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Hospitalization for malaria in the indigenous population of Roraima, in Brazil's Northern Amazon, 2008-2022

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ABSTRACT

Objectives: To examine the epidemiology of hospitalized cases of malaria in indigenous people living in the municipalities of Roraima in the northern Brazilian Amazon from 2008 to 2022.
Methods: Ecological study using secondary data and spatiotemporal analyses based on thematic maps. Average rates were calculated per study period and spatiotemporal clusters were estimated from spatial statistics.
Results: Of the 541 medical records, 77.08% were related to *Plasmodium vivax*. Higher rates were observed in municipalities in the south and center of the state. The rates increased throughout the study period. The analysis generated three clusters.
Conclusions: Although Roraima has characteristics that worsen the malaria problem, no studies were found that examined the transmission of the disease in the state as a whole. This increases the importance of this study, which contributes to the discussion in the field of indigenous health.

Introduction

Malaria, a disease resulting from social and natural factors [1], is scheduled to be eradicated by 2035. Consequently, greater efforts are needed to combat it, including the essential integration of health surveillance with primary care, aiming at measures for control, prevention, and effective eradication of the disease [2]. Although malaria is a major public health concern for Roraima and Brazil, there are few studies that provide an overview of the disease in the state. What is most published are reports and bulletins on malaria control [3]. No studies were found that prioritized the treatment of malaria in indigenous people nor on the indicators of hospitalization of this population due to this disease, which highlights the importance of this study because it can inform the organization and planning of malaria control measures in Roraima. Although it does not replace traditional methods of health systems, digital mapping is a useful approach for the health of indigenous people because it allows health measures to be assessed and planned with reference to the spatial distribution of deaths and populations. Through the processing of geographic data, it is possible to outline scenarios that illustrate the inequality profiles of indigenous people [4]. Because of this, this study aimed to analyze the epidemiology of hospitalized cases of malaria in indigenous people living in the municipalities of Roraima in the northern Brazilian Amazon from 2008 to 2022.

Methods

Study area

The state of Roraima in Brazil's Legal Amazon comprises 15 municipalities (all with indigenous portions to their populations). It is covered by three Special Indigenous Health Districts (*Distritos Sanitários Especiais Indígenas* [DSEIs]): Manaus, East Roraima, and Yanomami (the latter two with offices in the state) (Figure 1).

Study type

This ecological design study used secondary data and spatio-statistical analysis with the support of thematic maps.

Data sources

Records of hospital morbidity from external causes were collected from the Unified Health System Hospital Information System (*Sistema de Informações Hospitalares do Sistema Único de Saúde*) [5] and filtered for cases of malaria. This is a disease with compulsory weekly notification that is regular in the Amazon region and every suspected case of malaria

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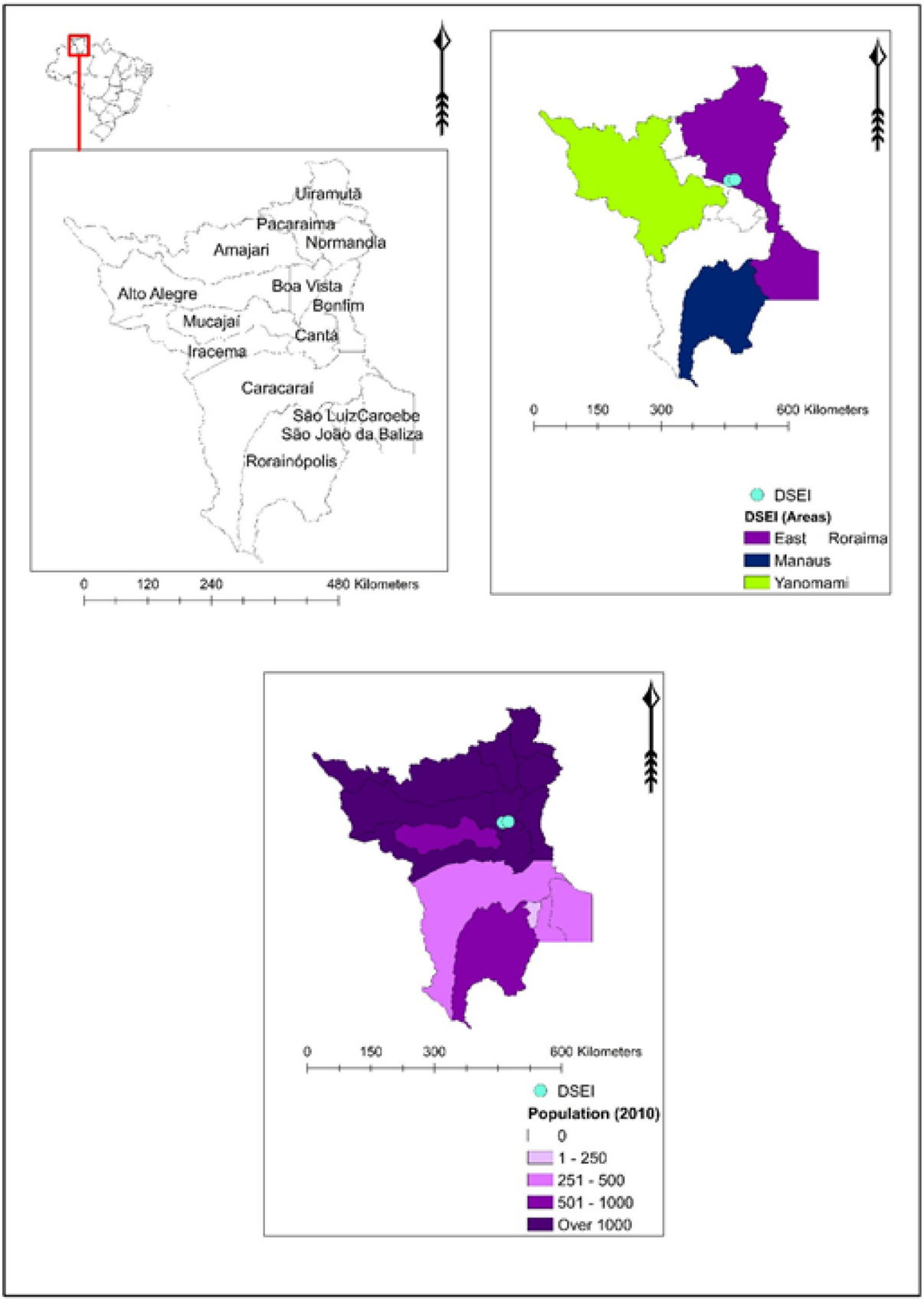

Figure 1. Characteristics of the territory and the indigenous population of the state of Roraima, North Brazilian Amazon.

must be reported within 7 days to the health authorities using a specific disease instrument.

The records were also filtered for indigenous color/race and organized by year of treatment, municipality of residence, type of malaria (*Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae*, other forms of malaria, and unspecified malaria), sex, and age group.

Data on the indigenous population were sourced from the 2010 census [6]. Population estimates for 2011-2022 were calculated from the mean indigenous population growth rate (1.1% per year) [7] and a population decrease rate of the same value was calculated for 2008 and 2009.

The digital meshes for the DSEI offices and areas were obtained from the National Indigenous Foundation (*Fundação Nacional do Índio*) [8,9]. All maps were drawn using the QGIS program, version 2.18.20.

Data analysis

Annual malaria rates were calculated by municipality by dividing cases by population, then multiplying the result by 100,000. A mean rate was calculated for each study period (2008-2011, 2012-2015, 2016-2019, and 2020-2022) by adding the rates and dividing by the number of years in the period. In addition, spatiotemporal malaria clusters were estimated by cylindrical scan statistic based on resident population. An area of 30,000 km^2 was used and a 5% level of significance. This stage was performed using SaTScan, version 9.6.

Results

Of the 541 records found, most were concentrated in 2009 (50; 9.24%), 2018 (47; 8.69%), 2019 (74; 13.68%), and 2020 (71; 13.12%). Women accounted for 325 admissions (60.07% of the total cases). The age groups with most records were children aged under 1 year (108; 19.96%) and aged 1-4 years (118; 21.81%). Among those aged 20-29 years, there were 91 records (16.82%). By malaria type, 417 (77.08%) records related to *P. vivax* and 102 (18.85%) to *P. falciparum*.

The spatial pattern of observed mean rates showed the highest values in municipalities in the center and south of the state. Overall, the values were observed to increase from the first to fourth periods, most prominently in the municipalities of Alto Alegre (where there were consecutive increases from 23.35 to 212.65), Caracaraí (103.21-790.91), Iracema (0.00-244.48), and Mucajaí (93.28-221.68). In the first study period, high values were observed in Normandia (153.09, placing it in the stratum with the highest values) and in Pacaraima (145.50). In the second period, the highest rate was observed in São João da Baliza (153.85). In the final period, Amajari, Boa Vista, Bonfim, Rorainópolis, and Uiramutã also returned high values (82.42, 49.83, 59.20, 55.19, and 91.77, respectively). No records were found in São Luiz (Figure 2).

Three Spatiotemporal clusters were observed: cluster 1 (RR 2.77), comprising six municipalities (Alto Alegre, Boa Vista, Cantá, Caracaraí, Iracema, and Mucajaí) and clusters 2 and 3, containing one municipality each for Normandia (RR 4.64) and Pacaraima (RR 3.32) (Figure 3).

Discussion

The state of Roraima has three regions where the transmission of malaria is favored by environmental conditions, such as dense tropical forest, gallery vegetation on the banks of *igarapé* channels and rivers, major hydrographic basins, high humidity and precipitation, migratory flows, the agent-vector-host triad responsible for the dynamics of transmission of the disease, and municipalities close to forested areas [10]. A study considering vegetation, climate, geomorphology, population distribution, and the pattern of distribution anopheles identified eight ecoregions in Roraima and showed that conditions favored the state's continuing potential for endemicity [11].

Given these conditions and despite the country having a structured program, high rates of transmission of this disease persist. Difficulties in accessing work and land, which have never been achieved permanently because the development centers only temporarily specify large contingents of available workers, force individuals to move continuously, preventing them from settling down and, consequently, from investing in improving housing and sanitation. The factors that prevent them from settling down are, therefore, responsible for the process that generates malaria, the difficulties faced by the country in effectively using traditional measures, and the reintroduction of malaria where its transmission had already been interrupted [12].

Since the 1970s, there have been studies [13] addressing malaria's historical relationship with the indigenous populations of Roraima as one of the consequences of contact with non-indigenous people (mainly due to activities connected with gold prospecting), which led to an epidemic transmission as the population density rose and the natural environment was altered, both contributing to the proliferation of anopheles. That situation experienced by the indigenous populations in the 1980s and 1990s continues down to the present day and has even had an impact on transmission of COVID-19, a scenario aggravated by child malnutrition and disorders from helminthiases and respiratory diseases [14,15].

As what has occurred with COVID-19, the transmission of malaria tends to increase with the invasion of indigenous territories by gold miners, which leaves village health vulnerable, in addition to having impacts on the indigenous way of life. In 2019, autochthonous cases of malaria were observed in mining areas (generally accessed by way of clandestine landing strips or rivers and areas of forest in the municipalities of Alto Alegre, Amajari, Caracaraí, Iracema, and Mucajaí). This hinders disease control measures in that many of these mining projects are illegal and pose the need for special provision for security and logistics [16,17].

Although there are no epidemiological justifications for the 2019 rates to be higher, significant political and social transitions were taking place in the country, such as budget cuts in the health sector, in addition to the recognition of human rights violations in Venezuela being considered by Brazil and so welcomed a significant number of refugees this year [18].

Added to this scenario are the changed characteristics of this portion of the population, because there is now a multiplicity of everyday situations: indigenous people are being born in villages, towns, and farms outside their territories. There are even indigenous people who have been displaced from their lands and are living in urban centers, often coexisting with the non-indigenous population. In fact, many have two residences and transit between their villages and the capital, Boa Vista [19]. In this context of urbanization, in São João da Baliza (a Roraima municipality with autochthonous malaria and the largest number of cases of urban malaria in the state), there are areas with insufficient housing infrastructure, inadequate basic sanitation, lack of public services, and a precarious drainage system, all contributing to the breeding and proliferation of anopheles in the urban environment [20]. Adding weight to these findings, the results of this study suggest high rates of transmission in the municipality in question, drawing attention to the fact that malaria in indigenous people may also be occurring in urban environments, as exemplified by the higher rate observed during the second study period.

Furthermore, a review of the literature on malaria from 2000 to 2013 found one of the highest transmission rates in Roraima, which is explained by the disordered urbanization process, plus farming- and mining-related activities [21]. That study also showed a greater number of notifications involving *P. vivax*, which agrees with the findings of this study. There is a greater number of records of malaria in women and in children aged up to 4 years, which can be explained by the vector's expansion in periurban and/or peridomiciliary areas [22], which would

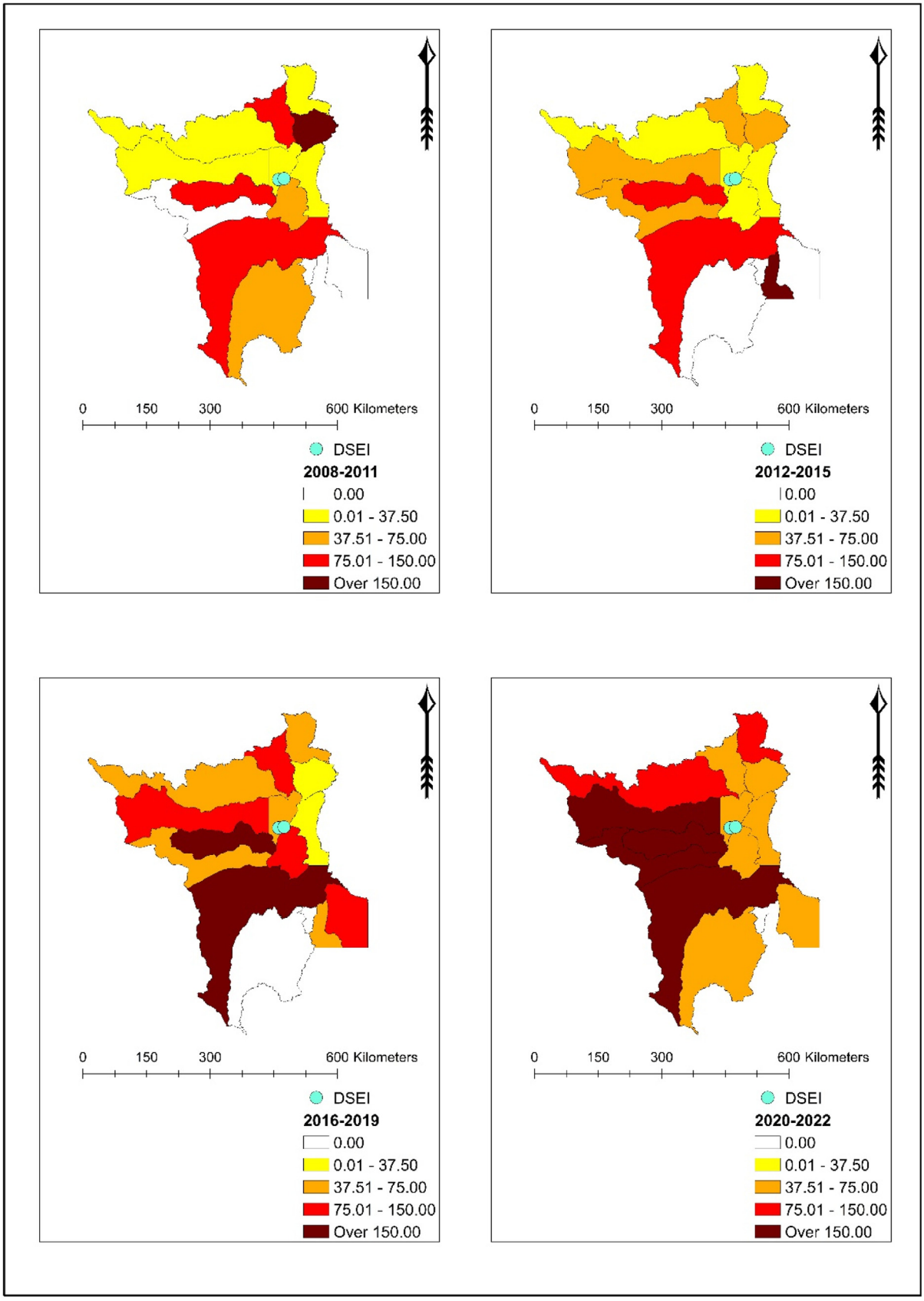

Figure 2. Mean hospital admission rates for malaria among indigenous people residing in Roraima, Northern Brazilian Amazon, 2008-2022.

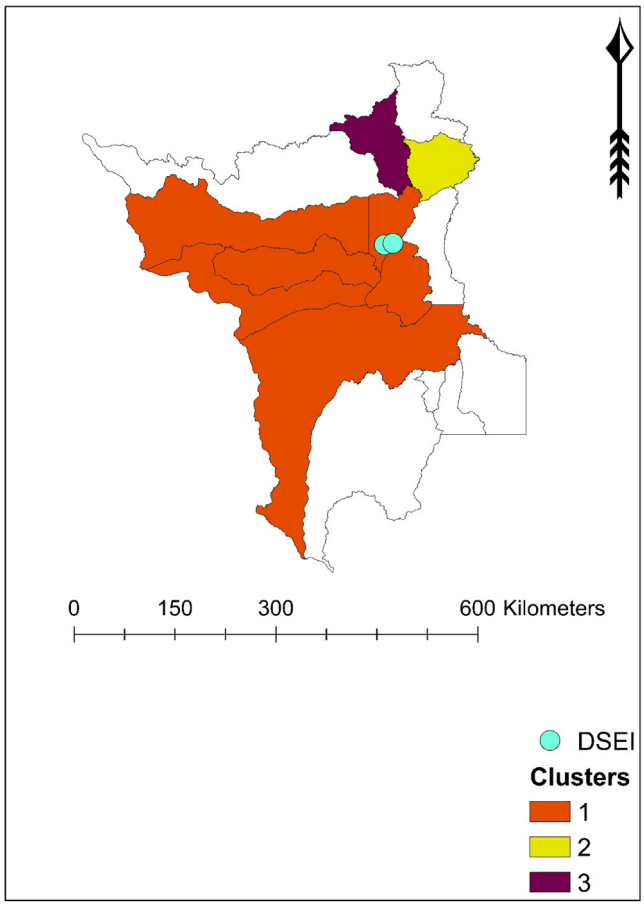

Figure 3. Spatiotemporal clusters of admissions for malaria among indigenous people residing in Roraima, Northern Brazilian Amazon, 2008-2022.

expose women and young children more to infection because it is these members of the indigenous population who generally remain in areas close to their residences.

Also to be considered is the Venezuelan migration into Roraima, which contributes to the resurgence of autochthonous cases of malaria in the state's indigenous population because the latter offer shelter to refugees who come to the state capital, Boa Vista. The Venezuelans experience a range of health problems during their journey and in the camps inside Brazilian territory, such as the lack of food and drinking water, poor medical care, and overcrowding and, thus, can transmit various infectious diseases to indigenous Brazilians [17,23].

The findings of this study reinforce the previously mentioned observations. Pacaraima (a municipality bordering on Venezuela) returned a high rate in the first period and forms part of cluster 3. As observed in other municipalities (Alto Alegre, Iracema, Normandia, and Uiramutã), 70% of the territory of Pacaraima is occupied by indigenous areas, where cases of malaria are concentrated [17]. Another municipality that stood out was Normandia, which forms part of cluster 2. Both municipalities are in northern Roraima, where the indigenous population is larger. However, the highest mean rates were observed in the towns of the central and southern portions of the state, which can be explained by their proximity to DSEI offices, making it easier to record notifications.

Although malaria is an important concern for public health in Roraima, few studies offer an overall panorama of the epidemiology of malaria in the state. What are published more are malaria control reports of numbers of cases [5]. In the context of indigenous health, no studies were found to address malaria exclusively in indigenous populations, reinforcing the importance of this study as a starting point for planning and organizing health to improve these people's quality of life considering that rates were observed to increase over the course of the study period.

Because secondary data acquired at the collective level were used, it is possible that confounder or erroneous relations may have occurred, and this one of the possible limitations of the study. Furthermore, the use of data from the 2010 population census may have led to errors in the population size (among other things because race/color classification is self-reported and many indigenous individuals fail to declare themselves as such because of historical prejudices) [24–26].

Conclusion

Despite the importance of the subject to state and national public health, there are few studies of the issue in question, which heightens the importance of this study as a tool for planning and intervention in indigenous health. A spatiotemporal analysis was used to identify priority areas for health service supply, with a view to strengthening health surveillance in areas where less care is available to these people.

From the data used here, it cannot be said that cases are underreported in the records; it is striking that lower rates were found in municipalities with larger shares of the indigenous population (notably, in northern Roraima), which may indicate greater difficulty in recording hospital admissions in towns that are further from the DSEI offices, thus hindering notifications.

The subject is far from completely clear and it is suggested that new studies be conducted to address the issue of malaria in the indigenous population of Roraima in a more specific context, requiring primary data collection, which should yield more in-depth analyses. In addition, special mention must be made of the participation by professionals from different fields in that malaria is not limited to the agent-vector-host relationship but rather amenable to multidisciplinary approaches involving economic, social, environmental, and cultural issues, which would strengthen health surveillance actions in the region.

With the analysis of the spatial distribution of hospitalization cases of the indigenous population in Roraima, Brazil, it is necessary to highlight the limitations and challenges of this study, which also indicate possibilities for further investigation and the need for more research to build knowledge on malaria in the academic population.

Declarations of competing interest

The authors have no competing interests to declare.

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Ethical approval statement

This study was not submitted to the ethics committee because it dealt with secondary data.

Author contributions

Mário Ribeiro Alves (Study design, Data collection, Data analysis, Writing). Mary Hellem Silva Fonseca (Data collection, Data analysis, Writing). Nilma Vitor Sant'Anna (Data collection, Data analysis). Ricardo de Mattos Russo Rafael (Data analysis, Writing). Magda Guimarães de Araujo Faria (Data analysis, Writing). Mercedes Neto (Study design, Data collection, Data analysis, Writing).

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