Malaria epidemiology in the State of Piauí, Northeastern Brazil: a retrospective study with secondary data

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ABSTRACT

Introduction: Malaria is not considered endemic in State of Piauí. Methods: Malaria epidemiology was examined using surveillance data. Results: During 2002-2013, of the 484 cases of malaria, 217 were classified as probably acquired in Piauí, most frequently in the Campo Largo, Buriti dos Lopes, and Luzilândia municipalities, and 267 were considered probably imported, from the States of Pará, Maranhão, Amazonas, Roraima, and Rondônia. Probably-imported cases occurred throughout the year, while 80.2% of the probably-acquired cases occurred in April-August, peaking at the end of the rainy season. Conclusions: Malaria surveillance should be intensified. Further ecoepidemiological and entomological studies are needed.

Keywords: Epidemiology. Malaria. Health surveillance.
Malaria is an obligatory notifiable disease in Brazil. Data from the System of Information for Notification Diseases (SINAN) were retrospectively reviewed to characterize the geographic and temporal distributions of malaria cases reported in Piauí from 2002 to 2013. Each case was confirmed by parasitological diagnosis using thick blood smears. Cases were included only if the Giemsa-stained thick blood smears were positive for *P. vivax, P. falciparum*, or *P. malariae*. Only malaria cases with well-established parasite-specific positive thick blood smears were included.

Climatic data were obtained from the National Meteorology Institute (INMET) at http://www.inmet.gov.br/ (accessed April 15th, 2015 at 2:00 PM). The maximum temperatures, minimum temperatures, and precipitation levels were retrieved; monthly averages were calculated for the 2002-2013 period. The selected climate data were obtained at an INMET station (3°27'40"S/42°22'18"W) near the cities at which the highest numbers of cases were recorded.

All suspected (probable) infection sites were reported on the notification forms. However, it is not possible for the agents responsible for this information to perform a systematic search to definitively establish where each patient was infected with malaria. Agents are limited to asking where each patient has traveled in recent weeks and if he/she is returning from a known malaria-endemic region. Thus, in this study, cases were classified into the following categories: probably acquired in Piauí, if the reported infection site was a municipality belonging to the State of Piauí, or probably imported, if the infection site reported in the notification form was a municipality outside Piauí.

Malaria cases were distributed by month, year, geographic location (probable site of infection), and demographic characteristics. Spatial distribution was performed with QGIS (QGIS Development Team, available at http://www.qgis.org/en/site/). Statistical analyses were performed with SPSS® (IBM Corp., Armonk, NY, USA). Data are presented as descriptive statistics, and the characteristics of probably acquired versus probably imported cases were compared using the chi-square test. Statistical significance was set at 5%.

This study was approved by the Ethics Research Committee at Oswaldo Cruz Institute/FIOCRUZ, license number 3940551470000524.

From 2002 to 2013, 484 parasitologically confirmed cases of malaria were recorded. Of these, 217 cases were likely acquired in Piauí, and 267 cases were probably imported. The positive thick blood smear results were as follows: *P. falciparum*, n = 86 (17.8%); *P. falciparum* with gametocytes, n = 7 (1.4%); *P. vivax*, n = 362 (74.8%); *P. falciparum + P. vivax*, n = 25 (5.2%); *P. vivax + P. falciparum* gametocytes, n = 2 (0.4%); and *P. falciparum* gametocytes, n = 2 (0.4%). The proportions of infection with *P. falciparum* among the probably-acquired cases and probably-imported cases were 13.8% and 34.4%, respectively (p < 0.001). The monthly and annual distributions of malaria cases, including the variation in the proportions of *P. falciparum* infection, are shown in Figures 1A and 1B. While the probably-imported cases occurred throughout the year, 80.2% of the cases classified as probably acquired occurred from April to August. A marked increase in the number of cases was observed in 2004. The climatic characteristics are displayed in Figure 2 and reveal that the number of the probably-acquired cases increased at the end of the rainy season in the state.

Cases probably acquired in Piauí (probable site of infection) were reported most frequently in the municipalities of Campo Largo do Piauí (n = 70 [32.3%]), Buriti dos Lopes (n = 25 [11.5%]), Luzilândia (n = 24 [11%]), Uruçuí (n = 12 [5.5%]), and Porto (n = 11 [3.1%]). The cities that recorded the highest numbers of probably-acquired malaria cases are located on the banks of the Parnaíba River, bordering the State of Maranhão (Figure 3A). In contrast, the majority of the probably-imported cases were reported in the States of Pará (n=90 [33.7%]), Maranhão (n=51 [19.1%]), Amapá (n=12 [4.5%]), and Amazonas (n=11 [4.1%]). The probable sites (municipalities) of infection for the imported cases are presented in Figure 3B.

The proportions of cases probably acquired and probably imported in children aged 0-12 years were 18.4% (n = 40) and 3.4% (n = 9), respectively (p < 0.001). The proportions of probably-acquired and probably-imported cases in women were 34.6% (n = 75) and 16.9% (n = 45), respectively (p < 0.001).

Extra-Amazonian cases of malaria have been reported in Brazil; consequently, the surveillance of such cases has increased[21]. Although the State of Piauí is situated outside the Amazon, it borders Maranhão and Tocantins, two states located in the Amazonian region. These two states have active transmission of malaria[111](12).

As presented here, Piauí records an average of approximately 40 malaria cases per year, nearly half of which are probably acquired in the state, i.e., are potentially autochthonous. Almost all of these cases were reported in the counties that border Maranhão; the Parnaíba River separates these two states. The middle-North region of Brazil is an extensive ecotone zone between the sub-humid pre-Amazonian region, Cerrado biome, and semi-arid Northeast. This region has an extensive network of drainage with the Parnaíba River as its main body of water. Piauí has remnants of the Atlantic Forest in its Northwestern region where many malaria cases were reported as well as in the central Southern region.

Entomological surveys performed in Piauí aimed at characterizing the local *Anopheles* species have provided interesting findings. The most recent of these data were acquired from 2000 to 2010. These surveys reported the presence of the *Anopheles* species in the Amazon region (*An. darlingi*) and in northeastern Brazil (*An. albitoris, An. aquasalis*), confirming the transitional character of the middle-North region of Brazil. In this context, *An. darlingi* has been identified in 55 municipalities ranging from the North to the South of Piauí, mainly in the western area of the state. *An. albitoris* has been observed in 97 municipalities, mainly in Eastern Piauí, whereas *An. aquasalis* has been captured in two coastal municipalities in the north. Captures of primary malaria vectors have been documented in 50.2% of all the municipalities in Piauí (Coordenação de Vigilância em Saúde Ambiental/Secretaria de Estado de Saúde do Piauí, unpublished data). Similar data were reported in
FIGURE 1 - Monthly distributions, annual distributions, and proportions of malaria cases caused by Plasmodium falciparum reported in the State of Piauí, Northeastern Brazil, between 2002 and 2013.

the State of Maranhão, illustrating the broad diversity of the Anopheles species in this transitional zone\(^{(13)}\).

The present study demonstrated that cases probably acquired in municipalities belonging to the state of Piauí exhibit distinct transmission dynamics of probably imported malaria. Moreover, a well-marked seasonality of probably autochthonous malaria was observed; specifically, the incidence increased at the end of the rainy season. Greater proportions of probably autochthonous cases compared with imported cases in women and children are also characteristic of this autochthonous pattern. Imported cases tend to occur more frequently in adult men, probably within an occupational context related to the migration of the workforce to and from Amazonian states in which malaria is endemic. The probable infection sites of most cases considered to be imported were in the South of Pará and in Rondônia, as well as in Manaus (the state capital of Amazonas) and Roraima. Thus, many subjects are likely to have been infected in areas with high incidences of malaria that are also associated with agriculture (including cattle raising), mining projects, and hydropower plant construction in the Amazon. These Amazonian areas continue to import members of the workforce from impoverished regions in northeastern Brazil. Many of these workers may have malaria when they return to their home cities in Piauí. Individuals with asymptomatic parasitemia coming from the Amazon can be an interface between introduced and autochthonous malaria because they represent a source of Plasmodium infection for the vectors. In this sense, the presence of parasitemic asymptomatic individuals during the period of increased vector density potentially produces autochthonous cases. The importance of asymptomatic and submicroscopic infections for transmission maintenance, as well as the need to improve diagnostic tools, has been demonstrated in different regions, as recently reviewed by Bousema et al.\(^{(14)}\). In this sense, Piauí is particularly receptive to malaria, as well as quite vulnerable due to its proximity to endemic states and the migratory flux of workers to the Amazon.
A marked increase in malaria incidence was observed in 2004, a year in which 70 cases were reported in the municipality of Campo Largo do Piauí during May, June, and July. All of these cases were considered to be acquired in the state and were not preceded by the notification of imported cases. However, one study proposed that this outbreak was related to the arrival of parasitemic clandestine gold prospectors from Suriname, an endemic country. Health care and epidemiological surveillance teams should be alerted to the presence of malaria in Piauí so that they can provide immediate treatment, improve patient prognoses, and reduce the maintenance of parasitemic individuals in the region. Moreover, Anopheles breeding sites should be identified and appropriately managed, especially in municipalities with high numbers of cases.

FIGURE 2 - Climatic characteristics and monthly distributions of malaria cases reported in the State of Piauí, Northeastern Brazil, between 2002 and 2013.

FIGURE 3 - Maps showing the probable municipalities of infection for malaria cases reported in the State of Piauí between 2002 and 2013.
CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

FINANCIAL SUPPORT

This study comprises the work towards a Master’s Degree in Tropical Medicine at the Oswaldo Cruz Foundation (FIOCRUZ)/Brazilian Ministry of Health for J.A.A. do Nascimento. Funding was provided by FIOCRUZ, Brazilian Ministry of Health. We thank Dr. Lindsay Carpp (Center for Infectious Disease Research, Seattle, WA) for English editing and critical revision of the manuscript.

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