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Research paper

Climate, socio-economic factors and spatial distribution of some global-occurrence arboviruses: literature review

Clima, fatores socioeconômicos e distribuição espacial de algumas arboviroses de ocorrência mundial: uma revisão da literatura

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ABSTRACT: Arboviruses' outspread can be influenced by factors, such as climate, socio-economic status and spatial distribution. Identifying populations facing the highest risks of being exposed to arboviruses is an important subject for the public health scenario. The present study is a literature review aimed at identifying associations between Dengue, Zika and Chikungunya Virus, and the social, environmental and economic aspects of individuals suffering with these arboviruses, based on analyzing the literature available about this topic. Articles published in Portuguese, Spanish and English, between 1997 and 2019, were included in the study. Exclusion criteria included studies approaching the clinic, infection, molecular biology, genetics, entomology and microbiology of these viruses, and studies about mathematical modeling and reviews. The search for articles was carried out in IBECS, CINAHL, MEDLINE, PubMed and Web of Science databases. PRISMA was used after data mapping for data extraction purposes. Based on the 32 articles included in the analysis, climate factors, such as temperature and rainfall, affect vectors' origin, evolution and distribution, and, consequently, the transmission of associated pathogens. When socio-economic aspects are taken into account, populations living in regions accounting for higher social vulnerability are more susceptible to get ill due to some arbovirus. These findings suggest that climate and socio-economic aspects are associated with arboviruses' spatial distribution. Therefore, it is essential developing measures to efficiently control and prevent arboviruses, mainly in the most vulnerable regions.

Keywords: Dengue Virus, Zika Virus, Chikungunya Virus, Social Indicators, Environmental Indicators.

RESUMO: *A disseminação das arboviroses pode ser influenciada por fatores como o clima, socioeconômicos e distribuição espacial. A identificação das populações com maior risco de exposição às arboviroses é uma temática importante no cenário da saúde pública. Deste modo, o presente estudo trata-se de uma revisão da literatura, que teve como objetivo identificar associação entre a distribuição espacial do Vírus da Dengue, Zika Vírus e Vírus Chikungunya e os aspectos sociais, ambientais e econômicos dos indivíduos acometidos pelas arboviroses, a partir da análise da literatura publicada acerca da temática. Foram incluídos artigos publicados nos idiomas português, espanhol e inglês, entre 1997 e 2019; e excluídos estudos que abordavam a clínica, infecção, biologia molecular, genética, entomologia e microbiologia dos vírus e estudos de modelagem matemática e revisões. A busca dos artigos foi realizada nas bases de dados IBECS; CINAHL; MEDLINE; PubMed; Web of Science. Após o mapeamento dos dados, foi utilizado o PRISMA para a extração dos dados. Sendo assim, dos 32 artigos incluídos na análise, os resultados apontaram que fatores climáticos como temperatura e precipitação afetam a origem, evolução e distribuição dos vetores; e, consequentemente a transmissão dos patógenos relacionados. Além disso, quando observados os aspectos socioeconômicos, populações de regiões com maior vulnerabilidade social apresentam maior risco de adoecer por alguma arbovirose. Portanto, esses resultados sugerem que os fatores climáticos e aspectos socioeconômicos possuem associação com a distribuição espacial das arboviroses, sendo essencial o desenvolvimento de medidas de controle e de prevenção eficientes das arboviroses, principalmente, nas regiões mais vulneráveis.*

Palavras-chave*: Vírus da Dengue, Zika Vírus, Vírus Chikungunya, Indicadores Sociais, Indicadores Ambientais.*

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INTRODUCTION

Population growth, migration movements, inappropriate urban buildings and transportation means capable of making travels faster are factors contributing to manifestations of infectious diseases, among them one finds those caused by arboviruses. (ALMEIDA, 2020).

Arboviruses are the cause of some pathologies. Their biological cycle comprises hematophagous arthropods that work as vectors capable of transmitting arboviruses that cause illnesses in humans (ARAÚJO, 2020).

Dengue, Zika and Chikungunya are arboviruses transmitted by the *Aedes aegypti* mosquito (*A. aegypti*). These arboviruses' clinical signs are similar to each other and they account for high morbidity rates, a fact that turns them into a concerning public health issue (CHOTIWAN et al., 2015).

A. aegypti is an arthropod and it is the main vector for Dengue (DENV), Zika (ZIKV) and Chikungunya (CHIKV) virus transmission. It also accounts for more than 390 million infections worldwide, on a yearly basis. These viruses are transmitted to humans through bites of infected female mosquitos that acquire them by feeding on contaminated individuals' blood (CHOTIWAN et al., 2015; LEPARC-GOFFART et al., 2014; LUCEY; GOSTIN, 2016).

Arboviruses impact on morbidity and mortality gets more intense as large epidemics increase the number of affected individuals. This process reflects on health services, mainly in case of lack of both treatment and other effective prevention and control measures (DONALISIO; FREITAS; ZUBEN, 2017).

These viruses' occurrence and outspread are influenced by several factors that, altogether, contribute to increase the frequency and distribution of cases in different regions around the world. They are also influenced by demographic, social, political, economic and, most of all, environmental determinants featured by population growth and mobility, unplanned urbanization, precarious housing, lack of basic sanitation and waste collection, as well as by weather conditions favorable to this vector (LOPES; NOZAWA; LINHARES, 2014).

In addition, the very information about these illnesses' spatial and time distribution allows understanding their dynamics by visualizing the susceptible zones, trends and associations with local features, such as social conditions. Along with environmental conditions, these local features allow stratifying the social and environmental risks posed to different population groups (VIONETTE; DANSA-PETRETSKI, 2012).

Time and space variations expose populations' health to risk. Yet, variations in health standards can be set by places where people live in, more than by individuals' features, themselves. Population health condition in sites accounting for high social privation indices and environmental risks is much worse than the expected for individuals' own features, in separate (KUCHARZ; CEBULA-BYRSKA, 2012).

Accordingly, the aim of the present literature review rose from considerations about the magnitude and complexity of these arboviruses' occurrence, in addition to the need of better understanding their distribution in urban spaces in order to make more effective health interventions aimed at the most vulnerable zones and at analyzing records and research about this topic. The objective was to identify associations between the spatial distribution of Dengue (DENV), Zika (ZIKV) and Chikungunya (CHIKV) viruses, and the social, environmental and economic aspects of individuals suffering with these arboviruses.

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METHODOLOGICAL PROCEDURES

The present study is a scope review based on following the methodological principles by *Joanna Briggs Institute* (JBI). The PCC strategy was adopted to build the guiding question. This strategy represents a mnemonic for Population (individuals suffering with arboviruses), Concept (DENV, ZIKV, CHIKV, environmental, social and economic indicators) and Context (spatial distribution). The question was: Is there any association between the spatial distribution of DENV, ZIKV and CHIKV, and social, environmental and economic aspects of individuals suffering with arboviruses?

The search for articles was carried out in the *Índice Bibliográfico Espanhol de Ciências da Saúde* (IBECS), Cumulative Index to Nursing and Allied (CINAHL), Medical Literature Analysis and Retrieval System Online (MEDLINE), US National Library of Medicine National Institutes of Health PubMed – NCBI and Web of Science databases. It was done between January and April 2020. The following descriptors were used for the search: Dengue Virus, Zika Virus and Chikungunya Virus; Social Indicators; Environmental Indicators; Economic Indicators.

Primary studies published in Portuguese, English and Spanish, between 1997 and 2019, were included in the review. Exclusion criteria were articles whose titles and abstracts did not meet the aim of the present investigation and research approaching the clinic, infection, molecular biology, genetics, entomology and microbiology of the assessed viruses, as well as mathematical modeling studies and reviews.

After searching in the databases, the selected studies were imported to *StArt State of the Art through Systematic Review* (StArt) web application in order to select studies at two levels. The first selection regarded reading articles' titles and abstracts, and it was followed by reading the full article. StArt review tool was developed by the Laboratory of Research in Software Engineering (LaPES) of Federal University of São Carlos (UFSCar) (FABBRI S et al., 2016).

The eligible studies were recovered for full reading and assessed by three researchers. Divergences, at both stages, were discussed until consensus was reached. Final selection took place after all the aforementioned stages were concluded. PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) was used for data extraction after data mapping (MOHER et al., 2015).

Relevant information in each selected article was collected, namely: author, country where it was carried out, publication country, study design and its main results. Results in the analyzed studies are shown in a chart, in descriptive format.

RESULTS AND DISCUSSION

In total, 1,082 articles were found in the databases, and 94 of them were excluded because they were duplicated, 845 were excluded after their titles and abstracts were read, and 111 were excluded after their full reading. Thus, only 32 articles were selected for the review, they approached associations between arboviruses' spatial distribution, and social, environmental and economic indicators, as shown in **Figure 1.**

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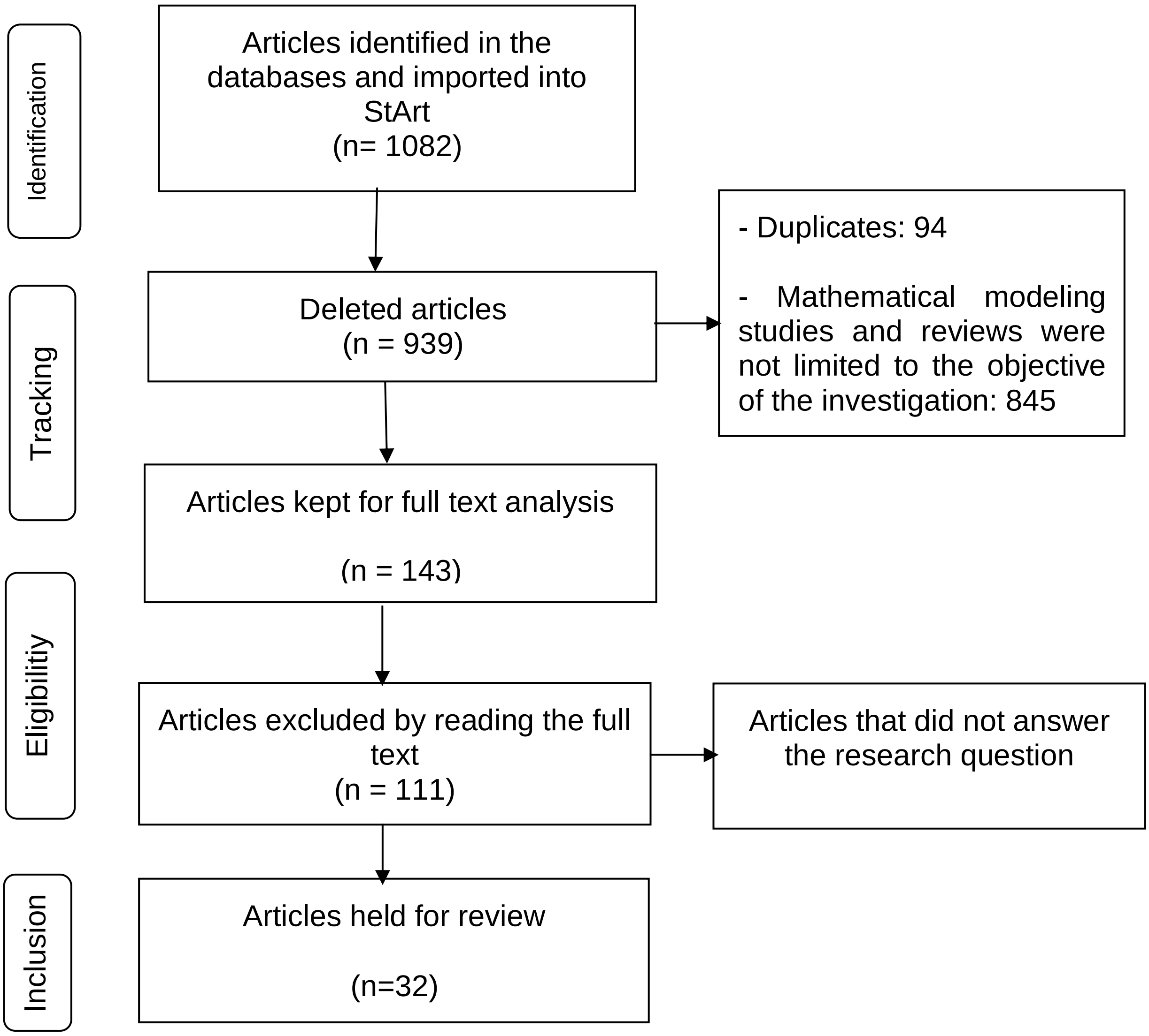
Figure 1. Reference flowchart: inclusion and exclusion of articles



The 32 herein included publications were published in 3 different languages: 30 (94%) in English, 1 (3%) in Portuguese and 1 (3%) in Spanish. With respect to countries participating in these studies, we highlight 12 (37.5%) publications in Brazil and 7 (21.95%) in the US. On the other hand, 16 articles (50%) were published in American journals and 7 (22%) in the United Kingdom. The articles were published between 2001 and 2019, with emphasis on 8 (255) articles published in 2018 and 4 (13%) in 2019. When it comes to study design, 16 (50%) were ecological studies and 10 (31%) were cohort studies (Chart 1).

RBCTI
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Chart 1. Articles description according to author, publication year, publication location, aim, study design and main results.

Author, year and local	Objectives	Type of study	Main results
Ahmad et al., 2018, Malaysia	Determine the contribution of three main factors i.e. entomological, epidemiological and environmental factors related to the dengue outbreak in Malaysia	Cohort Study	Environmental factors such as rainfall, temperature and humidity are significant in the dengue prediction model.
Arunachalam et al., 2010, India, Indonesia, Philippines, Thailand, Sri Lanka, Myanmar, Switzerland, Sweden	Study the reproduction patterns of the dengue vector under various conditions in public and private spaces; explore the ecological, biological and social (eco-bio-social) factors involved in vector breeding and viral transmission	Ecological study	Peridomestic and intradomestic areas are more important for pupae production than commercial and public spaces, except for schools and religious facilities.
Astuti et al., 2019, Indonesia and Australia	Explore the seasonality of dengue incidence among children and examine the short-term effects of climatic and environmental factors on dengue incidence	Estudo de prevalência incidência	Seasonal patterns of childhood dengue incidence had a strong association between rainfall, temperature, humidity and vegetation index variability During the rainy season the number of dengue infections reported was twice as high as that reported in the dry season.
Campos et al., 2018, United Kingdom and Brazil	Provide information on the unusual distribution pattern of microcephaly in Brazil	Ecological study	A distribuição incomum de microcefalia poderia ser acentuada pela pobreza e por infecção prévia ou coinfecção com outros patógenos. A região Nordeste teve a maior número de casas que acumulavam lixo e armazenavam água da chuva, fatores que podem contribuir para um aumento na proliferação de vetores.
Carabalet al., 2012, Colombia and Belgium	Present first-hand field experience from Colombia in the context of dengue control	Ecological study	O desempenho inadequado do sistema de vigilância pode mascarar o problema de maior incidência de dengue nas populações de baixa renda.
Fareed et al., 2016, Pakistan	Study the social, climatic and demographic covariates in the Dengue outbreak, (2) discover the	Estudo de prevalência	The unusual distribution of microcephaly could be accentuated by poverty and previous infection or co-infection with other pathogens. The

RBCTI
Revista Brasileira de Ciência, Tecnologia e Inovação
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	associations between different environmental and anthropic parameters	incidência	Northeast region had the highest number of houses that accumulated garbage and stored rainwater, factors that can contribute to an increase in the proliferation of vectors.
Ferreira et al., 2007, Brazil	Analyze the association between Aedes aegypti larval infestation rates and socioeconomic factors	Cohort Study	The inadequate performance of the surveillance system may mask the problem of a higher incidence of dengue in low-income populations.
Ferreira, 2014, Brazil	Examine the spatial distribution of the association between El Niño and dengue fever in the countries of the Americas during 1995-2004	Cohort Study	The majority of dengue cases occurred in urban areas with poor drainage patterns, a high housing density index, unplanned urbanization, mixed and interconnected housing.
Fischer et al., 2013, Sweden and Germany	Examine the factors driving the potential transmission of Chikungunya in Europe	Ecological study	It has been identified that the spread of A. aegypti in Europe is attenuated during the winter. The secondary vector, A. albopictus, is of great importance because its reproduction and survival process can withstand lower temperatures than *A.aegypti*.
Gagnon et al., 2001, Canada, French Guiana, Suriname and Indonesia	Analyze the correlation of the El Niño Southern Oscillation with dengue epidemics in Indonesia and a number of countries and territories in South America	Ecological study	The territories investigated have experienced warmer temperatures and less abundant rainfall, and these climatic factors have been associated with dengue epidemics. Between 1965 and 1993, only the 1993 El Niño was not associated with a dengue epidemic. Drought conditions trigger dengue epidemics in all the countries studied.
Gibson et al., 2014, Brazil	Analyze the association between the occurrence of severe cases of dengue in the 2008 epidemic and socio-economic indicators, as well as indicators of the availability of health services and previous circulation of the serotype-3 virus.	Ecological study	During the 2008 epidemic, at the ecological level, residents who declared black color or race had a higher incidence of severe dengue. The research points to the historical socio-economic vulnerability of this group, reflecting the variability of morbidity and mortality patterns, due to the absence of or low access to early diagnosis and/or clinical management. Districts with a Family Health Strategy (ESF) were more likely to have a lower

RBCTI
Revista Brasileira de Ciência, Tecnologia e Inovação
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			incidence rate of severe dengue in the 2008 epidemic.
Grossi-Soyster et al., 2017, United States, Kenya and United Kingdom	Increase knowledge about seroprevalence and factors associated with increased exposure to alphaviruses and flaviviruses in a population of children and adults living in western Kenya	Incidence prevalence study	A soroprevalência de flavivírus e alfavírus pode estar associada a áreas com maior porcentagem de aldeias rurais. Áreas próximas a corpos d'água, lagos, pântanos e rios foram associados a soroprevalência. Episódios de inundação apresentam correlação com casos de infecção, enquanto a seca não apresentou relação.
Hu et al., 2012, Australia	Examine the impact of socio-ecological factors on dengue transmission and assess potential predictors of locally and overseas acquired dengue cases in Queensland	Ecological study	It was described that there was a 6% increase in locally acquired dengue cases when there was a 1mm increase in average monthly rainfall and when the average maximum temperature increased by 1°C.
Hurtado-Díaz et al., 2007, Mexico	Test the hypothesis that the El Niño Southern Oscillation cycle affects the weekly incidence of dengue cases in the municipalities of Veracruz, Mexico	Ecological study	An increase in the number of dengue cases was associated with a one-degree increase in temperature and weekly minimum temperature. Rainfall was also a significant factor in the increase in dengue cases.
Kikuti et al., 2015, Brazil and the United States	Examine whether specific characteristics of an urban slum community were associated with dengue risk	Cohort Study	Low socioeconomic status was independently associated with increased dengue risk; in slum communities with a high level of absolute poverty, factors associated with the social gradient influence dengue transmission.
Lazcano et al., 2006, Cuba	Identify local ecological factors that could influence the higher vector infestation by *A. aegypti* observed in four urban health areas of Havana City, Cuba, as well as the types of	Descriptive study	There was an association between the number of infested larval deposits and the presence of vegetation and trees, location in partially or completely shaded areas and lack of domestic hygiene. Tanks that are uncovered, with the presence of organic matter and located in the shade and outdoors

RBCTI
Revista Brasileira de Ciência, Tecnologia e Inovação
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	deposits with the highest number of larvae		are the ones that present the greatest risk factor for *A. aegypti* breeding sites.
Lippi et al., 2018, United States and Ecuador	Describe the spatial distribution of dengue risk and identify local socio-ecological factors associated with a dengue outbreak in the city of Guayaquil, Ecuador	Ecological study	The most significant socio-ecological risk factors for the increase in dengue cases were precarious housing conditions and poor access to public services (running water, sewage and garbage collection).
MacCormack-Gelles et al., 2018, Brazil and the United States	Evaluate the epidemiological characteristics and determinants of epidemic and inter-epidemic dengue transmission, using data from the fifth largest city in Brazil (Fortaleza), at fine spatial and temporal scales.	Ecological study	The months with the highest rainfall have a higher transmission rate than other months. Literacy had a divergent aspect in relation to the sexes: males with literacy had an increase in the incidence rate, while females with literacy had a correlation with lower rates. Junkyards and places where tires accumulate have a higher risk of dengue incidence nearby.
Machado et al., 2009, Brazil	Analyze the relationship between living conditions and the occurrence of dengue, and investigates the possible relationship between socioeconomic inequalities and temporal variations in the incidence of the disease by neighborhoods in the Municipality of Nova Iguaçu, State of Rio de Janeiro, Brazil, from 1996 to 2004.	Cohort Study	It indicated a weak association between exposure and outcome at the neighborhood level, with the possibility of dengue infection being slightly higher in neighborhoods with better living conditions. The presence of gas stations, tire repair shops and junkyards along Nova Iguaçu's main access roads was also considered a risk factor for dengue.
Pham et al., 2011, Vietnam	Elucidate the relationship between climatic factors, mosquito indices and dengue incidence.	Ecological study	Detection of new larval breeding sites outside the domestic area, breeding sites in drainage basins located under sidewalks. Larval control carried out in drainage basins significantly reduced epidemiological risk patterns.

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Ocampo et al. 2019, Colombia	Enable local health authorities to monitor risk factors for the transmission of urban arboviruses and thus facilitate the design and evaluation of focused evidence-based strategies for their prevention and control.	Ecological study	Detection of new larval breeding sites outside the domestic area, breeding sites in drainage basins located under sidewalks. Larval control carried out in drainage basins significantly reduced epidemiological risk patterns.
Ong et al., 2019, Singapore	Introduce a new vector index based on routine inspection data, with greater spatial resolution and better relevance to the risk of spatial dengue transmission.	Cohort Study	Associação de áreas com porcentagem de criação de *A. aegypti* entre o total de habitats de reprodução, os índices mais altos apresentam um maior número de casos.
Pint et al., 2011, Brazil, United Kingdom and Singapore	Correlate dengue cases with climatic variables for the city of Singapore.	Ecological study	There was an association between dengue incidence and temperature variation, but there was a 79% probability of new cases being attributed to other causes, such as sanitation, water accumulated in containers, flower pots and poorly tended gardens.
Raude et al., 2009, France	Examine the role of environmental and individual factors in the social epidemiology of chikungunya disease on the island of Mayotte (southwest Indian Ocean).	Cohort Study	The study identified an association between outdoor plumbing, traditional housing or unsealed courtyards (houses with more exposed areas) being positively associated with Chikungunya infection. The risk of infection was more than double among indigenous people compared to migrants.
Rodrigues et al., 2018, Brazil and the United States	Describe the spatio-temporal evolution of dengue in Brazil from 2001 to 2012 and analyze the relationship between reported cases and sociodemographic and environmental factors.	Cohort Study	Tropical areas with high population density, informal settlements, low income and poor basic sanitary conditions are those most at risk of diseases transmitted by *A. aegypti.*

RBCTI
Revista Brasileira de Ciência, Tecnologia e Inovação
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Souza et al., 2028, Brazil	Evaluate the sociodemographic and maternal and neonatal care factors involved in the microcephaly outbreak in Recife, Brazil, and to analyze the spatial distribution and risk of incidence of newborns with microcephaly in relation to various socio-environmental indicators.	Ecological study	Most of the cases of newborns with microcephaly were the children of mothers who gave birth in public hospitals, who did not attend college, were aged nineteen or under and lived in poorer areas. The risk of microcephaly was directly associated with worsening socio-environmental and vector variables. The results obtained by the study indicated an association where the risk of microcephaly was higher in places where garbage collection rates were lower.
Stewart-Ibarra et al., 2014, United States, Venezuela, South Africa and Ecuador	Characterize the spatio-temporal dynamics and climatic and socio-ecological risk factors associated with the largest dengue epidemic to date in Machala, Ecuador.	Cohort Study	The following risk factors were identified: poor housing conditions, greater access to piped water in the home, shorter distance from the central hospital and older, female heads of household.
Teurlai et al., 2015, New Caledonia, France, Brazil	Analyze the spatial distribution of dengue in New Caledonia during epidemic years, identify some of the main underlying factors and predict the spatial evolution of dengue under varying climatic conditions.	Cohort Study	The results of the study indicated an association between dengue incidence rates and average temperature (22 to 25°C) and average rainfall.
Tipayamongkholgu et al., 2011, Thailand	Analyze sociogeographic predictors for the occurrence of all dengue cases reported at the village level in Prachuap Khiri Khan, a semi-urban province on the coast of Thailand.	Ecological study	The trend of increased dengue fever in rural Thailand has emerged in areas with a strong urban influence rather than remote rural areas.
Toledoet al., 2019, Brazil	Develop probabilistic models for local dengue transmission in a non-endemic city Identify dengue hotspots at high geographic resolution and determine	Incidence prevalence study	It identified that tropical and subtropical regions are suitable for prolonged seasonal and year-round dengue transmission. Countries located in the tropics and subtropics are at constant risk of dengue transmission, while

RBCTI
Revista Brasileira de Ciência, Tecnologia e Inovação
DOI: https://doi.org/10.18554/rbcti.v8i1.6971

	the association between local environmental characteristics and the distribution and transmission of the disease.		temperate areas are at risk in only a few months of the summer.
Wangdi et al., 2018, Australia and East Timor	Identify dengue outbreaks at high geographical resolution and determine the association between local environmental characteristics and the distribution and transmission of the disease.	Ecological study	The results show that if population migration and expansion are not planned, they can lead to substandard water supply and sanitation. Climatic factors such as rainfall and average temperature were important predictors of dengue cases.
Yue et al., 2018, China and the United States	Investigate spatial patterns and environmental and socio-economic risk factors for dengue fever.	Case study	Dengue cases were associated with land type, water index, land surface temperature during the day, land surface temperature at night, population density and gross domestic product.

Based on the main results extracted from the analyzed studies, as shown in **Chart 1**, climate and environmental changes have been getting worse in the last decades, and it implies a challenge for both public managers and society, mainly when it comes to the causes and impact of these changes on health conditions, with emphasis on cases linked to arboviruses.

Arboviruses of endemic, pandemic or reemerging order take place in almost all tropical and sub-tropical regions in the planet (VOORHAM et al., 2009). Countries located in these regions are more susceptible to *A. aegypti* proliferation and development. It happens due to global changes caused by climate changes and variability, land use, water storage and irrigation, human population growth and urbanization (BARCELLOS et al., 2009).

Since early 2000s, the largest number of Dengue cases in Brazil was recorded in the Atlantic coast (Northeastern and Southeastern regions) and in the countries' Southeastern hinterlands, in São Paulo State. Between 2001 and 2006, and between 2007 and 2012, cases outspread in Brazil's hinterlands, mainly in the Midwestern region. There was also increase in Dengue epidemics on international borders. The global incidence of cases in municipalities on the border of French Guiana, Bolivia and Venezuela, from 2001 to 2011, exceeded 400 cases per 100,000 people (RODRIGUES et al., 2016).

In 2002, when El Niño was quite strong, 89.6% of Brazilian municipalities recorded Dengue cases. Factors such as temperature, relative air humidity and rainfall influenced the vector's dynamics, as well as Dengue epidemics' peaks, mainly in the first semester of the year (VIANA; IGNOTTI, 2013).

El Niño-Southern Oscillation, also known as ENSO, is one of the climate phenomena related to yearly variability in global meteorological patterns influencing sea surface

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temperature and rainfall variability. This process has impact on human health due to extreme temperature and humidity conditions capable of speeding up the outbreak of some diseases transmitted by vectors, such as Dengue (FERREIRA, 2014).

This phenomenon interferes with spatial distribution, as well as with the maintenance of Dengue virus yearly patterns in Central America, in far Northern-Northeastern South America, and in East Timor in Southeastern Asia. (FERREIRA, 2014; FISCHER et al., 2013; PINTO et al., 2011; WANGDI et al., 2018). Some countries in Latin and Central America have reported association between arboviruses occurrence and ENSO-related meteorological events, such as storms and tornados (FERREIRA, 2014; FISCHER et al., 2013; PINTO et al., 2011).

Association between ENSO and yearly Dengue incidence seems to be more intense in far Northern South America, in some Andean regions, in Northeastern and coastal Central Pacific, and in Brazil. The interdependence between Dengue cases and ENSO was also confirmed in 2001 in Suriname and in the French Guiana, due to hotter temperatures and rainfall shortage. Although ENSO's climate effects reach continent scale, its influence on Dengue epidemics depends on local environments, as well as on demographic, social and economic features (KUCHARZ; CEBULA-BYRSKA, 2012; GAGNON; BUSH; SMOYER-TOMIC, 2001).

A study on ZIKV arbovirus has shown that this disease's outbreak in Latin America was likely caused by the El Niño phenomenon in 2015 and 2016. It is worth highlighting that the highest global transmission risk is faced in South America and in tropical countries due to highest *A. aegypti* concentration in these places (CAMINADE et al., 2016). Brazilian Northeastern and Southeastern regions are the most populous in the country, and they were the areas accounting for the highest ZIKV and CHIKV transmission risks (AGUIAR et al., 2018).

Costa Rica was the Latin American country showing altitude and temperature as the most significant climate factors for Dengue incidence. Regions located close to the coast, either in the Caribbean or in the Pacific, presented strong climate factors' influence on worsened incidence of the disease (QUEIROGA et al., 2012).

Seasonal winds and alternated rain/drought times feature the monsoon, and it has impact on Southeastern Asia regions. This phenomenon is closely related to associations between climate and dengue incidence. Countries located in tropical and equatorial zones are also quite affected by the monsoon phenomenon, as well as by El Niño (ACHARYA et al., 2016).

Studies carried out in Indonesia, Malaysia and Singapore have shown close link among rainfall, temperature, humidity and variations in vegetation indices, and Dengue incidence. This finding points towards the fact that climate and environmental data can be used to predict this disease's outbreaks (PINTO et al., 2012; ASTUTI et al., 2019; AHMAD et al., 2018).

Mean temperature and mean daily rainfall over the most humid three months of the year in New Caledonia archipelago, in Oceania, were assessed to check their association with Dengue epidemics in this region. Mean temperature ranging from 22ºC to 25ºC has positive association with Dengue incidence, and this finding is explained by the effect of temperature on the mosquito's life cycle and on extrinsic incubation-time duration (TEURLAI et al., 2015).

Transmission risk is quite seasonal in temperate regions, because they are *A. albopictus* habitat. This particularity increases ZIKV transmission risk in Southeastern USA,

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Southern China and, at lower degree, in Southern Europe during the boreal summer season (CAMINADE et al., 2016).

DENV mostly takes place in tropical regions; however, Dengue outbreaks in Florida (USA) point out how climate changes can increase transmission risks. Dengue's transmission potential was higher in summer (from July to September), although some locations in Florida and Texas recorded transmission cases in spring and fall (BUTTERWORTH; MORIN; COMRIE, 2017).

Global climate changes in Europe had stronger impact on the continent's Southern coast, including the Mediterranean region. Climate change consequences are not felt the same way, each region is affected by arboviruses' manifestations in different ways and intensity (GONZÁLEZ; ESCOBAR, 2011). Regions recording mean temperature higher than 20º C, for at least one month, have higher CHIKV transmission risk, despite risks resulting from low temperatures, because its secondary vector (*Aedes albopictus*) can keep on reproducing and survive under lower temperatures (FISCHER et al., 2013).

Dengue transmission geographic limits at global scale are strongly set by climate. By assuming that sources, infection means and susceptible human vectors remain the same, it was possible predicting that climate changes help rising the number of people and the rate of the population at risk of acquiring some arbovirus (HALES et al., 2002).

Environmental factors, such as temperature and rainfall, are the most often mentioned elements included in statistical models aimed at determining and predicting Dengue transmission, worldwide (GHARBI et al., 2011Temperature, relative humidity and rainfall systems can have straight and indirect impact on *A. aegypti* reproduction, survival, development and abundance, since they provide the proper conditions for its survival, as well as influence arboviruses' space-time distribution (PHAM et al., 2011; TIPAYAMONGKHOLGUL; LISAKULRUK, 2011; YU et al., 2010).

Dengue spatial occurrence in Argentina, which is a non-endemic country, was best explained by the combination of climate, demographic and geographic variables. Researchers have found positive association among likely transmission days, population size, population decrease and distance from waterbodies. The performance shown by demographic variables, in separate, was more remarkable than that by the climate and geographic ones. Thus, temperature does not fully describe Dengue occurrence distribution at country scale. Districts accounting for Dengue's autochthonous distribution were mainly located in sub-tropical regions that would extend themselves towards temperate-region latitudes (CARBAJO; CARDO; VEZZANI, 2012).

A study carried out in Kenya showed that areas located close to waterbodies, such as rivers, lakes and swamps, were seroprevalent areas (GROSSI-SOYSTER et al., 2017). Their increased Dengue risk was associated with higher temperatures and humidity, and with higher rainfall indices. The acknowledged intense surveillance stations featured by these characteristics help reducing losses caused by Dengue (PHAM et al., 2011).

Besides climate factors, a study carried out in Pakistan presented association among moisture content, vegetation canopy and mosquito breeding locations. In other words, adult *A. aegypti* and its eggs survive in locations where there is enough humidity available. Vegetation canopy reduces wind speed and protects the vector's eggs from straight sunlight, and it reinforces the high incidence of Dengue vectors' eggs and larvae in these areas. Results have shown association between most Dengue cases and high-density drainage areas, and the presence of streams and canals crossing urban areas (FAREED; GHAFFAR; MALIK, 2016).

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The association between demographic aspects and Dengue incidence lead to reversed association between Dengue occurrence and the rate of people living in the countryside. This finding evidences that the larger the urban population in the city, the higher the Dengue risk. It was also possible associating Dengue risk to population density, and it showed that the higher the population density, the higher the Dengue risk (RODRIGUES et al., 2018; RODRIGUES et al., 2016).

Population growth and demographic denssity, migration movements, economy, tourism, as well as goods' exchanging and transportation, also influence vectors and viruses' distribution and maintenance, mainly *A. Aegypti*. *Aedes* adapts to both human flow and urban zones, so it gets to keep on reproducing in population agglomerates (FERREIRA, 2014; HU et al., 2011; YUE et al., 2018; RAUDE; SETBON, 2009).

Eco-bio-social determinants for Dengue vectors' breeding were assessed in Chennai, Indonesia, Myanmar, Philippines, Sri Lanka and Thailand. The most productive vectors' reproduction locations were outdoor open water containers placed under trees and untouched for at least one week (ARUNACHALAM et al., 2010).

Local ecological factors in Cuba contributing to increase *A. aegypti* vector infestation were observed in four urban-health zones, which were also the deposit type accounting for the largest number of larvae. There was correlation between number of infected outdoor deposits and shaded places without appropriate domestic hygiene, and the presence of vegetation and trees (LAZCANO et al., 2006). Thus, clean areas and proper care for squares, parks and woods are relevant aspects for governmental actions, because they help promoting public-health.

Other studies have found that social groups' segmentation in cities, which have different access to resources and service, can influence Dengue cases' space and time distribution. It also contributes to increase the number of Dengue cases recorded in neighborhoods accounting for both the worst socio-economic conditions and hard access to urban resources and services (CARABALÍ; HENDRICKX, 2018; LAZCANO et al., 2006; MACCORMACK-GELLES et al., 2018; KIKUTI et al., 2015).

Studies have shown that the highest risk to acquire arboviruses in neighborhoods presenting higher social vulnerability is linked to socio-economic aspects (RODRIGUES et al., 2018). These aspects' influence on population's health conditions has been broadly discussed as important tool to analyze and assess the risk they pose to health, mainly when it comes to risks related to the environment and to populations' socio-economic profile (BARCELLOS et al., 2005; FERREIRA; NETO, 2007).

The growth recorded for slums, settlements and urban buildings' concentration, where basic sanitation conditions are precarious and garbage collection is not satisfactory, proved to be the very factors favoring *A. aegypti* reproduction (RODRIGUES et al., 2018; FERREIRA; NETO, 2007; SOUZA et al., 2018).

There was association between high rates of Zika cases, and houses presenting garbage accumulation and rainwater storage, in Northeastern Brazil. It is so, because these conditions help vectors' proliferation and, consequently, virus' transmission (CAMPOS et al., 2018).

According to the aforementioned study, the reversed association between GDP and Dengue risk in Dengue cases' distribution is related to socio-economic factors. The higher the GDP, the lower the Dengue risk. There is straight association between Gini index levels and Dengue risk, i.e., the higher the Gini index, the higher the Dengue risk. Yet, there was reversed association between sewage network extension and Dengue risk, i.e., the lower

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the sewage network rate, the higher the Dengue risk (RODRIGUES et al., 2016; CAMPOS et al., 2018; CARABALÍ; HENDRICKX, 2012; CORDEIRO et al., 2011).

Socio-economic conditions affect Dengue's distribution and incidence, because the population exposed to higher unemployment and poverty rates lives under precarious conditions. It oftentimes lives in overcrowded informal settlement buildings without basic sanitation services (TEURLAI et al., 2015; CAMINADE et al., 2016).

Another study carried out in Brazil showed that, although there was no evidence of linear relation between life conditions and Dengue occurrence due to weak statistical association between these factors, spatial patterns have shown higher concentration of Dengue cases in areas close to roads and under precarious housing conditions. These inequalities also influence Dengue occurrence time trends – the number of cases remains stable in lower-risk neighborhoods (MACHADO; OLIVEIRA; SANTOS, 2009; REES et al., 2018).

WHO recommends surveillance over vectors to quantify Dengue vector's fluctuation size (ONG et al., 2019). Supported entomological surveillance must be carried out in locations accumulating waste and old tires, mainly during inter-epidemics times and in urban peripheries (MACCORMACK-GELLES et al., 2018). Territories counting on Family Health Strategies (ESF) in Brazil presented the highest probability of recording lower severe Dengue incidence rates in the 2008 epidemics (GIBSON et al., 2014).

The present study provided a descriptive and general overview of associations between DENV, ZIKV and CHIKV, and socio-economic and environmental aspects. Such knowledge is a necessary step towards new studies on this topic. The present research highlights the need of further studies including quantitative and qualitative information about water supply, research on sex differences and arboviruses incidence, on borderline regions and arboviruses' incidence, and, after all, the need of research focused on developing efficient arboviruses' control and prevention.

CONCLUSIONS

The present analysis led to arboviruses' outspread linked to several factors, mainly to those related to climate and the environment. Regions prone to higher social vulnerability due to lack of satisfactory sewage services and water supply have higher risk of having their populations exposed to diseases caused by arboviruses' distribution in their territories.

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