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Epidemiologic Analysis of Malaria Cases Notified in the Municipality of São Gabriel da Cachoeira, Amazonas, Brazil

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***Abstract*—** *Malaria is one of the main public-health issues in the state of Amazonas. The aim of this study was to carry out an epidemiologic analysis of malaria cases in the municipality of São Gabriel da Cachoeira, Amazonas, from 2014 to 2018. The study is a descriptive, ecological study with secondary data collected in the Malaria Epidemiologic Surveillance Information System. The variables of interest were autochthonous cases of malaria; annual parasite incidence (API); sex; age; race & skin color; years of schooling; and Plasmodium species. The results for the number of positive malaria cases per year were: 4,533 cases (2014); 5,071 cases (2015); 10,415 cases (2016); 12,274 cases (2017); and 15,371 cases (2018). The API for malaria varied from 115.9 to 393.2 cases. In 2014, 2015 and 2016, Plasmodium vivax was associated with 99% of positive cases, in 2017 with 92% and in 2018 with 63%. The results of this study show that there is a need to intensify epidemiologic surveillance measures in order to raise awareness of and prevent malaria. Preventive measures should be implemented constantly and intensified so that the population can be protected from malaria even in areas of the municipality where the disease is not endemic.*

I. INTRODUCTION

Malaria is responsible for high morbidity and mortality rates throughout the world. The worst affected regions are Africa, South America and Asia(1). Nearly all malaria cases in Brazil (99%, or 315,809 cases) are reported in the Legal Amazon, where geographic, economic and social factors favor transmission of the disease and limit the extent to which standard control measures can be applied. The incidence of malaria is lower in areas where rubber is extracted and higher in areas that were settled in the last ten years as well as in open-pit mining areas. Some peripheral urban areas also have a high incidence of malaria, largely as a result of human migration from abandoned agricultural settlements where malaria is present(2,3,4).

Mortality due to malaria varies according to the species of *Plasmodium*, *P. falciparum* being the most lethal. In Africa, which accounts for 91% of mortality due to malaria worldwide, 99.7% of cases are caused by this parasite. In the Americas, the predominant species is *P. vivax*, which accounts for 64% of cases of malaria in the region. The Americas has the highest number of malaria cases involving this parasite, followed by the Eastern Mediterranean, where it is responsible for 42% of cases. In

the Americas, there were 650 deaths in 2016 compared with 407,000 in Africa[5].

Brazil has a long history of fighting malaria. The first anti-malaria campaign was launched in 1905 during the construction of the port of Santos[6]. Some 10,000 people, including immigrants, are estimated to have died of malaria during construction of the Madeira-Mamoré Railroad in the state of Rondônia between 1907 and 1912[7].

Malaria is considered a major public-health problem in the Amazon region, where the number of cases reported corresponds to 99% of all cases in the country. The high incidence of malaria has a significant impact on the economic growth and development of the affected populations, most notably those in the states of Acre (AC), Amazonas (AM), Amapá (AP), Pará (PA), Rondônia (RO) and Roraima (RR). The states of Maranhão (MA), Mato Grosso (MT) and Tocantins (TO) account for only around 1% of all cases in the Legal Amazon region[8].

In the Amazon region, the main vector is *Anopheles (Nyssorhynchus) darlingi*, which is highly anthropophilic, a factor that helps to maintain the endemicity of this disease even in situations where there is a low mosquito population density. An efficient vector of both *P. vivax* and *P. falciparum*, *An. (Nyssorhynchus) darlingi* is active at night with peaks of activity at dawn and dusk. This characteristic enables it to adapt to habitats with and without light[9].

The state of Amazonas is notable for its high incidence of malaria, and the municipality of São Gabriel da Cachoeira, on the Upper River Negro, is considered vulnerable because of the high transmissibility of malaria and significant annual parasite incidence (API) in the municipality. In 2005 and 2006, respectively, 2,568 and 2,541 cases were reported[10].

As malaria is an important infectious disease that is classified as one of the most common in the state of Amazonas and as the municipality of São Gabriel da Cachoeira has been experiencing a high incidence of this disease, the aim of this study was to carry out an epidemiologic analysis of malaria cases notified in the municipality from 2014 to 2018.

II. METHOD

The study is a descriptive, ecological study with secondary data from the Malaria Epidemiologic Surveillance Information System (SIVEP-Malaria). The analysis unit was the municipality of São Gabriel da Cachoeira in the state of Amazonas. The study population consisted of individuals living in the municipality diagnosed with malaria between 2014 and 2018.

Information about the number of cases of malaria notified between 2014 and 2018 was collected from secondary data in SIVEP-Malaria and then processed in a DBF file. The sociodemographic data for the population of the municipality of São Gabriel da Cachoeira, Amazonas, were collected from the census carried out by the Brazilian Institute of Geography and Statistics (IBGE) in 2010 using the IBGE Automatic Recovery System (SIDRA)[11].

According to this census, the state of Amazonas has a population of 3,483,985, making it the second largest in the Northern region of the country, with approximately 1.8% of the population of Brazil[11]. Amazonas covers an area of 1,559,161.682 km^2 and consists of 62 municipalities. The capital, Manaus, the largest city in the Northern region, has a population of 2.1 million[11].

São Gabriel da Cachoeira is the third largest municipality in Brazil in terms of its area. It covers 109,184.896 km^2 and has a population of 46,303[11]. Some 81.66% of the territory in the municipality is demarcated indigenous land that has been regularized since the 1990s[12]. The municipality is a largely indigenous population with possibly the largest concentration of different indigenous ethnicities in Brazil.

The variables of interest in the present study were the number of notified malaria cases in the municipality of São Gabriel da Cachoeira, Amazonas, between 2014 and 2018. The API per 1,000 inhabitants was calculated using the number of slides that were positive for malaria and the at-risk population. The variables sex, marital status, race & skin color, age, years of schooling, number of autochthonous cases of malaria and *Plasmodium* species were also selected.

Descriptive statistics were used to analyze the data, and the initial exploratory analysis included an estimate of the relationships between autochthonous malaria cases and sociodemographic variables. SPSS was used for the data analysis and handling. The study complied with the guidelines in Resolution 466/2012 of the National Health Council at the Ministry of Health[13]. Approval from the Research Ethics Committee was not required as the secondary data used in the study are in the public domain and the study participants are not identified.

III. RESULTS AND DISCUSSION

The municipality of São Gabriel da Cachoeira has the highest number of malaria cases in the state of Amazonas, making this disease one of the most important public-health issues in the state. The numbers of malaria cases per

year diagnosed as positive were: 4,533 cases (2014); 5,071 cases (2015); 10,415 cases (2016); 12,274 cases (2017); and 15,371 cases (2018). There was a significant increase in malaria cases between 2014 and 2018 and an increase of 5,344 cases from 2015 to 2016. These figures are a cause for concern and highlight the limited effectiveness of the malaria-control program in the municipality (Figure 1).

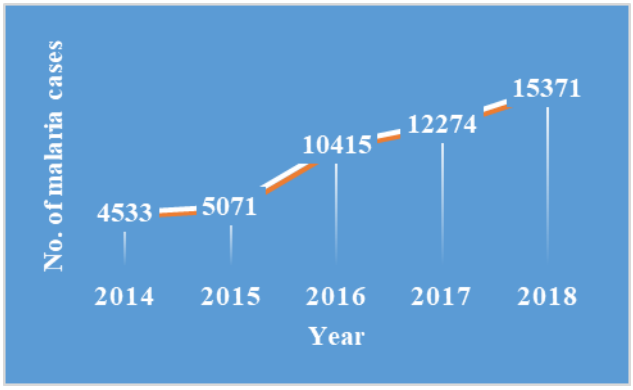

Fig. 1: Distribution of malaria cases registered from 2014 to 2018.

Source: Santos, (2021).

The API for malaria in the municipality varied from 115.9 to 393.2 per 1,000 inhabitants in the period 2014 to 2018 (Figure 2.) There was a significant increase in the API in the years analyzed, particularly in 2016 (266.4 cases per 1,000 inhabitants), 2017 (313.9 cases per 1,000 inhabitants) and 2018 (393.2 cases per 1,000 inhabitants).

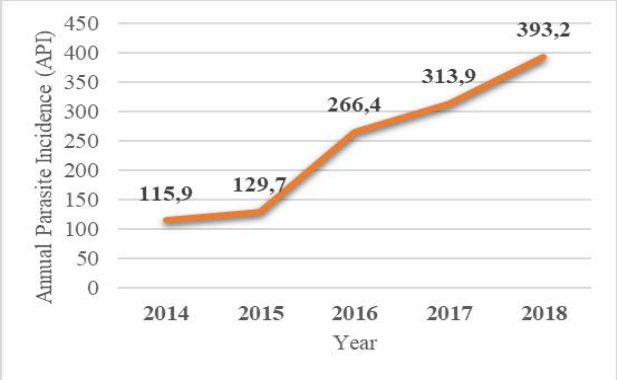

Fig. 2: Annual Parasite Incidence (API) for malaria in São Gabriel da Cachoeira, Amazonas, in the period 2014 to 2018.

Source: Santos, (2021).

This progressive increase in the API can be attributed to the transmission dynamics of the disease, which have been affected by the extensive anthropogenic environmental changes and expansion of fish farming in the region, factors which probably expanded the vector's habitats and density, rendering vector-control strategies ineffective. Human migration between municipalities, states and countries can also be an important factor[14].

The distribution of malaria cases by sex shows that the only year in the study period when there was a greater proportion of cases among females was 2015 (3,060 cases) (Figure 3). These results are consistent with the findings of a study in Tocantins which reported a larger percentage of notified malaria cases among males (77%)[15].

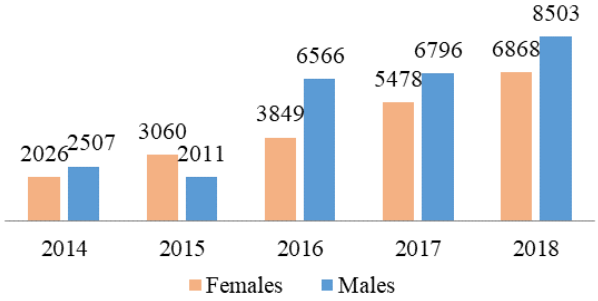

Fig. 3: Distribution of malaria cases registered from 2014 to 2018 by sex.

Source: Santos, (2021).

Another study, in the municipality of Boca do Acre in the state of Amazonas, also found that males were more affected by malaria. The authors reported that throughout the whole study males were more affected by malaria[16]. The greater number of cases in males can be attributed to the fact that they spend more time in areas where they come into contact with the vector as a result of extractive activities such as hunting, fishing and rubber tapping[17].

The distribution by age group is shown in Figure 4. The years are represented by the following colors: blue (2014), orange (2015), gray (2016), yellow (2017) and red (2018). The age group with the largest number of positive malaria cases was the 20 to 29 years age group followed by the 30 to 39 years age group. Both groups had their highest values in 2017 and 2018. These results show that malaria is more common among the economically active younger population in the municipality.

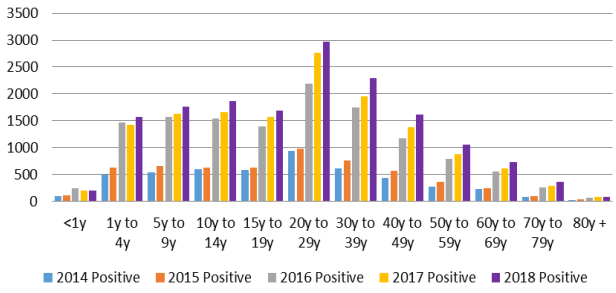

Fig. 4: Distribution of positive malaria cases registered from 2014 to 2018 by age group.

Source: Santos, (2021).

Worthy of note are the < 1 year and > 80 years age groups, for which the incidence of malaria was much lower than for the other groups. However, individuals in these two age groups are more likely to contract severe forms of the disease and to develop complications as well as a deteriorating clinical condition because of decreased immune response to infections. According to data reported by the Pan American Health Organization (PAHO), children under the age of five years are particularly susceptible to infection, disease and death; more than two thirds (70%) of all deaths due to malaria occur in this age group[18].

The distribution of the species of *Plasmodium* analyzed during the study period (2014 to 2018) is shown in Figure 5, where pink represents *P. vivax*, orange *P. falciparum* and green *P. malariae*. The highest percentages of *P. vivax* positive cases were in 2014, 2015 and 2016 (99%). *Plasmodium vivax* is the commonest causative agent of malaria in Brazil and the least aggressive.

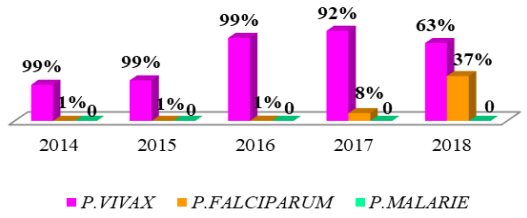

Fig. 5: Distribution of positive malaria cases registered from 2014 to 2018 by Plasmodium species.

Source: Santos, (2021).

In 2017 and 2018, the corresponding percentages for *P. vivax* were 92% and 63%, respectively, and in 2018 *P. falciparum* accounted for 37% of cases. The number of *P. falciparum*-positive cases increased significantly, particularly in 2018. This is a worrying finding as this species is more common in Africa and causes the more severe type of malaria. There were no cases associated with *P. malariae*, the least common species in Brazil.

Studies have shown that *P. vivax* and *P. falciparum* circulate in most areas in Brazil where malaria is endemic and that recurrences of *P. vivax* malaria follow a different temporal pattern[19]. *P. vivax* is more difficult to control and eliminate than *P. falciparum* because of the tendency for a relapse to occur after the primary infection[19,20,21]. This is reflected in the total number of malaria cases and the relationships between the variables as the number of cases due to *P. vivax*, the principal causative agent of malaria in the state of Amazonas, is associated more with relapses than with environmental characteristics[22].

IV. CONCLUSION

This study has reported high values of API between 2014 and 2018 in the municipality of São Gabriel da Cachoeira, Amazonas. The study findings show that malaria is a serious public-health issue in the municipality and that there is a need to intensify epidemiologic surveillance measures in order to help raise awareness of and prevent malaria. The findings can also be used by health managers and professionals to support the development of malaria-control measures and to assist decision-taking with a view to enhancing the effectiveness of public-health policies and awareness strategies.

Preventive measures should be implemented constantly and intensified so that the population can be protected from malaria even in areas of the municipality where the disease is not endemic. A variety of methods, both individual and collective, for reducing the number of malaria cases should be adopted, including the use of mosquito nets, repellents and clothes that protect the arms and legs, as well as drainage and cleaning of rivers and *igarapés* (small, narrow, navigable rivers). Educational measures are also needed to raise awareness of and prevent vector-borne diseases.

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