Geographical distribution and monitoring of dengue in 141 municipalities in the center-west of Brazil

Distribuição geográfica e monitoramento de dengue em 141 municípios no centro-oeste do Brasil

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ABSTRACT
In fact, it appears that dengue is characterized as a disease that has relevance to public health in the country. For the year 2019, 1,544,987 cases of dengue could be reported, with the presence of 782 confirmed deaths. Regarding the interruption of dengue epidemic cycles, it was noted that measures associated with vector control have not been successful. This study aims to analyze the spatial distribution associated with dengue cases present in the municipalities of the state of Mato Grosso, from 2015 to 2018, in order to identify the municipalities that have the highest risk rates related to the presence of arbovirus. Gross and Smoothed Rates were used through the Local Empirical Bayesian method. In order to calculate these Bayesian rates, a neighborhood matrix was developed with the presence of the continuity criterion that removed the zero risk of dengue from this calculation, thus minimizing the effects associated with the random fluctuations present in the areas that were monitored. Of course, the SaTScan software was used to calculate the Relative Risk (RR), and it was found that in this spatial scan clusters of low, medium and high risks were identified, demonstrating statistically significant data. The use of statistical techniques and spatial analysis employed in the study expanded the more detailed examination of the risk of transmission in the monitored areas, contributing significantly to the formulation and planning of integrated prevention and control strategies aimed at monitoring the arbovirus present in the state of Mato Grosso.

Keywords: spatial analysis, bayesian rates, relative risk, collective health.

RESUMO
De fato, verifica-se que a dengue é caracterizada como uma doença que possui relevância para a saúde pública no país. Para o ano de 2019, puderam ser notificados 1.544.987 casos de dengue, com a presença de 782 mortes confirmadas. Com relação à interrupção dos ciclos epidêmicos da dengue, notou-se que as medidas associadas ao controle do vetor não têm obtido resultados. Este estudo possui como objetivo fazer uma análise da distribuição espacial associada aos casos de dengue presentes nos municípios do estado de Mato Grosso, de 2015 a 2018 com o intuito de poder identificar os municípios que possuam as taxas mais elevadas de risco relacionadas com a presença da arbovirose. Utilizaram-se as Taxas Brutas e Suavizadas través do método Bayesiano Empírico Local. Para a realização do cálculo dessas taxas Bayesianas, desenvolveu-se uma matriz de vizinhança com a presença do critério de continuidade que removeu desse cálculo o risco zero de dengue, minimizando desta forma, os efeitos associados com as flutuações aleatórias presentes nas áreas que foram monitoradas. Por certo, tem-se que foi utilizado o software SaTScan para o cálculo do Risco Relativo (RR), e verificou-se que nessa varredura espacial que foram identificados clusters de baixo, médio e alto riscos demonstrando dados estatisticamente significativos. A utilização de técnicas de estatística e análise espacial empregadas no estudo ampliaram o exame mais detalhado do risco de transmissão nas áreas monitoradas contribuindo de maneira significativa para a formulação e planejamento de estratégias integradas de prevenção e controle voltadas para o monitoramento da arbovirose presente no estado de Mato Grosso.

Palavras-chave: análise espacial, taxas bayesianas, risco relativo, saúde coletiva.

1 INTRODUCTION

The epidemiological setting concerning the dengue in Brazil has been distinguished by the concurrent circulation regarding the four serotypes of the dengue virus (DENV), which has been accompanied by an important number of serious cases and deaths. These are often preventable. The introduction of the Zika (ZIKV) and Chikungunya (CHIKV) viruses in Brazil, in 2014 and 2015, respectively, with wide dispersion throughout the country, has made the suspicion and differential clinical diagnosis of these three types of arboviruses very complex, turning this situation into more challenge. Thus, greater rigor on the part of health services and professionals is imperative, so that complications and occurrence are avoided (BRASIL, 2019).

Dengue has been considered the most important resurgent transmitted disease among the other viral diseases transmitted by biological vectors, and also shows in epidemic bouts, occurring mainly in urban areas (PIGNATTI et al, 2012).

In fact, it could be noted that the incidence concerning dengue has significantly grown throughout the world over the last few decades. The real number of cases of this disease is undernotified and many cases are wrongly classified. Recent estimates have put the incidence of dengue at around 390 million infections per year (consisting of a Confidence Interval (CI) of 95%, from 284 to 528 million), of which the total of 96 million (67 to 136 million) cases have clinical manifestations, whatever the severity of the disease. According to another study regarding the prevalence of dengue, it could be estimated that the total of 3.9 billion people, living in 128 countries, may be at some risk of infection by the Dengue Virus (DENV) (WHO, 2019; GUODOND et al, 2015; GUZMAN et al, 2016).

The DENV belongs to the genus *Flavivirus* and to the family *Flaviviridae*. The DENV is transmitted by arthropod vectors (mosquitoes) from the genus *Aedes*, the main transmitting mosquito being *Ae. aegypti*. At present, four different serotypes of the dengue virus are known: DENV-1, DENV-2, DENV-3 and DENV-4. However, cases of a fifth serotype, DENV-5, have been reported in Malaysia (MAROUN et al. 2008; CASTANHA et al, 2016).

In Brazil, in 2019 up to Epidemiological Week (SE) n.º 52 (30 December 2019), 1,544,987 possible cases with respect to the dengue could be reported (consisting of the Incidence Rate (IR) of 735.2 probable cases per 100 000 inhabitants). This means an increase of 545.4% in the number of cases, when compared to the same period of 2018, when 239,389 notified cases of dengue were reported. The number of dengue deaths in 2019 is 5.36% higher than that recorded in 2018. By SE 52, 782 deaths from dengue had been confirmed. The states with the greatest number of deaths under investigation are: São Paulo (265), Minas Gerais

(172), Goiás (81), Distrito Federal (58), Espírito Santo (34) Bahia (32), Paraná (31) and Mato Grosso do Sul (29) (BRASIL, 2020).

The Midwest Region presented 1,349.1 probable cases per 100 000 inhabitants, followed by the Southeast (1,159.4 probable cases per 100 000 inhabitants), Northeast (376.7 probable cases per 100 000 inhabitants), North (195.8 cases per 100 000 inhabitants) and South (165.2 probable cases per 100 000 inhabitants). The states of Sao Paulo, Minas Gerais and Goiás stand out, which concentrated 66.2% of the probable cases in the country (BRASIL, 2020).

In MT between the years 2015 to 2018, 78,800 probable cases of dengue were reported, with confirmation of 24 deaths. The accumulated incidence in the study period in the state ranged from the minimum in 2018 of 197.2/100 thousand inhab., to the maximum incidence in 611.4/100 thousand inhab., in 2015, the same year with the record of 6 deaths, the largest of the period (BRASIL, 2020).

Indeed, it could be observed that the spatial distribution of diseases may be analyzed and mapped using the Geographical Information System (SIG), which is able to store geographical information, and establish correlations with table data, and which can be used for collection, storage, querying and presentation of spatial data, helping with the spatial location of the diseases and the graphic analysis of epidemiological indicators. According to the World Health Organization (WHO), this is an efficient tool for the administration of the *Programa Nacional de Controle da Dengue* (PNCD) (in English National Programme for Dengue Control) (ESRI, 2020; MS, 2002).

In fact, it is essential to use maps in the health area, in relation to the planning process and for the control of the disease (Lima et al., 2006). Spatial epidemiology allows one to acknowledge the distribution, importance and frequency concerning the distinct factors that may have a bearing on the increase of certain risks for health, as well as providing the identification of groups that share similar risks (BARCELOS et al, 2005).

Indeed, the characterization and identification of these areas may be performed by the spatial and temporal scanning window, which can be performed in the SaTScan software (KULLDORFF, 1997), in which this software may calculate the Relative Risk (RR) regarding the incident of an event present in a study area. This software is used worldwide by the epidemiologists in order to describe spatial clusters of chronic and infectious diseases, risk factors and disease vectors (SHERMAN et al, 2014).

As aforementioned, this research aimed to analyze the spatial distribution of probable dengue cases in the 141 municipalities in the state of MT between 2015 and 2018, in order to make a comparison between the spatial distribution regarding the Incidence Rates (IR) with Smoothed Rates by the local empirical Bayes method, thus possibly identifying the risk areas of transmission in the 16 health regions in the state of MT.

2 METHODS

2.1 STUDY DESIGN

This study was of the ecological type, where the unit of observation is associated with the community or population within a defined geographical area. In the study, we used data of notification of cases of dengue by municipality of abode, obtained through the *Sistema Nacional de Agravos de Notificação* (SINAN) (in English National System of Notifications of Disease) of the Ministry of Health (Brazil), between January 2015 and December 2018, comprising the 141 municipalities of the Mato Grosso state, in Midwestern Brazil.

2.2 TERRITORY OF THE STUDY

The Brazilian state of MT has a total area of 903,357.908 km^2. It is the third largest state in Brazil, after Amazonas and Pará. The urban area of MT comes to 519.7 km^2, which means that it is only 11th place in the league table of Brazilian states with largest urban sprawl. The state accounts for 1.59% of the total population of Brazil. In addition, 81.9% of the population live in the urban part of the state, compared to 18.1% in the rural part. The number of men is slightly more than the number of women: men account for 51.05% of the population and women for 48.95%. The rate related to the population growth for Mato Grosso state is 1.9% per annum (IBGE). The area covered in this study includes all 141 municipalities of MT, a state that lies in the Midwest Region of Brazil and has an estimated population of 3,035,122 inhabitants, according to the *Insitituto Brasileiro de Geografia e Estatística* (IBGE) (in English Brazilian Institute of Geography and Statistics) (IBGE, 2020) These municipalities are divided among five mesoregions of the State: Centre-South of MT; Northeast of MT; North of MT; Southeast of MT; and Southwest of MT. The 141 municipalities of the state are also divided into 16 regional health offices, which are the main object of risk analysis, namely: Alta Floresta; Água Boa; Cáceres; Barra do Garças; Cuiabá; Colíder; Juara; Pontes e Lacerda; Juína; Diamantino; Peixoto de Azevedo; Rondonópolis; Porto Alegre do Norte; Sinop; São Felix do Araguaia; and Tangará da Serra, representing the units analyzed in this work (Figure 1).

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2.2.1 Population and study period

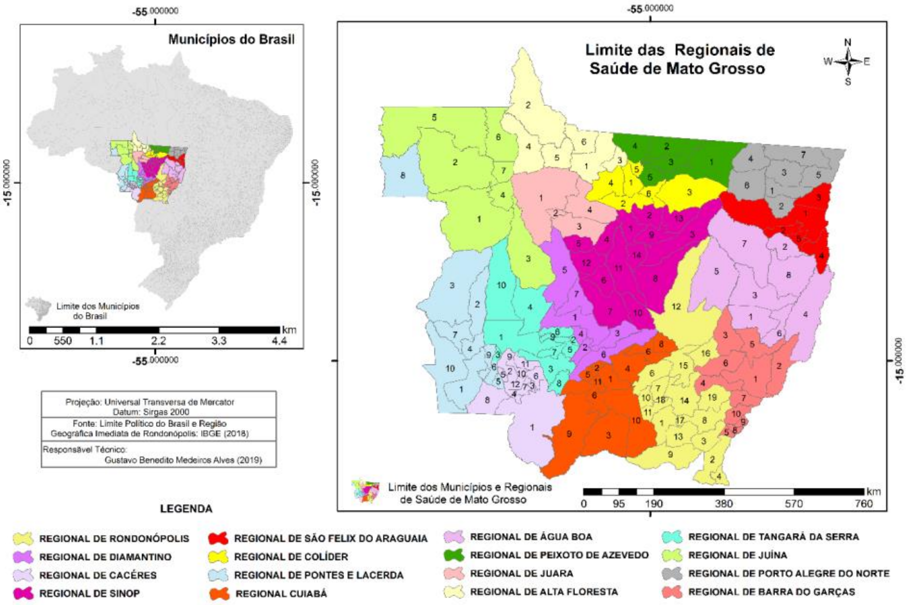
The population for this study comprised all cases of dengue, duly notified by municipality of abode at the SINAN in the 141 municipalities of the State of MT between 2015 and 2018. Throughout the study period, the annual population could be estimated by the IBGE was used to construct incidence rates and smoothed rates.

2.3 CHARACTERIZATION OF RISK AREAS FOR DENGUE

The regional health centers, with the municipalities they cover, have been categorized following the criteria set by the National Programme of Dengue Control (Programa Nacional de Controle de Dengue – PNCD), as follows: low incidence (up to 100 cases per 100 000 people); medium incidence (between 100 and 300 cases per 100 thousand inhabitants), high incidence (between 300 and 1,000 cases per 100 thousand people) and also the epidemic areas (consisting of more than 1,000 cases per 100 thousand people) (BRASIL, 2002; BOHM et al, 2016).

The classification of 141 municipalities in MT according to their size is related to their total inhabitants and obeys the following characterization: a) Small I, with up to 20,000 inhabitants - 104 (73.76%) municipalities; b) Small II, from 20,001 to 50,000 inhabitants - 26 (18.44%) municipalities; c) Medium, from 50,001 to 100,000 inhabitants - 6 (4.25%) municipalities; d) Large, 100,001 to 900,000 inhabitants - 5 (3.55%) (IBGE, 2019; SEPLAN, 2018).

Figure 1 - Location of the area studied in this paper



Legend: Numerical identification of the 141 municipalities in the Brazilian State of Mato Grosso (MT) as distributed among the 16 Regional Health Offices:

- Rondonópolis Regional Health Office: 1. Rondonópolis, 2. Alto Araguaia, 3. Alto Garças, 4. Alto Taquari, 5. Araguainha, 6. Campo Verde, 7. Dom Aquino, 8. Guiratinga, 9. Itiquira, 10. Jaciara, 11. Juscimeira, 12. Paranatinga, 13. Pedra Preta, 14. Poxoréo, 15. Primavera do Leste, 16. Santo Antônio do Leste, 17. São José do Povo, 18. São Pedro da Cipa, 19. Tesouro.
- Diamantino Regional Health Office: 1. Diamantino, 2. Alto Paraguai, 3. Nobres, 4. Nortelândia, 5. Nova Maringá, 6. Rosário Oeste, 7. São José do Rio Claro.
- Cáceres Regional Health Office: 1. Cáceres, 2. Araputanga, 3. Curvelândia, 4. Glória D'Oeste, 5. Indiavaí, 6. Lambari D'Oeste, 7. Mirassol d'Oeste, 8. Porto Esperidião, 9. Reserva do Cabaçal, 10. Rio Branco, 11. Salto do Céu, 12. São José dos Quatro Marcos.
- Sinop Regional Health Office: 1. Sinop, 2. Cláudia, 3. Feliz Natal, 4. Ipiranga do Norte, 5. Itanhangá, 6. Lucas do Rio Verde, 7. Nova Mutum, 8. Nova Ubiratã, 9. Santa Carmem, 10. Santa Rita do Trivelato, 11. Sorriso, 12. Tapurah, 13. União do Sul, 14. Vera.
- São Felix do Araguaia Regional Health Office: 1. São Félix do Araguaia, 2. Alto Boa Vista, 3. Luciara, 4. Novo Santo Antônio, 5. Serra Nova Dourada.
- Colíder Regional Health Office: 1. Colíder, 2. Itaúba, 3. Marcelândia, 4. Nova Canaã do Norte, 5. Nova Guarita, 6. Nova Santa Helena.
- Pontes e Lacerda Regional Health Office: 1. Pontes e Lacerda, 2. Campos de Júlio, 3. Comodoro, 4. Conquista D'Oeste, 5. Figueirópolis D'Oeste, 6. Jauru, 7. Nova Lacerda, 8. Rondolândia, 9. Vale de São Domingos, 10. Vila Bela da Santíssima Trindade.
- Água Boa Regional Health Office: 1. Água Boa, 2. Bom Jesus do Araguaia, 3. Canarana, 4. Cocalinho, 5. Gaúcha do Norte, 6. Nova Nazaré, 7. Querência, 8. Ribeirão Cascalheira.
- Peixoto de Azevedo Regional Health Office: 1. Peixoto de Azevedo, 2. Guarantã do Norte, 3. Matupá, 4. Novo Mundo, 5. Terra Nova do Norte.
- Juara Regional Health Office: 1. Juara, 2. Novo Horizonte do Norte, 3. Porto dos Gaúchos, 4. Tabaporã.
- Alta Floresta Regional Health Office: 1. Alta Floresta, 2. Apiacás, 3. Carlinda, 4. Nova Bandeirantes, 5. Nova Monte Verde, 6. Paranaíta.

- Tangará da Serra Regional Health Office: 1. Tangará da Serra, 2. Arenápolis, 3. Barra do Bugres, 4. Campo Novo do Parecis, 5. Denise, 6. Nova Marilândia, 7. Nova Olímpia, 8. Porto Estrela, 9. Santo Afonso, 10. Sapezal.
- Juína Regional Health Office: 1 Juína, 2. Aripuanã, 3. Brasnorte, 4. Castanheira, 5. Colniza, 6. Cotriguaçu, 7. Juruena.
- Porto Alegre do Norte Regional Health Office: 1. Porto Alegre do Norte, 2. Canabrava do Norte, 3. Confresa, 4. Santa Cruz do Xingu, 5. Santa Terezinha, 6. São José do Xingu, 7. Vila Rica.
- Barra do Garças Regional Health Office: 1. Barra do Garças, 2. Araguaiana, 3. Campinápolis, 4. General Carneiro, 5. Nova Xavantina, 6. Novo São Joaquim, 7. Pontal do Araguaia, 8. Ponte Branca, 9. Ribeirãozinho, 10. Torixoréu.
- Cuiabá Regional Health Office: 1. Cuiabá, 2. Acorizal, 3. Barão de Melgaço, 4. Chapada dos Guimarães, 5. Jangada, 6. Nossa Senhora do Livramento, 7. Nova Brasilândia, 8. Planalto da Serra, 9. Poconé, 10. Santo Antônio do Leverger, 11. Várzea Grande.

2.4 ANALYSIS OF DATA

For the demarcation of risk areas and visualization of the geographical distribution of cases of dengue, we used incidence rates. Indeed, the IR is associated with the easiest risk estimators as well as those most used for mapping occurrences of diseases and disorders; however, these rates normally generate significant instability on showing the risk of an event when it is rare and when the population related to the region of the occurrence is not relevant (CARVALHO et al, 2007).

The most usual form of rate mapping uses the so-called Incidence Rate, given by the expression:

$$Tbi = Yi / Pi \times 100{,}000,\ i = 1, \ldots, n$$

being, Yi the number of cases that could be observed, Pi is associated with the total population-at-risk and n is related to the number of geographical units (for instance, municipalities) contained in the map. Through this calculation, the observed number of events in each municipality i ($i = 1, \ldots, n$) is obtained in a base population of 100 thousand people (CARVALHO et al, 2011).

Considering that the state of MT has many small municipalities, it is necessary to flatten the incidence rates, because, as the denominators of these areas are low in value, the results obtained can be easily masked. Out of the available alternatives for flattening, we used the Local Bayesian Approach.

The Empirical Bayesian Estimators bring the incidence rates of small areas closer to the average rate of their neighbours (SOUZA et al, 2007). These corrected rates can be more stable, since according to their calculation, they may consider information about the neighbourhood associated with the area. In this way, maps based on these estimates are more informative. The Global Empirical Bayesian Estimator aims at approximating the average rate of the group of municipalities, while the Local Empirical Bayesian Estimator works with the mean incidence value found near the municipality (DRUCK et al, 2004).

To reduce the random variability of incidence rates, the Local Empirical Bayesian Estimator was used, which smoothes rates, which allows comparisons between different populations and also takes into consideration the regional variances (BARBOSA e SILVA, 2015; SILVA et al, 2015). Calculating the rate locally, using only the geographic neighbors of the area in which it is desired to estimate the rate, converging towards a local average (MARSHALL, 1991). The corrected rates are more stable, considering in their calculation not only the information of the area, but also the information of its neighbourhood. Thus, the estimates become closer to the reality of the events (CARVALHO *et al*, 2011; CÂMARA et al, 2004). The local Bayesian estimate consists of a small change in the global Bayesian method proposed by Marshall (1991): instead of $\hat{m}$ and $\bar{n}$, $\hat{m}_i$, $\bar{n}_i$, are used, representing, respectively, the local rate in the vicinity of the area i and the average number of events in this area neighbourhood.

$$_i = C_i r_i + (1 - C_i)\hat{m}_i$$

An essential procedure for the evaluation of spatial dependence is the preparation of a neighbourhood matrix, which shows the spatial relationship between each area and the others. It is possible to draw up a matrix based on the list of neighbours of each area, using the distance between the areas, or even based on the presence or absence of a border between two specific areas, weighted using the length associated with the common border. A value of one (1) is assigned to adjacent areas and a value of zero (0) to non-adjacent areas. Areas where there is a direct neighbourhood are known as first-order neighbours. Next, the self-correlation function compares the value of the indicator to the values of the same indicator in neighbouring areas (SOUZA et al, 2007).

For production of theme maps, we used the list of municipalities based on the IBGE. The free geoprocessing software, TerraView 4.2.2, could also be used to calculate the local empirical Bayesian estimates and for the preparation of thematic maps. The automatic process of the geocoding tool of the *ArcGis10.5* programme was also performed.

2.5 ANALYSIS OF RISK RELATIVE (RR)

For RR calculation with a significance level of 99% and data analysis, it could be used the SaTScan software, which is available on the website www.satscan.org.

In this software, it may be observed that the area is related to a single point which is presented in a polygon, *i.e.*, characterized by the centroid. Thus, it is noted that the RR may be calculated from the observed number of cases that will be divided by the respective expected number of cases. Then, RR > 1 shows that the observed number of cases may be more relevant than the expected value. In fact, the RRT is related to a relative measure of association which is founded on the force of combination that has been usually applied to epidemiological studies (KALE et al, 2009). The statistical significance can be expressed in terms of 999 replications and *p* value (0.05) (JONES e KULLDORF, 2012).

To calculate the RR, data on the population annual, number associated with the confirmed cases of a certain disease and plan coordinates were used (Lambert's Conical Projection: Central Meridian: W56.0; Latitude of Origin: S13.0, metric units) centroid of each municipality. In fact, it could be used the Poisson probability model, that includes the analysis concerning the count data, that is, it considers the number of individuals that can be affected by a certain disease (MCCULLAGH e NELDER, 1989).

2.6 ETHICAL CONSIDERATIONS

The Research Ethics Committee of the *Universidade Federal do Mato Grosso* (UFMT) approved the present study, comprising the research project that introduces the general title of: "Prevention and control: viral analysis in *Aedes aegypti (Linnaeus, 1762)* for the identification of risk areas and factors that determine arboviruses" (CAAE No. 58645516.2.0000.5541), being in compliance with the requirements set out by Resolution No. 466 associated with the National Health Council, December 12, 2012.

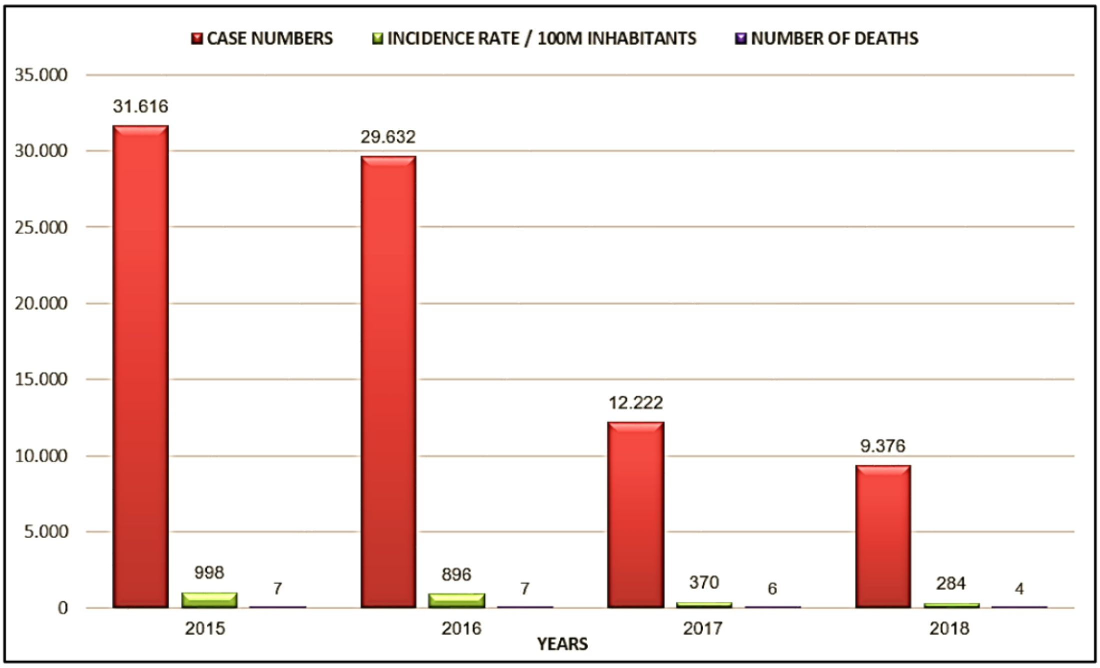
3 RESULTS

The grouped data of 2015 and 2016, for analysis (Figure 2), within the monitoring of cases of dengue in the state of (MT) up to epidemiological week (SE) N.º 50/2016 (up to 17 December 2016), considering cumulative incidence (consisting of the total number of cases that was informed in the period) considered the state of MT as being of high risk for the transmission of the disease, due to its high incidence of dengue (comprising 896 cases per 100 000 people). The number of probable cases of dengue in 2016 (29,632 cases) suggests a reduction of 6.3% in relation to the same period of 2015 (MINISTÉRIO DA SAÚDE, 2017a).

The grouped data from 2016 to 2017, with respect to analysis, includes the monitoring of cases of dengue in the state of (MT) up to epidemiological week (SE) n.º 52/2017 (up to 30 December 2017), considering accumulative incidence (representing the total number of cases that could be notified in the period) considered the state of MT as being of high risk for the transmission of the disease, due to its high incidence of dengue (370 cases per 100 thousand people). However, the number related to the probable dengue cases that was recorded in 2017 (12,222 cases) suggests a reduction of 59% in relation to the same period of 2016 (MINISTÉRIO DA SAÚDE, 2017b).

The grouped data for the analysis of the years 2017 and 2018 within the monitoring of cases of dengue in the state of Mato Grosso (MT) up to SE n. º 52/2018 (to 30/12/2018) and considering the total incidence, shows that the state of MT has a medium incidence of dengue (284/100 thousand people). In 2018, there were 9,376 recorded probable cases of dengue, which suggests a reduction of 23.3% in relation to the same period of 2017 (MINISTÉRIO DA SAÚDE, 2018).

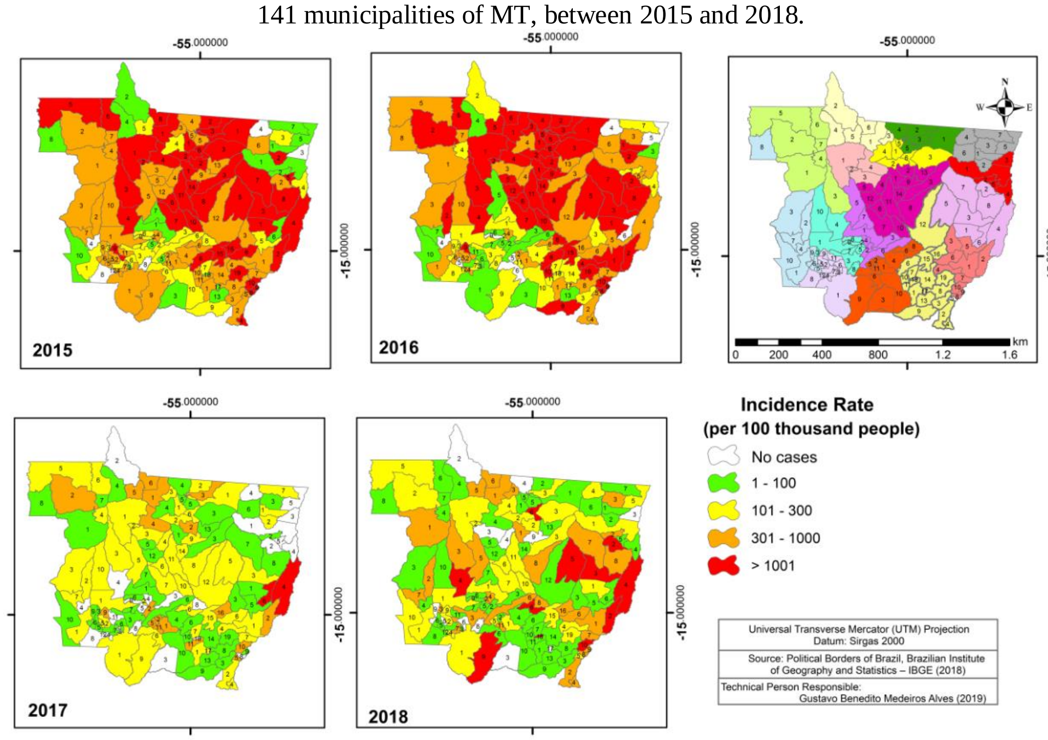
Figure 2 - Total number of probable dengue cases, incidence rate / 100 thousand inhabitants and confirmed deaths, by municipality of residence, from 2015 to 2018, in Mato Grosso state.



Source: Data obtained from SINAN (2015 - 2018).

The figure 3 shows the spatial distribution of incidence rates per 100 thousand inhabitants of probable dengue cases in the 141 municipalities regarding the Mato Grosso state with respect to their respective risk characterizations in the study period from 2015 to 2018.

Figure 3 - Shows the geographical distribution of the incidence rates for dengue, per 100 thousand people, in the 141 municipalities of MT, between 2015 and 2018.



According to the characterization of risk areas in geographic analysis, we see that in the year 2015 incidence of dengue was low in 24 municipalities, corresponding to 17.0% of the total for the state; 20 municipalities (14.2%) had medium incidence. 52 (36.9%) municipalities had high incidence, and 45 (31.9%) municipalities showed very high or epidemic incidence (defined as more than 1,000 cases/ 100 thousand people).

In the year 2015, the high risk of transmission of dengue was present in 68.79% of the municipalities of the state. All 16 Regional Health Offices of the state, in 2015, had at least one municipality with an incidence rate of 300 to 999/100 thousand people (high risk).

Stressing the critical point of the risk of transmission in the 16 Regional Health Offices, we see that 13 (81.25%) showed at least one municipality, in 2015, with an incidence rate over 1,000 cases/100 thousand people; consisting of a very significant or epidemic incidence, dependent on the number of municipalities covered by each Regional Health Office, we observed the following percentages of epidemic risk: Juara Regional Health Office (75%); Água Boa Regional Health Office (75%); Colíder Regional Health Office (66.66%); Sinop Regional Health Office (64.28%); Peixoto de Azevedo Regional Health Office (60%); Barra do Garças Regional Health Office (50%); Juína Regional Health Office (42.86%); Alta Floresta Regional Health Office (33.33%); Rondonópolis Regional Health Office (26.31%); São Félix do Araguaia Regional Health Office (20%); Cáceres Regional Health Office (16.66%); Porto Alegre do Norte Regional Health Office (14.28%); and Tangará da Serra Regional Health Office (10%). We also point out that the highest incidence for the annual year has been associated with the municipality of Santa Carmem (6,513.76 cases/100 thousand people), in the catchment area of the Sinop Regional Health Office.

In the year 2016, in geographic analysis, we see that 26 municipalities of MT (18.44% of the total) showed low incidence of the disease; 25 (17.73%) has shown a medium incidence of dengue; 36 municipalities (25.53%) had high incidence of dengue, and 54 municipalities had incidence of very high or epidemic proportions (over 1,000 cases/100 thousand people). All 16 Regional Health Offices of MT, in 2016, had at least one municipality with incidence rate between 300 and 999/100 thousand people (high risk).

Giving emphasis to the critical point of transmission, in the 16 Regional Health Offices, we see that 14 Regional Health Offices showed at least one municipality, in 2016, with an incidence rate over 1,000 cases/100 thousand people; with a very high incidence rate in proportion to the number of municipalities subject to each Regional Health Office, the following percentages of epidemic risk were recorded: Juara Regional Health Office (100%), Peixoto de Azevedo Regional Health Office (100%), Sinop Regional Health Office (78.57%), Água Boa Regional Health Office (75%), Colíder Regional Health Office (75%), Alta Floresta Regional Health Office (66.66%), Barra do Garças Regional Health Office (60%), Juína Regional Health Office (42.85%), Porto Alegre do Norte Regional Health Office (28.57%), Rondonópolis Regional Health Office (21.05%), Cáceres Regional Health Office (16.66%) and Tangará da Serra Regional Health Office (10%). Here we mention that the highest total incidence was recorded in the municipality of Terra Nova do Norte (5,413.28/100 thousand people), which is subordinate to the Peixoto de Azevedo Regional Health Office.

The geographic analysis for 2017 shows us that 70 municipalities (49.64%) of MT presented low incidence of dengue; 52 (36.88%) had medium incidence; 17 (12.06%) had high incidence, and two municipalities (1.42%) had incidence of very high or epidemic proportions (more than 1,000 cases/100 thousand people).

In 2017, nine (47.36%) of the 16 Regional Health Offices of MT had at the minimum one municipality consisted of an incidence rate between 300 and 999/100 thousand people (high risk). In proportion to the number of municipalities covered by each Regional Health Office, in the period the following percentages of high risk of transmission of dengue were recorded: Alta Floresta Regional Health Office (50%), Cuiabá Regional Health Office (36.36%), Juara Regional Health Office(25%), Barra do Garças Regional Health Office (20%), Juína Regional Health Office (14.28%), Diamantino Regional Health Office (14.28%), Rondonópolis Regional Health Office (10.52%), Cáceres Regional Health Office (8.33%) and Sinop Regional Health Office (7.14%).

Emphasising the critical point of transmission in the year 2017 with an incidence rate over 1,000 cases/100 thousand people, we see that very high or epidemic incidence was recorded in only two municipalities, namely Nova Nazaré (1,942.54/100 thousand people) and Cocalinho (1,174.35/100 thousand people), both within the area of the Água Boa Regional Health Office, corresponding to 25% of the total area of the State.

In 2018, the geographical distribution of incidence rates for dengue show that 68 of the municipalities in MT (48.23% of the total) showed low incidence, 32 municipalities (22.69%) showed medium incidence, 30 municipalities (21.28%) showed high incidence and 11 municipalities (7.80%) showed incidence rates of more than 1,000 cases per 100 thousand people.

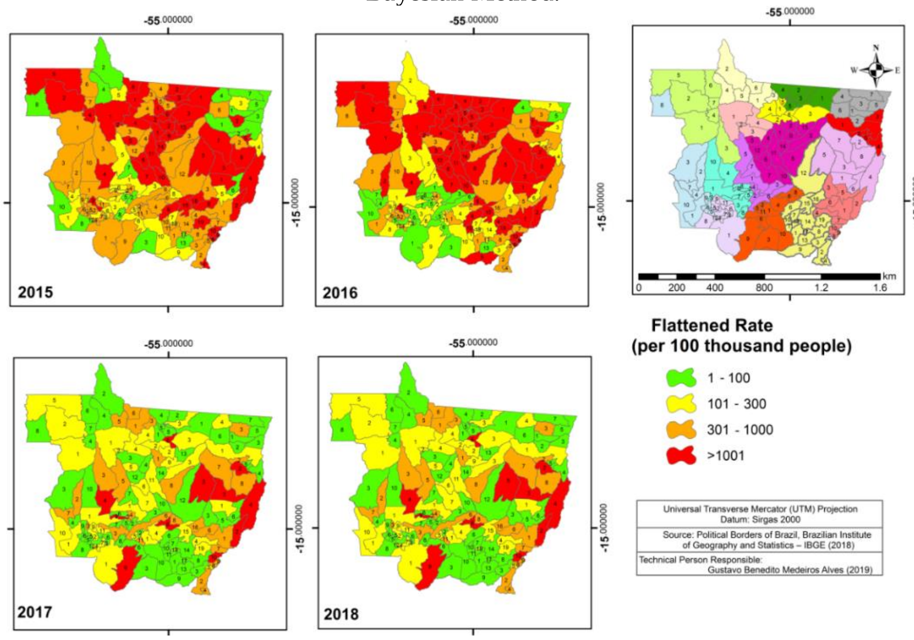
Out of the 16 Regional Health Offices of the state of MT in 2018, 13 of them (81.25%) had at least one municipality with an incidence rate between 300 and 999/100 thousand people, (high risk). In proportion to the number of municipalities covered by each Regional Health Office, the following percentages of high transmission risk were recorded in this period: Alta

Floresta Regional Health Office (66.66%), Barra do Garças Regional Health Office (50%), Regional de Diamantino (42.86%), Juara Regional Health Office(28.57%), Água Boa Regional Health Centre (25%), Tangará da Serra Regional Health Office (20%), Lacerda e Pontes Regional Health Office (20%), São Félix do Araguaia Regional Health Office (20%), Cuiabá Regional Health Office (18.18%), Rondonópolis Regional Health Office (15.78%), Porto Alegre do Norte Regional Health Office (14.28%), Sinop Regional Health Office (14.28%) and Cáceres Regional Health Office (8.33%).

Highlighting the critical point for transmission, in the 16 Regional Health Offices, in 2018, we see that 5 of these Regional Health Offices (31.25%) have demonstrated at the minimum one municipality recorded in 2016, with an incidence rate of more than 1,000 cases/100 thousand people, with a very high or epidemic incidence, in proportion to the number of municipalities covered by the respective Regional Health Office. The following percentages of epidemic risk were recorded: Água Boa Regional Health Office (50%), Barra do Garças Regional Health Office (20%), Tangará da Serra Regional Health Office (20%), Cuiabá Regional Health Office (18.18%) and the Colíder Regional Health Office (16,66%). Here we highlight that the highest accumulated incidence for 2018 was recorded in the municipality of Bom Jesus do Araguaia (3,606.77/100 thousand people), part of the Água Boa Regional Health Office.

The figure 4 the geographic analysis represents the flattened incidence rates per 100 thousand people, for the 141 municipalities of the Mato Grosso state, from 2015 to 2018.

Figure 4 - Flattened rates per 100 thousand people, for the years 2015 to 2018, using the Local Empirical Bayesian Method.



In 2015, comparing the maps of incidence rates with those generated by flattened rates, we see that the number of municipalities that presented zero risk passed from 5 to zero municipalities, while it could be noted an increase related to the total of municipalities with recorded low and medium incidence rates in 43 municipalities, distributed among the 16 Regional Health Offices of MT. The Regional Health Offices that showed very high incidence rates in 2015, in decreasing order of risk, were: Água Boa, Juara, Colíder, Sinop, Peixoto de Azevedo and Barra do Garças.

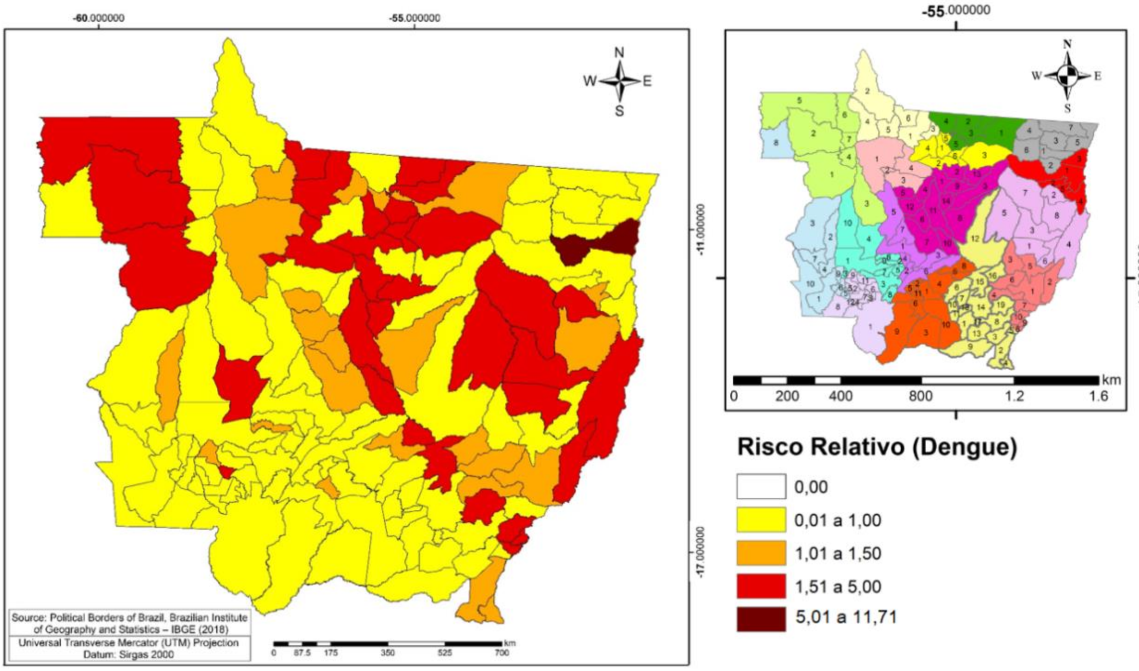
In 2016, the number of municipalities that presented zero risk fell from eight to zero, while this same year showed a rise from 43 to 52 in the number of municipalities reporting low incidence, also scattered among the 16 Regional Health Offices of MT. The Regional Health Offices with very high incidences in 2016, in descending order of risk, were: Porto Alegre do Norte, Juara, Sinop, Água Boa, Colíder, Alta Floresta and Barra do Garças).

In 2017, the number of municipalities that presented zero risk fell from 24 to zero, while this same year showed a rise from 98 to 124 in the number of municipalities reporting low incidence, also scattered among the 16 Regional Health Offices of MT. The Regional Health Offices with very high incidences in 2016, in descending order of risk, were Alta Floresta and Água Boa.

In 2018, the number of municipalities which presented zero risk fell from 14 to zero, while this same year showed a rise from 86 to 102 in the number of municipalities reporting low incidence, also scattered among the 16 Regional Health Offices of MT. The Regional Health Offices with high incidences were Alta Floresta and Barra do Garças, and the one with very high or epidemic incidence levels was the Água Boa Regional Health Office.

The figure 5 - Relative risk (RR) of the 141 municipalities distributed in the 16 health regions with respect to Mato Grosso state, in Brazil, 2015-2018 (Figure 5a). Analysis of the spatio-temporal scanning statistic in the identification of the statistically significant areas distributed in the clusters (Figure 5b).

Figure 5(a) - Relative risk (RR) of the 141 municipalities distributed in the 16 health regions in the state of Mato Grosso, Brazil, 2015-2018.



Organizer: Mário Ribeiro Alves (2020).

Figure 5(a) highlights the relative risk of 141 municipalities distributed in 16 health regions in the state of MT between 2015 and 2018. The purely spatial scanning methodology carried out by SaTScan found that 58.87% (N = 83) of the municipalities distributed in the 16 health regions, that have shown RR <1. The municipalities consisting of RRs values from 1.01 to 1.50 represented 16.31% (N = 23) distributed in 12 regional health regions in MT; the municipalities with RRs between 1.51 and 5.00 correspond to 23.40% (N = 33) also distributed in 12 health regions in the state. During the study period, the highest RR was registered in the municipality of Cana Brava do Norte belonging to the Regional Health of Porto Alegre do Norte and in the municipality of Luciara belonging to the Regional Health of São Felix do Araguaia, *i.e.*, both municipalities with (RR = 11. 71) corresponding to 1.42% (N = 2).

Figure 5 (b) - Analysis of the spatio scanning statistic in the identification of the statistically significant areas distributed in the clusters.

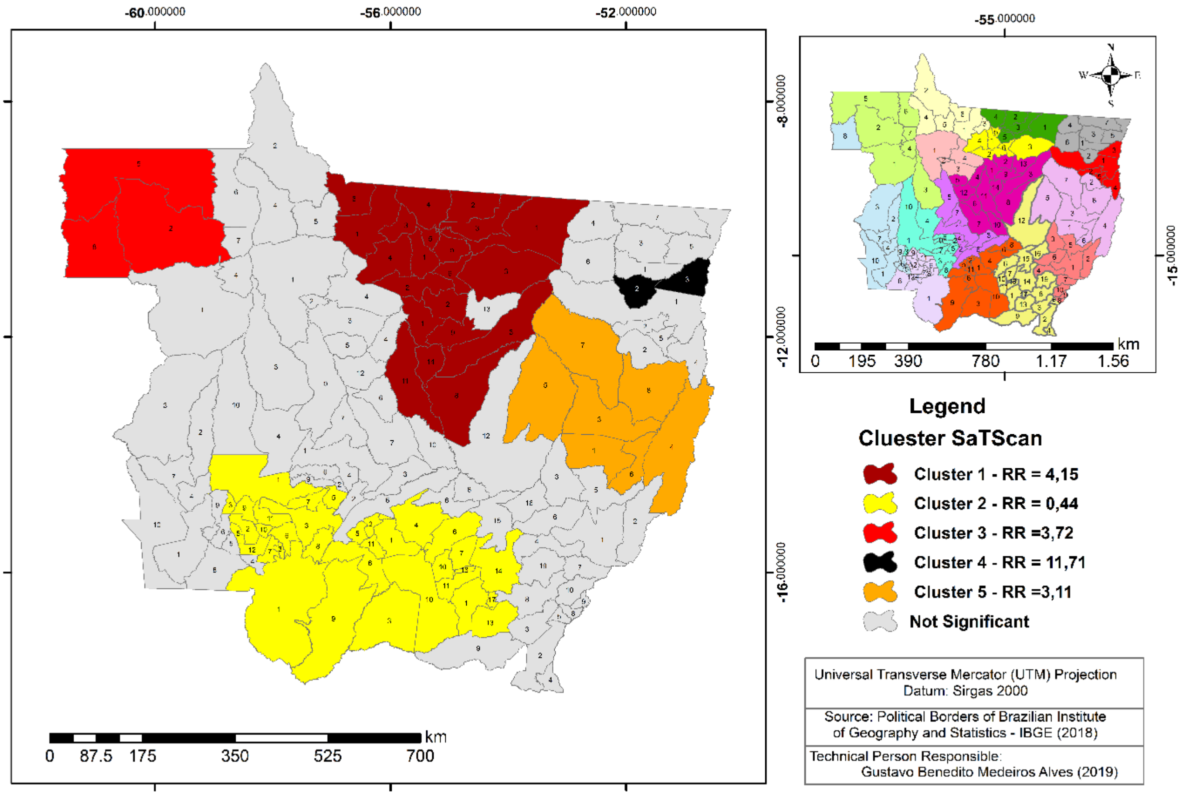


Figure 5(b) – The SaTScan aims to identify the statistically significant areas distributed in the clusters.

Cluster 1 Municipalities: Colíder, Itaúba, Nova Guarita, Nova Canaã do Norte, Nova Santa Helena, Carlinda, Terra Nova do Norte, Santa Carmem, Sinop, Novo Mundo, Vera, Cláudia, Alta Floresta, Guarantã do Norte, Feliz Natal, Peixoto de Azevedo, Matupá, Nova Ubiratã, Sorriso, Marcelândia and Paranaíta. Statistically significant cluster (p-value <0.01), with RR of 4.15.

Cluster 2 Municipalities: Várzea Grande, Santo Antônio do Leverger, Nossa Senhora do Livramento, Porto Estrela, Cuiabá, Jangada, Barão de Melgaço, Acorizal, São pedro da Cipa, Jaciara, Barra do Bugres, Poconé, Chapada dos Guimarães, Juscimeira, Lambari D'Oeste, Rondonópolis, Rio Branco, Salto do Céu, Dom Aquino, Curvelândia, Campo Verde, Pedra Preta, Reserva do Cabaçal, São José do Povo, Nova Olímpia, Mirassol D'Oeste, São José dos Quatro Marcos, Araputanga, Denise, Cáceres, Poxoréu, Tangará da Serra and Indiavaí. Statistically significant cluster (p-value <0.01), with RR of 0.44.

Cluster 3 Municipalities: Rondolândia, Aripuanã and Colniza. Statistically significant cluster (p-value <0.01), with RR of 3.72.

Cluster 4 Municipalities: Luciara and Canabrava do Norte. Statistically significant cluster (p-value <0.01), with RR of 11.71.

Cluster 5 Municipalities: Cocalinho, Nova Nazaré, Canarana, Água Boa, Ribeirão Cascalheira, Querência and Gaúcha do Norte. Statistically significant cluster (p-value <0.01), with RR of 3.11.

4 DISCUSSION

The present study demonstrates that in the evaluated period (2015 - 2018) the thematic maps (Figure: 3, 4 and 5) in general showed that the occurrence of dengue is dispersed in the 16 health regions of the state of MT, being the regional health with the highest number of accumulated notifications in decreasing order: Cuiabá (17454) number of cases, Sinop (16178) cases, Rondonópolis (9762) cases, Juína (5109) cases, Tangará da Serra (4885) cases, Água Boa (4358) cases, Alta Floresta (4134) number of cases, Peixoto de Azevedo (4121) number of cases, Barra do Garças (2937) number of cases, Colíder (2699) cases, Cáceres (1840) cases, Porto Alegre do Norte (1786) cases, Juara (1471) cases, Bridges and Lacerda (1215) cases, Diamantino (707) cases, however, the region with the least notification was that of São Felix do Araguaia (199) cases.

It is believed that in this period the number of probable dengue cases was higher than that reported and that there may have been diagnostic confusion with the Zika virus outbreak in 2015 and Chikungunya in 2016. On the contrary, it is noted that many dengue cases are underestimated, albeit it is a notifiable disease in the country.

In Figure 3, it was observed that 51 (36.17%) municipalities in MT that, according to the incidence rate, would present zero risk for dengue, as it does not correspond to reality. 5 (3.55%) municipalities did not register the disease in 2015, 8 (5.67) in 2016, 24 (17.02%) in 2017 and 14 (9.93%) in 2018. The analysis of the spatial distribution a dengue proved to c regions of MT. It is possible to identify areas of high occurrence of arbovirus in all years analyzed. Thus identifying the priority areas for control programs according to their risk classification. In view of the relevance of data from the studied areas, the use of the incidence rate without any treatment was considered little indicated due to its high random variability, especially when part of the studied geographical units has very low populations. The Local Spatial Empirical Bayesian Rate attributed greater influence to the geographically close municipalities, presenting more regionally consistent results, smoothing the extreme values presented in the sample.

The zero risk of the incidence rate was rectified by making a refinement making them safer for its evaluation. This method of spatial analysis proved to be viable for mapping large areas, and areas of risk detected were useful for directing public policies related to disease control.

In figure 4, with the smoothing of the dengue incidence rates seen, there was a reduction in the effects of fluctuations, revealing a trend of continuity of transmission to areas could be classified as very high, high and medium risk. The regional health centers that have the municipalities with the highest number of notifications and / or deaths from the disease are the regions of greatest concern for monitoring and formulating integrated risk analysis, control and prevention strategies by the public authorities.

In fact, it is observed that the Bayesian approaches applied for informing the dengue cases in Goiás for the flattening of indices as notified found similar results and reduced the random fluctuations of Gross Rates as calculated, showing that the Estimators minimize the influence of population size with respect to the municipalities of Goiás state. The Local Estimator reported a higher number of municipalities of Goiás as having medium to high incidence of dengue fever, compared to the values recorded through the incidence Rates (NUNES, 2013).

On studying the geographical pattern of distribution of incidence of dengue fever concerning Manaus, there was also the application of the Local Bayesian method, and smoothened incidence rates were obtained, in a study where the neighborhood's represent their values based on their neighbours, following the reasoning that closer neighborhood's tend to have similar patterns of behaviour, while the districts further afield tend to behave somewhat differently, allowing the identification of which districts have a greater number of cases of the disease (ARAÚJO, 2014).

Reinforcing the view that the Bayesian estimator "smooths" the rates and that the census sectors nearby tend to behave similarly, and the more distant ones differ, agreeing with the pattern found in a study put into effect in the state of Goiás (CARVALHO et al, 2017).

After application of the local empirical Bayesian estimator, a greater number regarding census sectors with high and medium incidence could be identified, which demonstrates that this method reduces the random fluctuation caused by the calculation of the incidence rate, corroborating the study that deals with the spatial distribution related to the dengue cases in Rio de Janeiro state (Carvalho et al., 2017). From the use of the Bayesian estimator, the smoothing of the incidence rates was observed, which clarifies the proximity of tones of the microregions, showing more groupings, highlighting the number of homogenization rates among neighboring census sectors. Another study carried out in Espírito Santo, which also used this method corroborated this finding (HONORATO et al., 2014).

In this context, geographical statistical analysis is a relevant factor in the identification of possible correlations of the event and the space, with the stratification of risk areas for transmission of the disease. However, other factors should be monitored with the type of virus in circulation at the moment of the epidemic, and its track record, and other social, economic and environmental factors of the municipalities that could be key at the moment of an increase in the number of cases as notified at this point in time. These conditions could be taken into consideration as part of the context, as they are made up of a system of objects and actions that interact and have a dynamic relationship, showing historical variations. As time goes by, they undergo transformations through human actions (ROJAS, 2008; SANTOS, 2002).

Given the above, we observed that the state of MT has a similar behavior associated with the transmission profile of dengue disease when this state is compared to the rest of the other Brazilian states, with cycles of peak illnesses in Brazil that may occur from three to five years, almost regularly. Thus, as Brazil had its highest peak of cases and the highest number of deaths in 2015, in the state of MT that same year was a year considered epidemic, a situation that continued in 2016, in the two subsequent years 2017 and 2018 there was a decrease the incidence of the disease throughout Brazil, which was also monitored in the state of MT

In the figure 5(a), it could be noted that RR, *i.e.*,, measure applied in this study, comprises the proportion between the total of disease occurrence in a determinate area and time and total of people exposed at the same point in time and location. To sum up, it is noted that this measure may be highly influenced by a reduced size or rare occurrences concerning the population exposed. Notwithstanding, in this study, regardless of these municipalities they may be considered small consisting of an indicator that could describe some random fluctuation as well as making comparisons weak with other municipalities, it is relevant to take into account the use of Bayesian rates, which may estimate the municipal rate, that considers the values related to the neighbor municipalities, thus making the interpretation associated with the municipal rates more trustworthy and also correcting this bias (SOUZA et al, 2018).

In the analysis of the results, the application of the spatial scanning technique in order to calculate the RR was suitable for the identification of municipalities at risk of dengue transmission.

In figure 5 (b), in decreasing order of RR values, we had the following distribution in the municipalities of the state of MT for the analysis of the spatio statistics of the clusters in SaTScan (66 municipalities with statistically significant areas). Thus distributed:

In cluster 4 registered the statistically significant value with (p-value <0.01) and the highest Relative Risk of the space-time analysis (RR of 11.71). Covering 2 (1.42%) municipalities distributed in 2 region health of MT. The municipality of Luciara belongs to the Regional Health Department of São Felix do Araguaia and the municipality of Canabrava do Norte belongs to the Regional Health Department of Porto Alegre do Norte.

In cluster 1, the value was statistically significant with (p-value <0.01) and RR of 4.15. Covering 21 (14.89%) municipalities distributed in 4 health regions of MT (Regional Health Department of: Alta Floresta, Colíder, Peixoto de Azevedo and Sinop).

In cluster 3, the value was statistically significant with (p-value <0.01) and RR of 3.72. Covering 3 (21.28%) municipalities distributed in 2 region health of MT. The municipalities of Aripuanã and Colniza belonging to Regional Health Department of Juína and the municipality of Rondolândia belonging to Regional Health Department of Pontes e Lacerda.

In cluster 5, the statistically significant value was recorded with (p-value <0.01) and the RR = 3.11. Where 7 (4.96%) municipalities are: Cocalinho, Nova Nazaré, Canarana, Água Boa, Ribeirão Cascalheira, Querência and Gaúcha do Norte all belonging to the Regional Health Department of Água Boa.

In cluster 2, the value was statistically significant with (p-value <0.01) and RR of 0.44. Covering 33 (23.40%) municipalities distributed in 4 health region of the state (Regional Health Department of: Cáceres, Cuiabá, Rondonópolis and Tangará da Serra).

Some limitations of this study regarding the possibility of underreporting and diagnostic confusion in the probable cases of dengue with zika and chikungunya, were also described in another study carried out in the state of Maranhão (Costa et al., 2018).

5 FINAL CONSIDERATIONS

Spatial analysis helps to identify the regions with the greatest risks for the incident regarding the arboviruses through their periodic epidemic cycles in the state, this analysis can contribute to the formulation of integrated monitoring strategies and significantly within the scope of practices aimed primarily at promotion, prevention of arboviruses in the population of these territories.

This study proposed to minimize the problem associated with the use of crude incidence rates and its high instability in demonstrating the risk of rare events associated with the regions of population situated in small areas, consisting of the use of the Local Empirical Bayes Method that uses information from the entire region or neighborhood to estimate the risk of the event occurring in each area.

The incidence rates that may be smoothed by this local empirical Bayes method corrected the eventual oscillations resulting from the problem of estimating small areas, that may contribute to reducing the variation, the random and the natural, present in the gross rates, eliminating the zero risk of dengue, reducing the effects of random fluctuations in the monitored areas improving the analysis of transmission risk in the territories.

The spatial analysis of local associations of incidence rates identified, through thematic maps, the priority areas in the 141 municipalities of the state of Mato Grosso for Health Surveillance performance, identifying a heterogeneity in the incidence of reported cases, also pointing out the existence of epidemiological silence of the dengue notifications by some municipalities during the study period. The incidence rate maps showed that the high risk of transmission ranged from 12.76% to 68.79% in 2017 and 2015, respectively.

The use of the spatial scanning technique with the application of the SaTScan software has been used in order to calculate the RR, demonstrating statistically significant data in the identification of risk clusters for disease transmission in the study period.

Dengue control is a major challenge for global public health. In the search for integrated control, the use of spatial tools and the elaboration of risk maps that characterize the transmission areas can facilitate this assessment for decision-making in a timely manner, establishing priority areas for the development of control program actions.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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