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ORIGINAL ARTICLE

SPATIAL PATTERN OF MALARIA IN INDIGENOUS AND NON-INDIGENOUS POPULATIONS IN THE STATE OF PARÁ

Rosinelle Janayna Coêlho Caldas[1]
Natália Cristina Costa dos Santos[2]
Ivaneide Leal Ataíde Rodrigues[1]
Bárbara Lopes Paiva[3]
Lidiane de Nazaré Mota Trindade[1]
Laura Maria Vidal Nogueira[1]

ABSTRACT

Objective: to analyze the spatial pattern of malaria in the indigenous and non-indigenous populations in the state of Pará. Method: an ecological study with analysis of 379,511 cases of malaria notified to the Malaria Epidemiological Surveillance Information System from 2010 to 2015 in the state of Pará. The data were geo-referenced with the aid of the QGIS program, version 3.14, and interpolated by using the Kernel Density Estimator, in order to create digital maps. The Annual Parasite Incidence of malaria in the meso-regions of Pará was calculated and analyzed. Results: higher Annual Parasite Indices were found in indigenous populations when compared to those found in non-indigenous populations, with Annual Parasite Incidence values of 163.05/1,000 inhabitants and 165.27/1,000 inhabitants among indigenous individuals, and 17.26/1,000 inhabitants and 14.26/1,000 inhabitants among non-indigenous individuals. Conclusion: the territorial distribution of malaria is unequal in the meso-regions, considering the condition of being indigenous or not, which suggests the need to value the cultural loco-regional specificities in order to direct more resolute control actions.

DESCRIPTORS: Spatial Analysis; Malaria; Indigenous Peoples; Epidemiological Monitoring; Public Health.

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[1]Universidade do Estado do Pará. Belém, PA, Brasil.
[2]Instituto Evandro Chagas. Ananindeua, PA, Brasil.
[3]Universidade Federal do Pará. Belém, PA, Brasil.

INTRODUCTION

Malaria still represents a sever public health problem in the world, especially in countries located in tropical areas[1]. The incidence of this disease is related to environmental, sociodemographic, biological, political and organizational factors, exerting an impact on the social and economic spheres in populations who live at risk of malaria, especially those exposed to precarious housing and sanitation conditions[2].

It is estimated that, in 2018, approximately 228 million people in the world were affected by malaria, with 405,000 deaths, of which 94% are concentrated in the African region[3]. In 2019, Brazil notified nearly 156,000 cases[4], with the Amazon region being considered the most endemic for the disease in the country, concentrating nearly 99% of the reports[5], which represents a different disease dynamics due to environmental determinants and to the difficulty of population's access to the health services[6]. The Brazilian North region presents population diversity[7] and peculiar demographic and socioeconomic characteristics, with the most malaria cases in the country[5].

In 2018, the state of Pará recorded nearly 21,189 cases and a reduction was identified in 2019 in relation to the previous year, with approximately 15,107 notified cases. In the first semester of 2020, 8,355 cases were notified in the state, representing a 45% reduction in relation to the same period in 2019. Analyzing the distribution of cases in the geographical space allowed visualizing greater concentration in the municipalities located in the South region of the state, inhabited by a significant proportion of indigenous population[8].

Pará is one of the states with the greatest incidence of malaria in the Amazon region[6]; furthermore, its territory houses population groups, such as indigenous peoples, which are considered more vulnerable to the disease because they live in rural areas, mainly near floodplains[9].

The presence of epidemics such as that of malaria among native peoples can generate epidemiological instability and heterogeneity in the risk of contamination and in spatial distribution, due to environmental, cultural and socioeconomic specificities peculiar to indigenous lands[9]. In addition to that, it was found that prevention activities are scarce and that control programs are not based on scientific evidence, thus providing resources with little efficacy for at-risk populations[9-10].

In search of scientific evidence related to the theme in the national and international literature, the need of conducting in-depth studies on the geospatialization of malaria was noticed, in order to identify areas with greater risk of transmission, mainly in indigenous populations from the state of Pará. We believe that these results may have an effect on the following aspects: disease control, formulation of public policies, execution of actions, and decision-making by health managers[11]. Therefore, the objective of this study is to analyze the spatial pattern of malaria in the indigenous and non-indigenous populations in the state of Pará.

METHOD

This is an ecological study conducted in the state of Pará, located in the Brazilian North region, whose estimated population for 2020 was 8,690,745 inhabitants, distributed in 144 municipalities[12]. According to the 2010 Census, the state totaled 39,081 indigenous people[13]. The study population comprised 379,511 cases of malaria notified to the Malaria Epidemiological Surveillance Information System (*Sistema de Informação de Vigilância Epidemiológica da Malária*, SIVEP – Malária) from 2010 to 2015, of which 356,881 were

reported in non-indigenous people and 22,630 in indigenous individuals. The choice of the time frame was driven by data availability, obtained from the Public Health State Secretariat of Pará (*Secretaria de Estado de Saúde Pública do Pará*, SESPA).

The following variables were studied: notification year, infection site and number of cases in the state's indigenous and non-indigenous population. In addition to these data, the study included information on Pará's population by year, obtained from the website of the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE).

The spatial analysis was performed in five stages. The first was conducted with public domain data referring to cartographic databases obtained from SIRGAS 2000 (2000 Geocentric Reference System for the Americas, *Sistema de Referência Geocêntrico para as Américas* 2000) and from population databases made available by the IBGE; as well as with epidemiological data on the notification of cases of malaria in indigenous and non-indigenous people made available by the SIVEP – Malária of the IT Department of the Unified Health System (*Departamento de Informática do Sistema Único de Saúde*, DATASUS), using the system of the National Register of Addresses for Statistical Purposes (*Cadastro National de Endereços para Fins Estatísticos*, CNEFE – IBGE).

In the second stage, the cases of malaria were refined using the Excel® 2019 software, in order to achieve greater consistency and completeness and to reduce the chance of redundancy in the database. After debugging, a Geographical Database (GDB) of the notified cases was created.

In the third stage, the geo-referenced database was manipulated using the QGIS program, version 3.14, for the development of thematic maps, thus enabling the identification of geographical areas with greater occurrence of disease.

In the fourth stage, the Kernel Density Estimator (KDE) was applied, a spatial exploratory data analysis method that allows for an easy and rapid visualization of the sites exposed by identifying the different degrees of magnitude of cases in the areas studied. In this study, it was decided to group the data from the municipalities according to the meso-regions established in the state of Pará (Figure 1), which were defined based on socioeconomic and environmental characteristics.

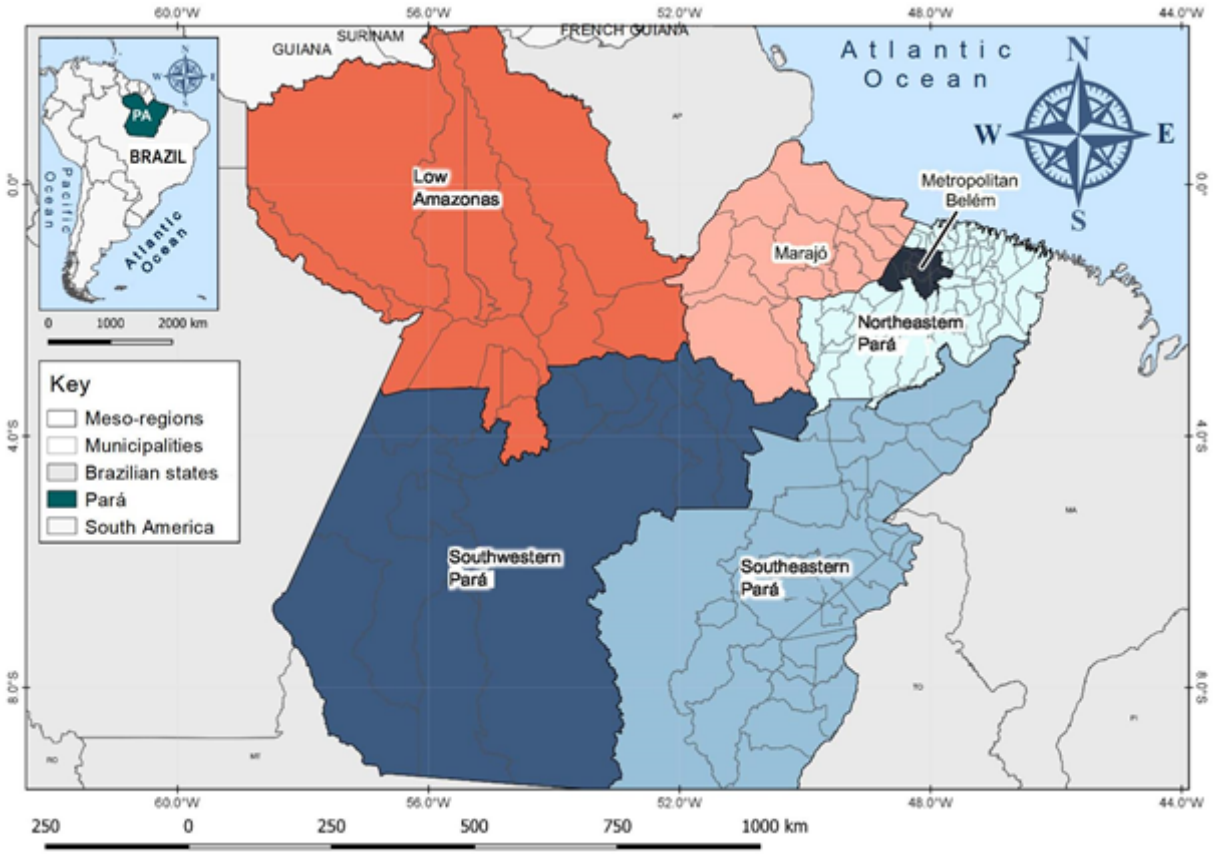

Figure 1 – Division of the state of Pará according to the meso-regions. Belém, PA, Brazil, 2020
Source: The authors (2020).

The fifth stage consisted in calculating and analyzing the Annual Parasite Incidence (API) among indigenous and non-indigenous people in the state of Pará, stratified by meso-regions, based on the following expression: number of positive malaria tests/total resident population in the year of analysis x 1,000. To such end, the data were classified into three categories: low risk area (API from 0 to 9.9); medium risk area (API from 10 to 49.9); and high risk area (API>50)[14].

The study was approved by the Research Ethics Committee of the Nursing Course at the State University of Pará, under opinion No. 1,802,305.

RESULTS

A total of 379,511 cases of malaria were analyzed, of which 356,881 and 22,630 were recorded among non-indigenous and indigenous people, respectively. Table 1 shows that the parasite indices were much higher in the indigenous population when compared to those of the non-indigenous population, over the entire period studied. In 2010 and 2011, the API values were higher than in the other years for both ethnic groups, with 163.05/1,000 inhabitants and 165.27/1,000 inhabitants among indigenous people, and 17.26/1,000 inhabitants and 14.26/1,000 inhabitants among non-indigenous people, respectively.

Table 1 – Distribution of the cases and Annual Parasite Indices of malaria, in the indigenous and non-indigenous population, state of Pará, during the 2010 – 2015 period. Belém, PA, Brazil, 2020

No. of cases and Annual Parasite Indices*	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
No. of cases in indigenous people	6.372	6.459	5.788	2.498	648	865
API*/1,000 (Indigenous)	163,05	165,27	148,1	63,92	16,58	22,13
No. of cases in non-indigenous people	130.174	109.646	74.523	22.997	10.822	8.719
API*/1,000 (Non-indigenous)	17,26	14,26	9,62	2,62	1,34	1,07

Total of cases studied=379,511. Total among indigenous people=22,630. Total among non-indigenous people=356,881.
Source: The authors (2020).

Application of the KDE (Figure 2) allowed visualizing the distribution of the cases in the meso-regions. In 2010-2012, greater occurrence can be seen among non-indigenous people in Marajó, in southeastern and northeastern Pará; and among non-indigenous people, in the Southwest meso-region. Since 2013, there has been a progressive reduction in the number of cases in both population groups.

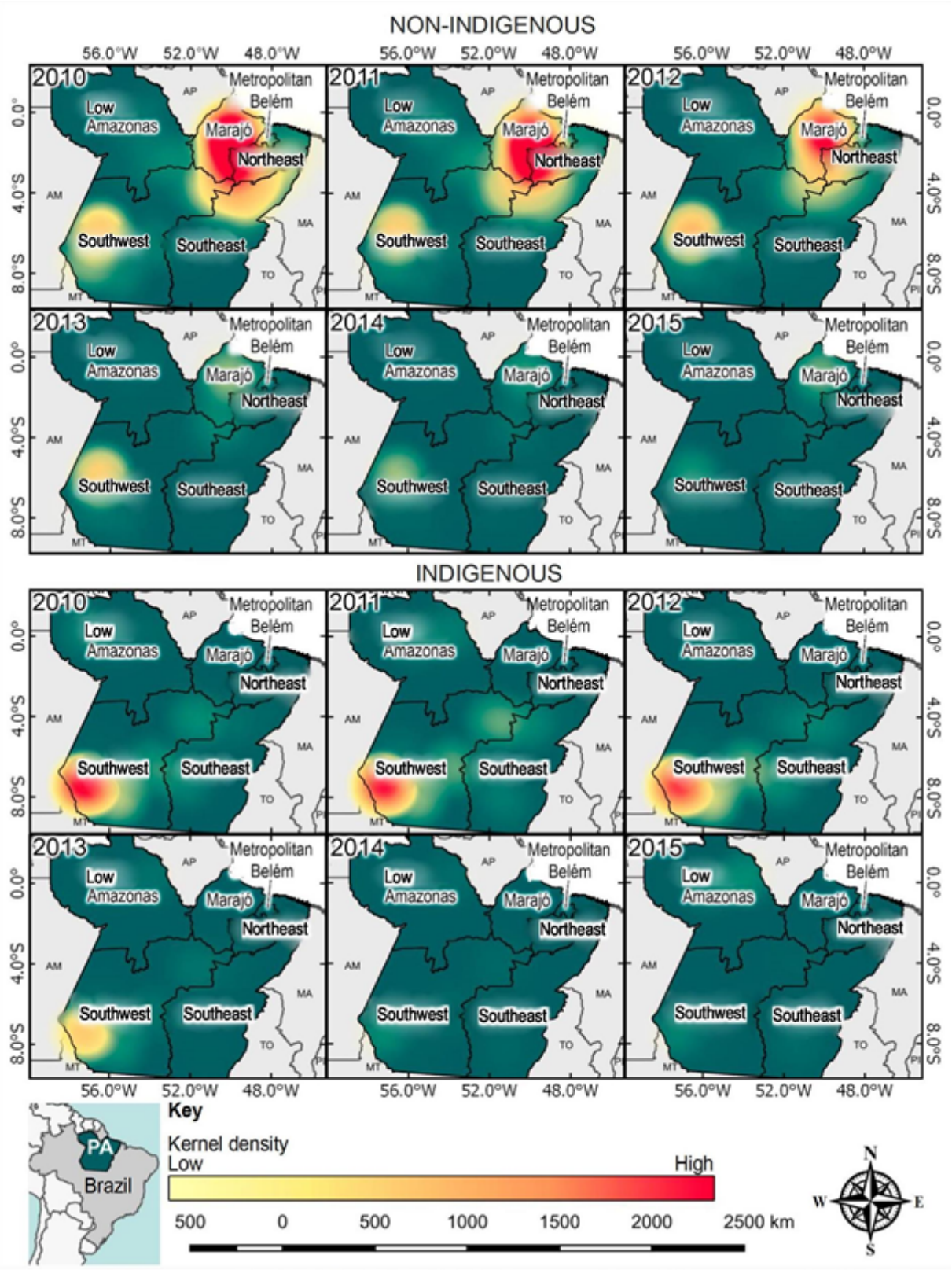

Figure 2 – Maps with the distribution of the density of malaria cases in the indigenous and non-indigenous populations, obtained in the state of Pará by means of the Kernel Density Estimator, during the 2010 – 2015 period. Belém, PA, Brazil, 2020
Source: The authors (2020).

Figure 3 shows the variation of the Malaria Parasite Index throughout the years studied, presenting important differences between the groups. It is noted that, among the non-indigenous people, the Marajó and Southwest meso-regions presented higher

indices during the 2010 – 2012 period. In 2014, incidence was approximately equal in both meso-regions, with a rise in northeastern Pará in 2011. Metropolitan Belém presented low incidence throughout the period.

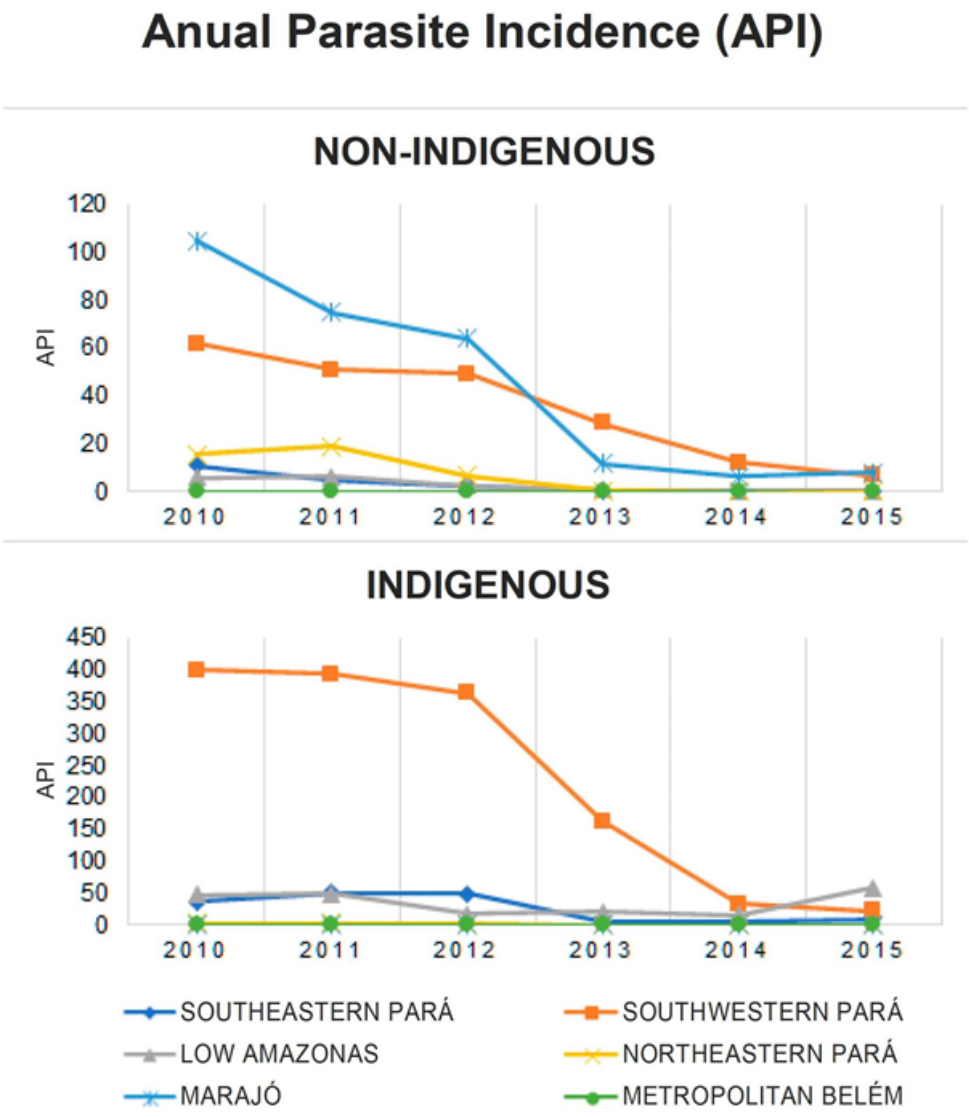

Figure 3 – Time series of the Annual Parasite Incidence of malaria, in the indigenous and non-indigenous population, in the meso-regions of the state of Pará during the 2010 – 2015 period. Belém, PA, Brazil, 2020
Source: The authors (2020).

Among the indigenous people, the Southwest meso-region stood out with quite high rates during the 2010 – 2012 period, with a decline since 2013. In the other meso-regions, occurrence of malaria was dynamic, in a fairly regular manner, with reduced risk of the disease for this ethnic group (Figure 3).

Figure 4 shows that API was classified as high in the Marajó meso-region; as medium in the Southwest meso-region; and as low in the Low Amazonas, Southeast, Northeast, and Metropolitan Belém meso-regions in the non-indigenous population. The Northeast meso-region with a low API during the 2012 – 2015 period deserves to be noted. The Marajó and Southeast meso-regions presented the highest variations, with the Marajó meso-region

presenting a high API in the 2010 – 2012 period, medium in 2013, and low in 2014 and 2015, and the Southeast meso-region with a high API in 2010 and 2011, medium in the 2012 – 2014 period, and low in 2015.

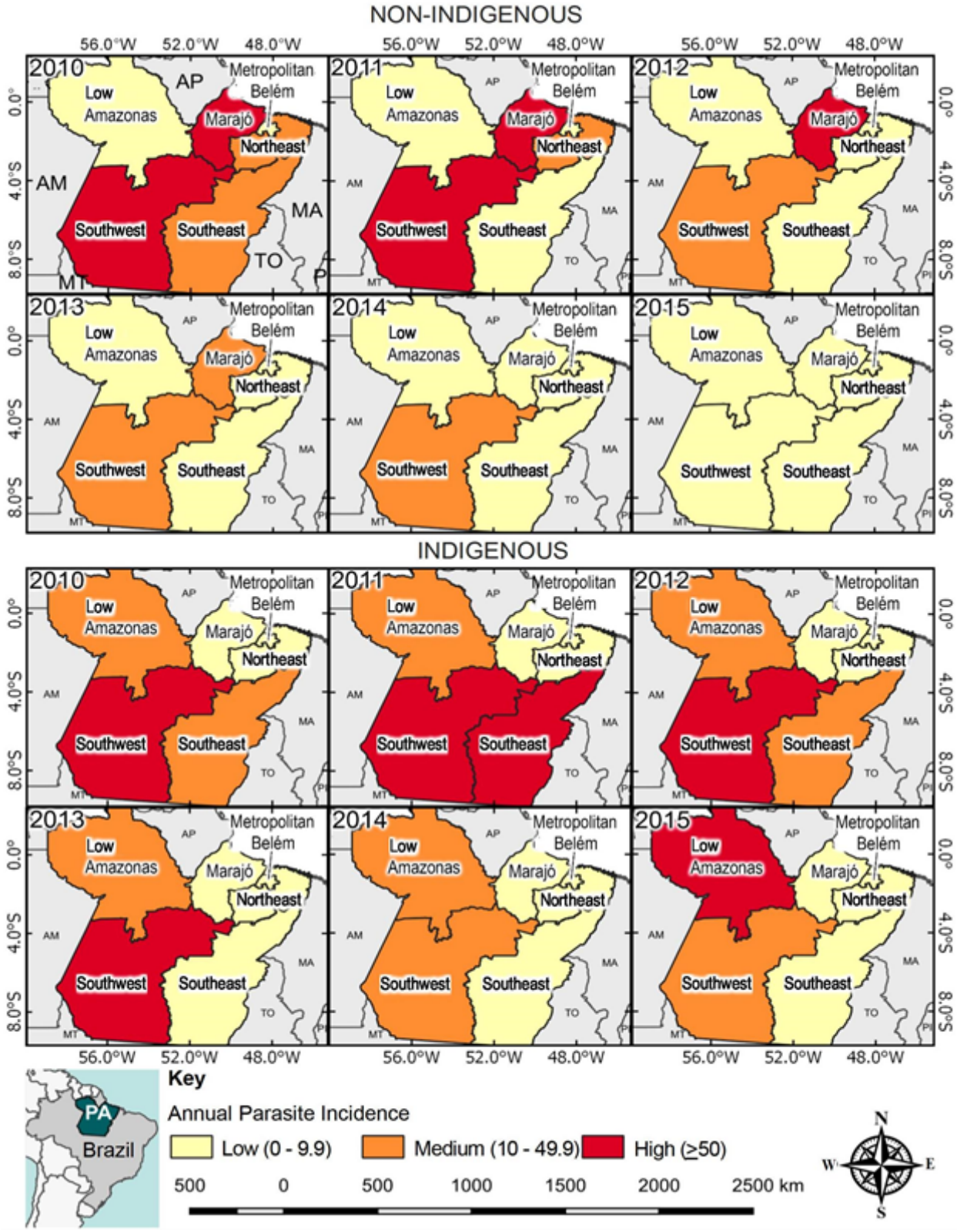

Figure 4 – Spatial distribution of the Annual Parasite Incidence of malaria, in the indigenous and non-indigenous population, in the meso-regions of the state of Pará during the 2010 – 2015 period. Belém, PA, Brazil, 2020
Source: The authors (2020).

In the indigenous peoples, the behavior of API presented a high rating in the Southwest, medium in the Low Amazonas, in the first five years; and low in the Northeast throughout the period. Throughout the years, API fluctuated in the Southeast meso-region, with a high rating in 2011, medium during the 2010 – 2012 period and low for 2013 – 2015. It is also important to emphasize the low figures observed in the Marajó and Metropolitan Belém meso-regions, as a consequence of the non-existence of indigenous populations in these territories (Figure 4).

DISCUSSION

The spatial distribution of the API for malaria in the state of Pará over the studied historical series presented remarkable differences, both with regard to the geographical space of the meso-regions and to the incidence of malaria in the population groups, especially when comparing its occurrence in the general population and in indigenous people.

The spatial analysis conducted in the non-indigenous population allowed evidencing the strong significance of malaria in regions with low socioeconomic conditions, corresponding to the Marajó and Northeast meso-regions of the state of Pará, and also in areas with major development projects, such as the construction of hydroelectric power stations and mineral extraction facilities in the Southwest meso-region. Such projects produce environmental changes capable of modifying the diversity and density of the malaria vectors, generating an increase in the transmission risk[15].

The Marajó meso-region presents quite peculiar living characteristics, and the municipalities have low quality patterns in the social and economic indicators. Social ills, low schooling level, life habits, and the precariousness of public policies greatly contribute to the epidemiological profile that accounts for a great number of cases of malaria[16].

This is a meso-region that presents low employment generation capacity, making the population dependent on the governmental social income transfer programs. The number of schools in the meso-region is lower than the demand for education. The population lives with deficient sanitary conditions, open sewage, ineffective water treatment, improper garbage storage and disposal, and an economy based on activities related to livestock breeding, particularly of buffaloes, extraction in forest areas, and small agriculture, enabling the creation of small settlements located on the banks of rivers and igarapés[17].

When the incidence of malaria in Marajó is discussed, according to what was detected in the mapping, it is important to also understand it in view of the sociocultural situation. This region is intersected by rivers and igarapés, which are hydrographic aspects that make river transport almost the exclusive mean of travel for the local residents. The population in this region predominantly lives along the river banks and uses the water of rivers and igarapés for personal hygiene, cooking, cleaning utensils and for fishing and extractive activities, at sunset, being exposed to the peak hours of biting by the disease vectors[18].

The results of this study are consistent with those of other surveys[16,19] that ratified the the persistence of endemic transmission in the Marajó meso-region, mainly due to determinants of biological (high concentration of vectors, etiological agent, and vulnerable population), environmental (high rainfall index, dimension of water structure, and vegetation coverage), economic (opening of roads, construction of hydroelectric power stations, and soil occupation), and social (population mobility, numerous groups of people living in precarious houses) origin.

Because of its geographical, natural and ecological specificities (with dense forests and high humidity and temperature levels), the state of Pará presents favorable

conditions for the occurrence not only of malaria but also of many other diseases, due to its environmental characteristics that favor proliferation of the malaria vector, thus facilitating disease transmission and dissemination[19]. These specificities can explain the fact that this state is considered endemic regarding the disease. Also regarding the association between malaria and the characteristics of the geographic space, a study with spatial analysis conducted in the state of Rondônia concluded that the territory has shown to be determinant for perpetuation of the disease in the state[20].

Another aspect to be noted and that certainly interferes with the dynamics of malaria in the territory of Pará are the characteristics of the houses, the so-called stilts, built in areas of floodplains, in direct contact with the forest and the rivers, which are very peculiar in the Marajó, Northeast, and Southwest regions of Pará and create a favorable environment for the proliferation of malaria[21-22]. The findings of this study are also consistent with diverse evidence indicating that socioeconomic issues can aggravate cases of malaria in the region and contribute to determining and perpetuating the epidemiological scenario of this disease[16,21].

The analysis of API variation in the non-indigenous population showed that the Northeast meso-region, which includes several municipalities with a Municipal Human Development Index below the national mean, had a medium API in 2010 and 2011. This is a meso-region whose economic growth is based on natural resources, on the pioneering character of extraction and agriculture, on handling of low-yield cattle and, recently, on mineral extraction, all of which represent drivers of anthropic changes to the environment[23].

With regard to the indigenous peoples, high parasite incidence was found in the Southwest meso-region of Pará, a finding that can be related to low level of socioeconomic development, deficient housing conditions, and peculiar life habits such as hunting, which lead to exposure to vectors. Once contaminated, the disease spreads easily and quickly in the villages, an aggravating factor in view of the difficulty accessing the health services. These circumstances were underscored in a number of studies[9,16] as determinants for the maintenance of a high number of cases in indigenous groups.

A study conducted in the Amazonas concluded that the indigenous population presented a higher risk of contracting malaria when compared to the non-indigenous population, in the entire state. The rate of disease incidence was 15-fold times higher in indigenous people when compared to the non-indigenous population, thus confirming previous research studies that revealed the vulnerability of the indigenous collective to malaria, highlighting the low level of socioeconomic development as a conditioning factor[24].

It is known that indigenous people are legally ensured the right to differentiations in education and health, considering that they are ethnically different peoples. However, there are major weaknesses in the planning and implementation of assistance actions for this population. These findings reinforce the importance of investments in the field, in order to implement specific strategies, such as training of specialist technicians to meet the specificities of these peoples, strengthening health practices, decision-making, and targeting of strategies that value the local culture[25].

The need of a specialized team for indigenous health care is presented in a previous study[10], which confirms that isolated actions for these populations have not yielded positive results, since these actions do not satisfactorily meet the population's needs. Instead, they produce progressive deterioration of indigenous health due to the low quality of the service provided.

The investment in qualifying health care to indigenous people is essential to control malaria in their villages. However, it is emphasized that the fluctuation in the parasite indices can also be associated with the dynamics of anthropic relationships[19]. The significant results identified in the Southwest meso-region can be related to aspects that have a potential to disseminate the disease vector, namely: disorganized urbanization; population growth;

migration of susceptible individuals to non-endemic areas; deforestation; and development of large projects of Amazon exploration and occupation[26].

This scenario is a reality in the Southwest meso-region, which permanently experiences the presence of large agricultural, farming, industrial and mining projects, responsible for accelerated and disordered migration, leading people to be exposed to the malaria vector and favoring disease perpetuation and sometimes the increase in its incidence[26].

A similar event occurred in the municipality of Colniza, in the state of Mato Grosso[27], in which the increase in the cases of malaria was attributed to mining projects, construction of roads, irregular settlements and occupation, presence of unhealthy houses, deforestation and a large project of building a biodiesel plant.

In this sense, the state of Pará is a spatial territory favorable to the perpetuation of malaria, due to its geographical and cultural peculiarities and to the existence of many agricultural, farming and hydroelectric projects that greatly affect the environment and, consequently, the vectors' habitat, as shown in the disease behavior in the different meso-regions.

Using geo-processing allowed mapping the disease in the entire state, offering diverse information with the potential to assess risks and plan health actions. The use of the Kernel technique allowed identifying areas with greater concentration of malaria cases, which, in turn, present greater risks for disease transmission.

This study presents limitations due to the use of secondary data, susceptible to incompleteness, underreporting and inadequate recording, attributable to a possible deficit in the training of the professionals. Another limitation is related to the analysis by meso-regions, inferring the findings to the groups of municipalities that comprise it. More stratified studies are recommended to identify municipalities, villages and communities more affected by the disease. It is also important to point out that the data used presented certain time lapse, which does not invalidate the findings, since the disease transmission variables were maintained.

CONCLUSION

The study findings allowed identifying heterogeneity in the spatial pattern of malaria in indigenous and non-indigenous populations in the state of Pará, as well as significant parasite indices for the indigenous population, which denotes the vulnerability of this ethnic group to malaria. Such findings suggest the need to consider, in addition to the environmental factors, the cultural differences that permeate human groups, for the implementation of control measures.

The geo-processing techniques adopted also allowed mapping the disease in different ethnic groups and identifying the areas that should be prioritized for the control and prevention of malaria in the state and that can subsidize the formulation of strategies and actions aiming at better control and surveillance of the endemic.

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Corresponding author:
Rosinelle Janayna Coêlho Caldas
Universidade do Estado do Pará – Belém, PA, Brasil
E-mail: r_janayna@hotmail.com

Role of Authors:
Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work - Caldas RJC, Santos NCC dos, Rodrigues ILA, Paiva BL, Trindade L de NM, Nogueira LMV; Drafting the work or revising it critically for important intellectual content - Caldas RJC, Santos NCC dos, Trindade L de NM. All authors approved the final version of the text.

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