Correlation between dengue cases and meteorological variables in the Brazilian Northeast region (2010-2020)

Correlação entre os casos de dengue e variáveis meteorológicas em região do Nordeste brasileiro (2010-2020)

Correlación entre casos de dengue y variables meteorológicas en la región del Nordeste brasileño (2010-2020)

RESUMO

Objetivo: Analisar a correlação entre os casos de dengue e variáveis meteorológicas para a Região Metropolitana da Grande São Luís entre 2010 e 2020. Método: Estudo epidemiológico do tipo quantitativo e analítico. A fonte de dados utilizada foram os casos confirmados e prováveis de dengue entre 2010 e 2020 para a Região Metropolitana da Grande São Luís fornecidos pela Secretaria de Estado da Saúde do Maranhão. As variáveis meteorológicas foram extraídas do banco de dados meteorológicos disponíveis no site do Instituto Nacional de Meteorologia - INMET. Para compreender a relação entre os casos da doença e as variáveis meteorológicas foi aplicado o teste de análise de componentes principais seguido do teste de correlação de Pearson para verificar o grau de correlação entre as variáveis. Resultado: Em relação às variáveis temperatura máxima, umidade relativa do ar e pluviosidade observou-se incidência maior nos casos confirmados de dengue em apenas dois anos. Conclusão: De acordo com os dados observados não se pode inferir categoricamente que variáveis meteorológicas isoladamente podem apresentar influência com os casos de dengue, apesar de ter sido evidenciada relação entre algumas dessas variáveis e a incidência sazonal da doença.

DESCRITORES: Aedes; Estudos de Séries Temporais; Meio Ambiente e Saúde Pública; Medidas de correlação.

ABSTRACT

Objective: To analyze the correlation between dengue cases and meteorological variables for the Greater São Luís Metropolitan Region between 2010 and 2020. Method: Quantitative and analytical epidemiological study. The data source used were the confirmed and probable cases of dengue between 2010 and 2020 for the Metropolitan Region of Greater São Luís provided by the Secretary of State for Health of Maranhão. Meteorological variables were extracted from the meteorological database available on the National Institute of Meteorology - INMET website. To understand the relationship between the cases of the disease and the meteorological variables, the principal component analysis test was applied followed by the Pearson correlation test to verify the degree of correlation between the variables. Result: Regarding the variables maximum temperature, relative humidity and rainfall, a higher incidence was observed in confirmed cases of dengue in just two years. Conclusion: According to the observed data, it cannot be categorically inferred that meteorological variables alone can influence dengue cases, although a relationship between some of these variables and the seasonal incidence of the disease has been shown.

DESCRIPTORS: Aedes; Time Series Studies; Environment and Public Health; Correlation measures.

RESUMEN

Objetivo: Analizar la correlación entre los casos de dengue y las variables meteorológicas para la Región Metropolitana del Gran São Luís entre 2010 y 2020. Método: Estudio epidemiológico cuantitativo y analítico. La fuente de datos utilizada fueron los casos confirmados y probables de dengue entre 2010 y 2020 para la Región Metropolitana del Gran São Luís proporcionados por la Secretaría de Estado de Salud de Maranhão. Las variables meteorológicas fueron extraídas de la base de datos meteorológica disponible en el sitio web del Instituto Nacional de Meteorología - INMET. Para entender la relación entre los casos de la enfermedad y las variables meteorológicas, se aplicó la prueba de análisis de componentes principales seguida de la prueba de correlación de Pearson para verificar el grado de correlación entre las variables. Resultados: Con relación a las variables temperatura máxima, humedad relativa y precipitación, se observó una mayor incidencia de casos confirmados de dengue en apenas dos años. Conclusiones: De acuerdo con los datos observados, no se puede inferir categóricamente que las variables meteorológicas por sí solas puedan influir en los casos de dengue, aunque se ha demostrado una relación entre algunas de estas variables y la incidencia estacional de la enfermedad.

DESCRIPTORES: Aedes; Estudios de Series Temporales; Medio Ambiente y Salud Pública; Medidas de Correlación.

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INTRODUCTION

Dengue is an acute febrile disease transmitted to humans by mosquitoes of the Aedes genus. Tropical countries are the most affected due to their environmental, climatic and social characteristics. Climate is an important factor in the temporal distribution of arboviruses in general, such as dengue. The incidence of the disease has increased considerably worldwide in recent decades. 1 Data from the World Health Organization (WHO), indicated the incidence of 390 million infections per year, in addition to the estimate of 3.9 billion people living in regions at risk of transmission for the disease.[2].

The relationship between climatic variables and the incidence of arboviruses has been investigated by several authors. Studies through the analysis of time series are often carried out, with the aim of describing the temporal evolution, identifying patterns and even predicting cases. [3-6] Research on climate variables can contribute significantly to knowledge about seasonality and the prediction of epidemics, since the vector-climate relationship is as important as the vector-human relationship. [7]

For the region of interest in this study, there is the Metropolitan Region of Greater São Luís (RMGSL - Região Metropolitana da Grande São Luís) which was defined and regulated through State Complementary Law nº 174/2015 with all the instruments necessary for its effectiveness. This region is made up of the municipalities of: Alcântara, Axixá, Bacabeira, Cachoeira Grande, Icatu, Morros, Presidente Juscelino, Paço do Lumiar, Raposa, Rosário, Santa Rita, São José de Ribamar and São Luís. [8]

RMGSL has a socio-spatial structure with a territorial area of 383.8 km^2, with the capital São Luís concentrating the highest Gross Domestic Product (GDP) around 34% justified by its ability to articulate and concentrate goods, industrial poles, services and brings together the headquarters of the main public bodies at the state and federal level. [9] Aspects involving the relationship between metropolization and urban health directly influence the occurrence of infectious diseases, such as Dengue, Chikungunya and Zika. [10]

Dengue control in the state of Maranhão is a challenge for local public health authorities due to its geographical position in transition areas between the arid northeastern and humid Amazonian regions with areas colonized by Aedes aegypti.[11] In view of this, epidemiological knowledge about the distribution of this arbovirus and its relationship with meteorological variables is of paramount importance, as it allows public health planning by public managers and health authorities. [11] The objective of the present study is to analyze the correlation between probable and confirmed cases of dengue and meteorological variables for the Me-

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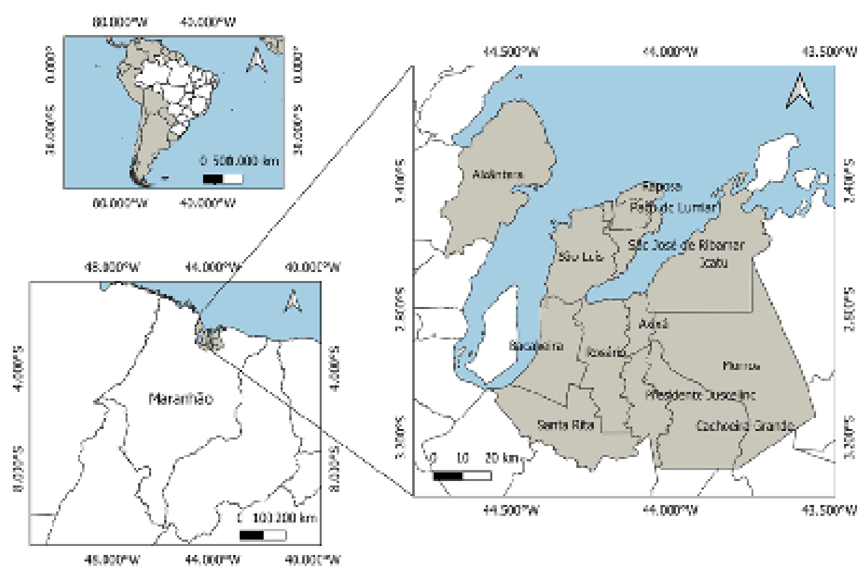
tropolitan Region of Greater São Luís between 2010 and 2020.

METHOD

Study field

The Metropolitan Region of Greater São Luís is located in the north of the state of Maranhão (Figure 1). As it is a coastal region located close to the equator, it is influenced by the Atlantic Equatorial Mass (to the north/east) and the Continental Equatorial Mass to the west, both hot and humid.

Figure 1 - Location of RMGSL.



Source: Aguiar [12] et al.

Study design and data collection

This is a quantitative and analytical epidemiological study. In studies with this focus, there is no exposure of individuals, but of the entire population group, and it makes it possible to verify the association between exposure versus disease/condition related to the community. [13] In the present study, probable and confirmed cases of dengue linked to the databases of the Municipal Health Secretariat (SES-MA) for the established period were used.

Data was received upon online request in November 2022 via the Electronic System of the Citizen Information Service. [14]

The meteorological variables were extracted from the station located in São Luís, capital of the state of Maranhão, located at 02.53º latitude and 44.21º longitude available on the Instituto Nacional de Meteorologia website. [15] Regarding the climatic variables, the monthly averages of average and maximum temperatures in degrees Celsius, precipitation in millimeters (mm^3) and relative humidity (%) were considered.

Statistical analyzes

The monthly averages of precipitation, average temperature, maximum temperature and relative humidity that showed gaps were filled in using the linear interpolation technique. This technique is recommended for time series as it takes into account the variation of the series over time. [16]

To understand the relationship between the number of dengue cases and climate variables, the Principal Component Analysis (PCA) test was applied, which aims to reduce the dimensions of the system, through a new base, where the components are the Principal Components, obtained by the covariance matrix of the original variables. [17] To verify the relationship between climate variables and records of dengue cases, only the first two principal components were considered, which explain most of the variance in the data. The degree of relationship between these variables was verified using Pearson's correlation coefficient [18] which is measured on a scale of -1 to 1 represented by the following equation:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(\sum(x_i - \bar{x})^2)(\sum(y_i - \bar{y})^2)}}$$

All analyzes were processed using the GraphPad Prism program considering $p<0.05$.

Ethical aspects

The present study used secondary data of public access respecting the ethical principles contained in the Resolution of the National Health Council nº 466/2012, so there was no need for submission to the Research Ethics Committee. [19]

RESULTS

Climatologies

Precipitation showed the highest values between the summer (December, January, February-DJF) and autumn (May, April, May-MAM) seasons with approximately 450 mm3. For winter (June, July, August-JJA) and spring (September, October, November), the same variable recorded total rainfall below 150 mm3. Relative air humidity followed the same seasonal patterns with maximum values close to 90% for autumn (MAM), and from the following season (winter - JJA), minimum values decreased and were close to 75%. Regarding Tmed and Tmax, the lowest values occurred close to 26.5 and 30.8º C in summer (DJF) and autumn (MAM) and for winter (JJA) and spring (SON), these values were

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27 .8 and 33.0º respectively.

Likely cases

The monthly climatologies and data related to probable and confirmed cases of dengue (Table 1) for the RMGSL showed the highest values in the rainy season in the region, which corresponds to the months of January to June. While the lowest values occurred in the dry season, corresponding between July and December.

To understand the relationship between dengue cases and climate variables, PCA was applied (Figure 3), which indicated that in the first component there was a greater relationship between relative humidity values and probable cases in the months of April and May in the municipalities of Paço do Lumiar, Raposa, São Luís, Axixá, São José de Ribamar and Icatu. Still in the same component, in the months of February and March, precipitation showed a greater relationship with the number of probable cases for the municipalities of Cachoeira Grande, Morros, Bacabeira, Presidente Juscelino, Alcântara, Rosário and Santa Rita with an explained variance of 61.90%. The variables Tmax and Tmed were not related to probable cases and the variance obtained was 14.56%.

Pearson's correlation analysis between meteorological variables and probable cases is shown in Figure 4, where humidity and precipitation showed a positive correlation, and mean temperature and maximum negative correlation with probable cases.

Figure 2 - Climatologies of average precipitation, maximum temperature, average and monthly relative humidity between 2010 and 2020 for the RMGS.

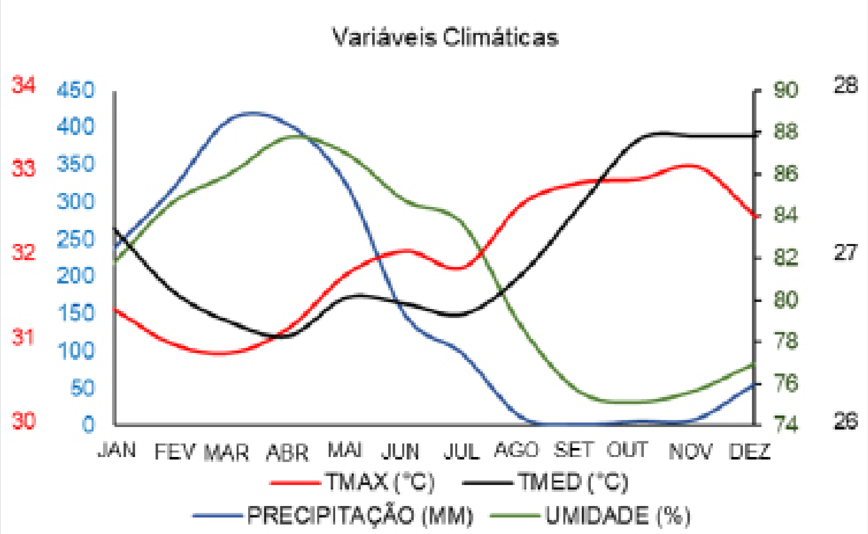

Table 1- Annual totals of probable and confirmed dengue cases and annual climatologies of meteorological variables for RMGSL (2010-2020).

Years	Likely cases	Confirmed cases	Precipitation (mm3)	MAXT (°C)	AVGT (°C)	Humidity (%)
2010	2901	-	146,30	32,18	27,53	82,43
2011	5609	-	226,11	31,21	26,82	82,44
2012	1360	-	94,43	32,23	27,37	80,24
2013	1292	21	132,85	31,68	27,22	80,44
2014	1078	711	152,83	31,77	26,85	81,14
2015	3273	2485	125,60	32,40	27,11	79,45
2016	6163	5597	128,61	32,51	27,38	80,65
2017	1319	1230	188,50	32,26	26,92	80,42
2018	738	715	194,23	31,68	26,63	82,53
2019	1280	1239	229,42	31,82	26,58	82,30
2020	850	783	226,46	31,92	27,01	84,18

Source: Prepared by the authors.

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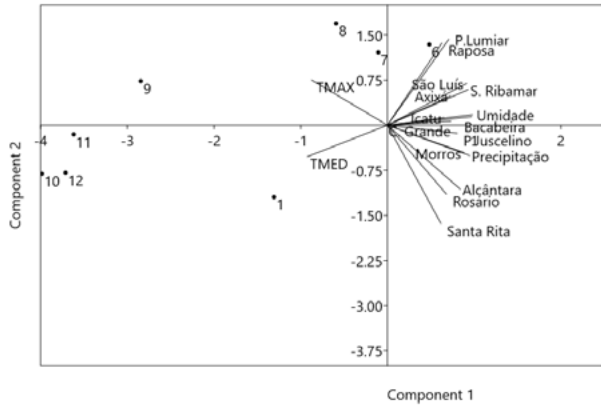
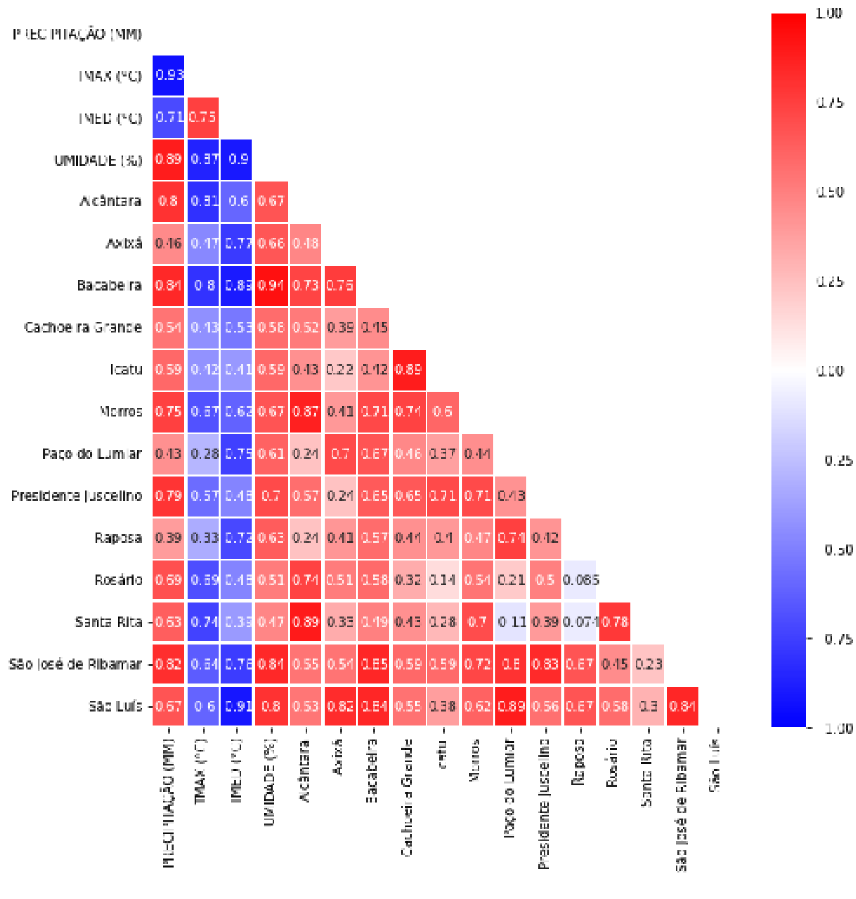
Figure 3 - Principal Component Analysis between climatology values and probable cases of dengue for RMGSL between 2010 and 2020.



Source: Prepared by the authors.

Figure 4 – Pearson correlation analysis between meteorological variables and probable cases of Dengue for RMGSL between 2010 and 2020.



Source: Prepared by the authors.

Confirmed cases

For confirmed cases, the PCA showed 52.00% variation in component 1 and 13.31% in component 2. This relationship suggested the occurrence of confirmed cases of the disease in the months of February and June, when the humidity varied on the scale between 74% and 90% and the precipitation was close to 450 mm3. Still in component 1, it was observed that humidity and precipitation showed a directly proportional linear relationship, which suggests that both can influence the occurrence of confirmed cases.

In component 2, AvgT and MaxT were related to confirmed cases in the months of August, September, October, November and December only in the municipality of Presidente Juscelino (Figure 5).

The degree of relationships between meteorological variables and confirmed cases (Figure 6) showed positive correlations between precipitation, humidity and confirmed cases, except for the municipality of Presidente Juscelino, which showed negative correlations between Tmax, Tmed and confirmed cases.

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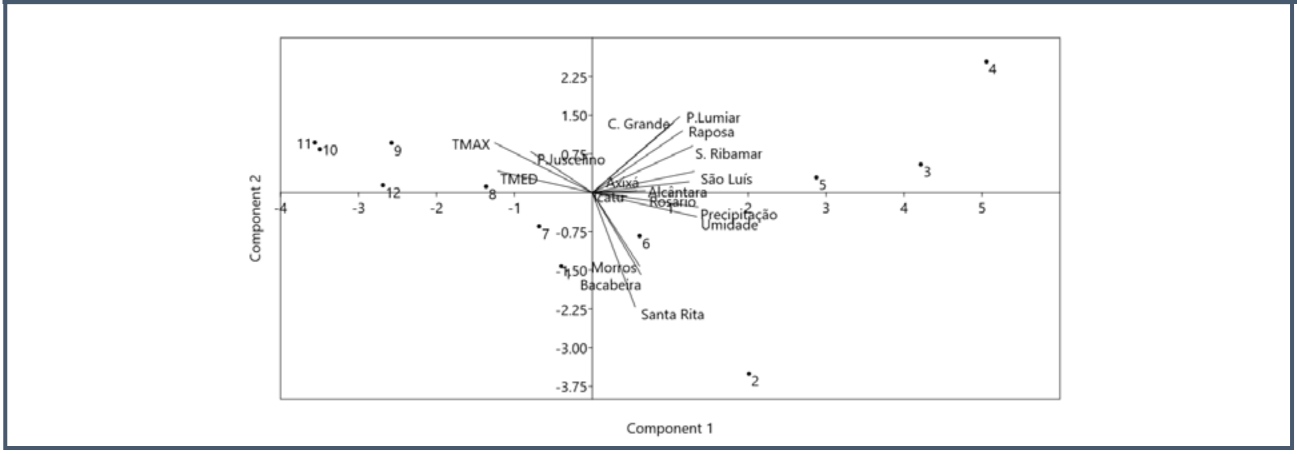
Figure 5 - Principal component analysis between climatology values and confirmed dengue cases for RMGSL between 2010 and 2020.



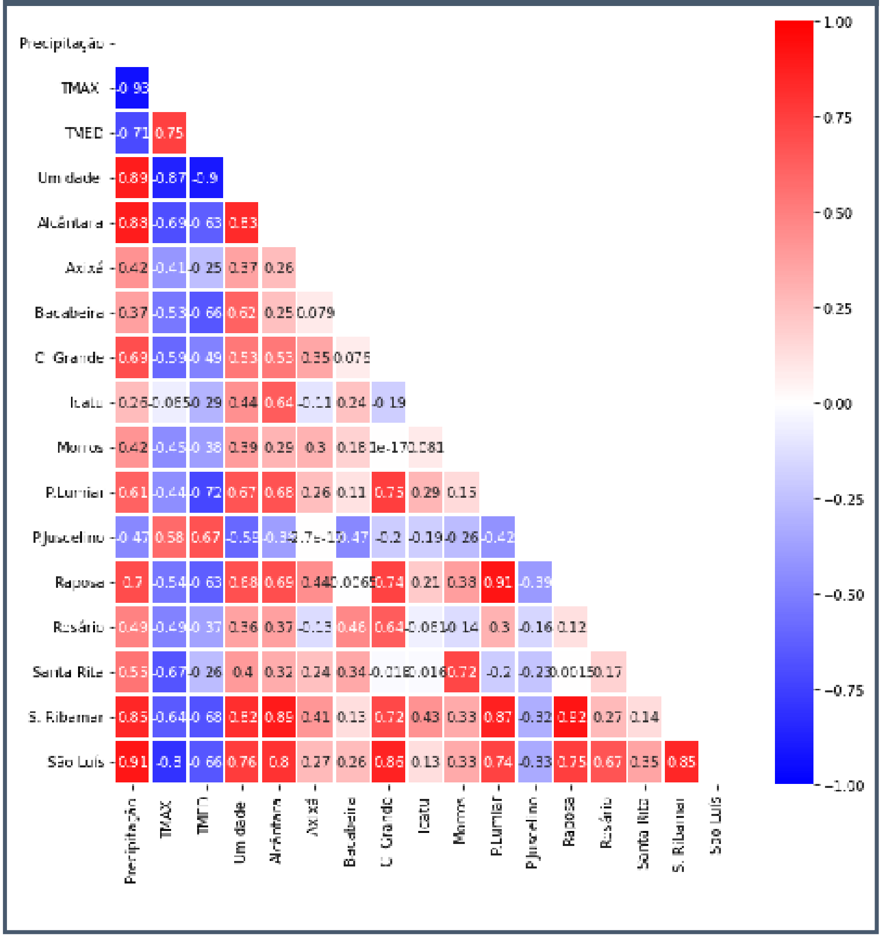
Source: Prepared by the authors.

DISCUSSION

This study revealed the largest records of confirmed cases in the years 2015 and 2016. During the epidemic years there was a positive correlation between dengue cases and relative humidity, maximum temperature and rainfall. In this context, it is important to highlight that climate change significantly impacts human health due to the increased incidence of infections caused by vectors, such as dengue fever. [20]

In 2016 there was an increase in the number of cases compared to 2015. For those same years, other municipalities in the state had high rates of the disease. [21] This difference can be explained by the possible underreporting of cases due to the similarity of signs and symptoms of the disease with other conditions, according to Medeiros et al. (2018) [22] reported in a study carried out in Rio Grande do Norte, that during this period there may have been records that would have been wrongly notified. It was noticed that in 2016 the Northeast region had the second highest rate with 324,299 notifications, behind only the Southeast region with 857,013 cases. [23] This scenario is linked, as pointed out by Rodrigues et al. (2020) [24] to urbaniza-

Figure 6 - Pearson correlation analysis between meteorological variables and confirmed dengue cases for RMGSL between 2010 and 2020.



Source: Prepared by the authors.

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tion, which facilitates the spread of the vector due to the existence of human conglomerates, low income, increased garbage, among others.

The analysis between the correlation of meteorological variables and notifications showed similar behavior with other studies, such as Torres et al. (2017)[25] which highlighted the relationship between precipitation and humidity and reported cases in a directly proportional trend and inversely proportional trend with the temperature variable in São Luís. As seen in our results, the month of february presented a relationship between the cases of the disease and the relative humidity of the air, which is evidenced in the literature that points out the highest records in the rainy months between november and may. [26]

However, rain and humidity are not the only factors responsible for the development of the vector. According to Meira et al. (2021) [27] demonstrate in a study carried out in Foz do Iguaçu that temperatures are of great importance for the growth of the Aedes aegypti mosquito. Another study carried out in Marabá-PA identified the ideal proliferation conditions for the mosquito between January and May, a period that records high rainfall, temperature and humidity indices with a reduction in the months of June to September. [28]

It is noteworthy that in recent years, temperature has been considered an important factor in the incidence of arboviruses. [29] Some studies have demonstrated the relationship between this variable and the incidence of dengue, although climatic factors alone are not capable of interfering with the incidence of the disease. But social issues, health education and public management with regular collection and proper disposal of garbage interfere in this process. [20,30]

In this sense, arboviruses, such as dengue, pose a challenge to public authorities. Epidemiological surveillance, planning and implementation of public policies and behavioral changes in the population can contribute to reducing and controlling the incidence of dengue. It is also worth highlighting the importance of considering the specific characteristics of each region to support studies with this design in order to enable the formulation and execution of local surveillance programs. [31]

As limitations for the development of this study, there are gaps in the databases, incorrect completion, which can lead to overestimation or underestimation of real values. But despite this, the choice of secondary data allows the development of low-cost studies, with representation of large samples and public domain access.[32]

CONCLUSION

According to the observed data, both the probable cases and the confirmed cases there was a seasonality in relation to rainfall and relative humidity, with a higher incidence of cases in the months of January to June, which correspond to the rainy season in the region. But when observing the variables maximum temperature, relative humidity and rainfall in relation to the number of confirmed cases of dengue in just two years, there was a higher incidence. However, in relation to probable cases, it was also two years, but different from those of confirmed cases.

Thus, climatic factors alone are not responsible for interfering with the incidence of the disease, but social factors, public policies for solid waste management can interfere in this process, in addition to underreporting of both probable cases and confirmed cases of the disease. Therefore, it is suggested that studies with longer periods associated with notification policies be carried out to better understand dengue fever cases and their relationship with meteorological variables.

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