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Association of demographic and meteorological variables with COVID-19 occurrences and deaths

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ABSTRACT
The health crisis caused by COVID-19 is considered the most severe pandemic in the last 100 years. Because it is a serious public health problem, there are many studies aimed at understanding the evolution of cases and possible associations of meteorological and demographic factors with the contamination by the virus. Given this scenario, the objective of this study is to portray, based on literature, the associations between meteorological and demographic variables with COVID-19 contamination and spread, taking into account the global panorama. Regarding demographic variables, it was found that the age group and sex of the population are associated with the spread of COVID-19. Regarding meteorological variables, scientific studies point to an association between temperature, relative humidity and air quality in advancing the spread of the COVID-19 virus. It is noteworthy that among the studies evaluated, divergences were observed in the type and level of association between demographic and meteorological variables with the spread of viruses. These results demonstrate the particularity for each region and there is a need for more specific and in-depth studies in each region.

Keywords: Pandemic, Coronavirus, Relation, Climate, Population.

1 INTRODUCTION

During the history of society, several crises in health and other sectors have been caused by pathogens. The recent health crisis caused by COVID-19 is considered the most severe pandemic in the last 100 years. The novel coronavirus (SARS-CoV-2), responsible for the COVID-19 pandemic, was first reported on December 31, 2019 by the World Health Organization. Originating in China, the etiological agent reached most countries of the world in a short period, causing a major global health crisis (WHO, 2020).

SARS-CoV-2 is a spherical virus enveloped with positive RNA and single strands (CAMPOS and SANTOS, 2020), with approximately 30,000 nucleotides (SIDDEL, 2020). It belongs to the *coronaviridae* family, being responsible for two major epidemics in the last 20 years and the recent COVID-19 pandemic (YANG et al., 2020). The first epidemic was caused by SARS-CoV (Severe Acute Respiratory Syndrome), originating in 2002-2003 in Guangdong province, China, with more than 770 deaths (CHAN-YEUNG and XU, 2003) and the second by MERS-CoV (Middle East Respiratory Syndrome), in the Middle East in 2012-2013, emerging in Saudi Arabia in 2012 and reaching 30% lethality (WHO, 2019).

In Brazil, the first officially recorded case of SARS-Cov-2 contamination was on February 26, 2020, in the city of São Paulo (BRASIL, 2020). Since then, the number of those infected has grown exponentially. Due to the proportions of the pandemic crisis, nations around the world, including Brazil, have adopted quarantine and social isolation as a way to contain the virus.

Because it is a serious public health problem, there is much scientific research aimed at understanding the evolution of cases and possible associations of meteorological and demographic factors with contamination by the virus. Previous studies conducted with SARS-CoV have shown that the transmission of the pathogen can be influenced by meteorological factors, such as: temperature and relative humidity of the air, wind speed, solar radiation and precipitation (CASANOVA et al., 2010; AHMADI et al., 2020, AULER et al., 2020; BASHIR et al., 2020; OLIVEIROS et al., 2020; SILVER et al., 2020; IQ et al., 2020; SOBRAL et al., 2020; WANG et al., 2020b).

In addition to these factors, demographic characteristics may also play a determining role in the rate of transmission of the virus in the population. According to Şahin (2020), there are indications of a direct relationship between the characteristics of the population and the number of cases, indicating the need to consider factors such as demographic density and age group of the population for the study of the evolution and behavior of the spread of COVID-19 in different regions. Given this scenario, the objective of this study is to portray, based on literature, the associations between meteorological and demographic variables with the occurrence of COVID-19 cases and deaths, taking into account the global panorama.

2 ASSOCIATION BETWEEN DISSEMINATION AND DEMOGRAPHIC FACTORS

When investigating the possible associations between demographic factors and virus contamination, Ahmadi et al. (2020) observed that one of the factors of greatest association with cases of SARS-CoV-2 contamination refers to population density. However, other factors such as gender and age group may also be associated with contaminations and deaths.

In this sense, soon after the outbreak of the COVID-19 pandemic in China, it was realized that there was an imbalance in the number of cases and deaths between men and women (ZHAO et al., 2020). In order to investigate this relationship, authors Gebhard et al. (2020) conducted a study in some European countries. In this study, it was verified that men had a higher rate of contamination in relation to women and it was also noted that the factor "age" had an influence on the result, due to the increase in the number of contaminated people over 60 years of age (GEBHARD et al., 2020).

The difference in contamination between the sexes may be associated with the different response of the male and female organism after infection of the virus. For men, diabetic or healthy, it is found that there is a higher level of ACE2 (angiotensin-converting enzyme receptor) circulating in the body (PATEL, 2013), which makes them more susceptible to contamination, since this is the gateway used by SARS-CoV-2. In view of this, there is also an increase in the level of ACE2 in the elderly, which is an indication of the elderly being more susceptible to contamination of this disease (GEBHARD et al., 2020).

Thus, in addition to man being more susceptible to contamination, the responses of the virus in the body are more severe for this genus. Since, men, proportionally, have fewer immune system cells when compared to women and, as a consequence, have worse immune responses (XIA et al., 2009; BOISSIER et al., 2003). It is noteworthy that sex hormones (testosterone, estradiol and progesterone) are factors that are part of the determination of this difference verified in the immune system (KOVATS et al., 2010).

Another aspect to be observed, in addition to the physiological between sex and age groups, is social behavior (practice of sports, consumption of alcoholic beverages and tobacco, etc.). Given that this produces consequences on biological factors. Worldwide, men represent the largest number of smokers and consumers of alcoholic beverages, which generates health problems, which can directly or indirectly influence the body's response to SARS-CoV-2. In addition, men have less medical follow-up and are less strict to hygiene habits, such as washing hands frequently (GLOBAL HEALTH, 2020).

3 ASSOCIATION BETWEEN DISSEMINATION AND METEOROLOGICAL FACTORS

By definition, meteorology is the study of atmospheric phenomena, manifested in a relatively short period and in specific locations. The set of meteorological characteristics is responsible for the formation of the climate (INMET, 2021a). In meteorology, the main characteristics studied are temperature and relative humidity, precipitation, winds, clouds and pressure. The study of these characteristics is carried out by supercomputers that accurately demonstrate the real situation at the time and specific region of interest. In Brazil, this work is mostly carried out by the National Institute

of Meteorology (INMET), but other institutions, such as universities and the support network for farmers, also do so.

Since the outbreak of the new coronavirus, researchers have presented studies in order to understand the dynamics of the new pathogen, considering the climatic and meteorological characteristics. Among the many studies, there are different methodologies applied in different regions of the world.

The study by Bashir et al. (2020), conducted in the United States of America, used the correlation coefficients of Kendall and Spearman to evaluate the association between contamination and deaths with the variables of temperature and relative humidity, wind speed, air quality and precipitation. Faced with this situation, the authors observed that the average and minimum temperature, in addition to air quality showed positive associations with new cases and total cases, and negative associations between air quality and mortality from coronavirus.

Already in a study developed by Briz-Redón and Serrano-Aroca (2020), aiming to evaluate the numbers of COVID-19 cases in Spain, it was observed that temperature (maximum, minimum and average) and non-meteorological factors such as population densities, population by age groups, number of travelers and number of companies as explanatory variables to model the natural logarithm of relative risk through spatio-temporal modeling techniques, considering the number of cases following the Poisson distribution. From this analysis, no evidence of a reduction in the number of SARS-CoV-2 cases with changes in air temperatures was identified.

On the other hand, in China, Shi and Zhu (2020) verified a negative association between air temperature and the number of cases, being verified through linear and nonlinear models. In addition to this study, the research of Xie et al. (2020), conducted in China, sought to understand the association between air temperature and the number of cases using a generalized additive model (GAM model). In this study it was not possible to conclude that the number of cases decreases as the air temperature increases, but they observed a reduction of approximately 4% in the number of cases in places with higher temperatures.

In Brazil, Auler et al. (2020) used multivariate procedures (principal component analysis and canonical correlation) to assess the association of rainfall, temperature, and relative humidity with the number of COVID-19 cases. This study found that temperature and relative humidity showed positive correlations with the number of COVID-19 cases. That is, according to the results of the study, warmer and wetter places tend to have a higher number of COVID-19 cases, when compared to places with milder air temperatures and lower relative humidity.

Prata et al. (2020) sought to understand the dynamics between weather conditions in subtropical cities in Brazil. For this purpose, the GAM model was used to evaluate the association of

the number of cases of the novel coronavirus with air temperature and population density. The results showed that there is a negative linear relationship between air temperature and COVID-19 cases, for air temperature values up to 25.8°C. When air temperature exceeds this threshold there is no evidence that the established relationship between air temperature and COVID-19 cases holds.

Considering only the city of São Paulo in the initial period of contamination by the new coronavirus, Rodrigues et al. (2020) evaluated possible associations between case and deaths with temperature and relative humidity, atmospheric pressure and wind speed. Through the Spearman correlation coefficient, it can be observed that the increase in air temperature during the study period was related to a reduction in the spread of the virus. On the other hand, on days when the relative humidity values were lower and the wind speed values were higher, there was an increase in SARS-CoV-2 contamination. Finally, on days of higher atmospheric pressure values, there was an increase in the spread of the virus when associated with other factors, such as wind speed, because there will be an increase in the concentration of pollution in the air, which may influence the behavior of the virus.

In studies conducted in Turkey, through the Spearman correlation coefficient, Şahin (2020) found that there is an association between the number of COVID-19 cases and meteorological factors, such as temperature and relative humidity of the air and wind speed. In Africa, the study conducted by Diouf et al. (2020) using temperature and relative humidity of the air and solar radiation, through the Pearson correlation coefficient showed that lower air temperatures and lower levels of relative humidity of the air, increase the transmission of COVID-19.

The authors Lolli et al. (2020), in a study conducted in Italy, sought to relate wind speed and atmospheric pressure with the transmission of SARS-CoV-2 using the correlation coefficient of Spearman and Kendall. The study was carried out in Milan, Florence and the province of Trento, and there was evidence of associations between the meteorological variables evaluated and the number of those infected by the virus.

In Latin America, Bolano-Ortiz et al. (2020) evaluated possible associations between cases and deaths with various meteorological variables in Argentina's capital, Buenos Aires. In this study, the Spearman correlation coefficient was used to measure the correlation between the variables: number of COVID-19 cases, mean, maximum and minimum air temperature, relative humidity, amount of rainfall and wind speed. The authors pointed out a negative association between COVID-19 cases and all meteorological variables in the study, except relative humidity.

Finally, in a systematic study covering 61 studies conducted in several countries, the authors Hoevemeyer et al. (2020) found that most of the studies evaluated indicate an association of new daily cases of coronavirus with the meteorological variables temperature, relative humidity and air quality.

As for the variables precipitation and wind speed, the authors found that most of the studies analyzed did not determine an association of these variables with new cases of COVID-19.

On the other hand, when evaluating the association of the number of daily deaths caused by COVID-19 with meteorological variables, the authors Hoevemeyer et al. (2020) found that temperature and relative humidity of the air and precipitation were the variables that showed the most association between the studies evaluated, and that wind speed and air quality showed no association in most studies.

Briefly, it can be seen in Table 1, the main results of research relating meteorological factors to SARS-CoV-2 contamination carried out in different countries.

Table 1: Studies on the association between meteorological factors and SARS-CoV-2 contamination in different regions of the world.

Country	Reference	Variables studied	Association between variables and number of cases
Africa	Diouf et al. (2020)	Temperature, Relative humidity, Solar radiation	There was an association between temperature and relative humidity in relation to contamination.
Argentina	Bolano-Ortiz et al. (2020)	Temperature, Relative humidity, Rainfall, Wind speed.	There was an association between all variables in relation to contamination.
Brazil	Auler et al. (2020)	Temperature, Relative humidity, Rainfall	There was an association between temperature and relative humidity in relation to contamination.
	Prata et al. (2020)	Temperature	There was an association between temperature and contamination.
	Rodrigues et al. (2020)	Temperature, Relative humidity, Pressure, Wind speed	There was an association between all variables in relation to contamination.
China	Shi et al. (2020)	Temperature	There was an association between temperature and contamination.
	Xie and Zhu (2020)	Temperature	There was an association between temperature and contamination.
Spain	Briz-Redón and Serrano-Aroca (2020)	Temperature	It did not present any association.
USA	Bashir et al. (2020)	Temperature, Wind speed, Rainfall, Relative humidity	There was an association between mean and minimum temperature with new cases and accumulated cases
Italy	Lolli et al. (2020)	Pressure, Wind speed	There was an association between pressure and wind speed in relation to contamination.
Turkey	Falcon (2020)	Temperature, Relative humidity, Wind speed	There was an association between temperature, wind speed and relative humidity in relation to contamination.

Source: Prepared by the authors, 2023.

From a review of scientific studies aimed at evaluating the association between COVID-19 cases and deaths in various locations around the world with demographic and meteorological characteristics, many studies can be observed pointing out some type of association, evidencing the importance of climate and population characteristics in the spread of the virus. However, due to the

observational character, the results should be interpreted with caution, not being an indicator of COVID-19 risk predictions based solely on meteorological or demographic characteristics.

4 CONCLUSIONS

Among the different studies presented, there is a discrepancy in the results of the association of meteorological and demographic variables in the characteristics of the spread of the COVID-19 pandemic. The divergences observed in the literature can be justified by the particularity of each locality. Thus, it verifies the need for more in-depth studies that are necessary for a better understanding of the behavior of the novel coronavirus in different microclimates and regions in the global scenario.

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