	0.92	0.21
Salvador	25.69	0.82	23.37	0.53	87.16	3.04	2.19	0.97
Belém	26.61	0.49	23.34	0.16	83.17	2.82	0.51	0.12
Brasília	20.36	0.59	17.10	2.09	83.87	9.26	2.02	0.52
Maceió	27.60	0.87	-	-	78.50	5.20	-	-
Macapá	26.54	0.20	23.56	0.29	84.64	1.63	1.54	0.18
João Pessoa	27.55	1.80	-	-	86.36	9.89	1.06	0.43
Belo Horizonte	20.74	0.77	14.59	1.74	69.71	4.06	1.44	0.61
Natal	27.09	0.50	24.21	0.37	84.82	1.06	2.48	0.84
Vitória	23.06	1.49	18.42	0.71	77.38	10.05	1.25	0.42
Boa Vista	28.70	1.34	20.87	1.21	64.54	9.11	2.01	0.28
Goiânia	23.17	1.76	18.43	2.35	77.04	9.62	0.79	0.28
Porto Alegre	20.42	1.78	14.92	1.72	73.52	5.26	1.17	0.10
Curitiba	17.40	2.18	12.35	1.39	66.94	8.01	1.21	0.25
Teresina	28.04	2.02	-	-	86.00	5.16	1.13	0.67
Florianópolis	21.39	0.54	15.90	0.90	72.27	3.67	1.63	0.30
Aracaju	26.60	0.60	20.49	0.86	69.93	5.24	1.60	0.32
Cuiabá	27.87	1.03	18.88	1.87	60.08	5.21	1.27	0.19
Campo Grande	24.40	0.98	14.04	1.99	53.99	5.06	2.83	0.58
Palmas	25.55	1.20	21.79	0.99	80.93	8.52	0.71	0.29

*SD – Standard Deviation.

Table 2. Spearman correlation between cases of COVID-19 and meteorological data in the capitals of Brazil, 2010.

	Rho
Dew point (n=22)	
Total population	0.704***
On the day	0.316
3 days ago	0.359
5 days ago	0.329
7 days ago	0.293
14 days ago	0.391
Average air Temperature (n=25)	
Total population	0.698***
On the day	-0.074
3 days ago	-0.110
5 days ago	-0.072

	Rho
7 days ago	-0.057
14 days ago	0.207
Average air Humidity (n=25)	
Total population	0.698***
On the day	0.392*
3 days ago	0.436**
5 days ago	0.431**
7 days ago	0.457**
14 days ago	0.217
Wind Speed (n=24)	
Total population	0.690***
On the day	-0.047
3 days ago	0.040
5 days ago	-0.054
7 days ago	0.061
14 days ago	-0.086

*p<0.1; **p<0.05; ***p<0.01

DISCUSSION

Using meteorological data available from April and May 2020, population data and pandemic data, this study investigated the correlation between climatic variables, population density and the occurrence of COVID-19 cases in the Brazilian capitals.

Among the components of the weather, only average air humidity was significantly correlated with the COVID-19 pandemic. However, this correlation was positive, contrary to the studies realized in cities in China, Spain and the United States, which showed a negative correlation between these variables[10,11,14,15]. These results contributed to the authors pointing out low humidity as a factor that can influence the transmission of SARS-CoV-2 and suggesting that the arrival of summer could decrease the cases of COVID-19[17].

We found a negative relationship between temperature and cases of COVID-19, although not significant. In contrast, this correlation was significant in the analyzes of countries in the Northern Hemisphere[10,12]. As COVID-19 had its appearance in less than six months worldwide and the published studies were analyzed in almost the same months, this difference between the results is likely due to the specificities of the climate in countries and cities. The seasonal climates of Brazil are nearly the reverse of the seasons in Europe and the United States of America. This inversion is visible for the case of influenza, which has marked circulation patterns in the Northern Hemisphere in the winter months of November to April, while in the Southern Hemisphere circulation begins in May.

Thus, despite the results of these individual studies, there is still no clear evidence that factors related to warmer climates may be sufficient and strong to control the pandemic, especially since other countries that are currently in the summer season also face a rapid spread of the virus, like Iran and Australia. This is quite similar to the Arabian Peninsula where Middle East Respiratory Syndrome Coronavirus (MERS-CoV) cases continue when temperatures are 45°C[18]. In addition, even in the northern hemisphere provinces, some analyses do not support the hypothesis that high temperatures could reduce the occurrence of COVID-19[19].

In turn, population density showed a significant strong positive correlation with the cases of COVID-19 in Brazilian capitals, similar to analyzes from other countries[10,12]. In this regard, it can be inferred that the people's mobility and crowd accelerate the spread of the virus. In fact, the density of the largest capital in Brazil, São Paulo, reaches more than 8000 inhabitants per km²; in only one of its most vulnerable communities lives 45 thousand inhabitants per km² and other aggravating socioeconomic factors are added to this population concentration, such as the lack of sanitary sewage, lack of running water, lack of adequate garbage collection, high rate of illiteracy and poverty[20]. This social reality further strengthens the importance of social isolation and health education work related to the use of masks and proper hand washing in the absence of a vaccine and specific treatment for COVID-19.

Our findings should be interpreted with caution. The study included secondary data and given the low availability of testing for diagnosis during the months studied, there is a strong possibility of underreporting of officially registered cases in Brazil. However, the analyzes carried out here can help central and local governments to deal with the emerging threat of COVID-19 at the current critical stage and contribute to the set of publications being carried out in other countries.

CONCLUSION

This study showed a positive correlation between the total number of COVID-19 cases, average air humidity and the population size of the capitals of Brazil. No other climatic data analyzed showed a significant correlation. The results found confront some expectations commented around the world about a possible seasonality of COVID-19 during periods of low humidity and can assist government and health authorities in decision making for measures to control the pandemic. Studies in other regions are important to strengthen the findings.

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