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Malária, anemia e hospitalizações entre crianças Yanomami em Roraima, Amazônia brasileira: uma visão a partir da hemoterapia

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Malaria, Anemia, and Hospitalizations Among Yanomami Children in Roraima, Brazilian Amazon: The Perspective of Hemotherapy Professionals

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Abstract

In this article, we discuss aspects related to the impact of malaria hyperendemicity on transfusion medicine in the state of Roraima, which has been the stage of the humanitarian crisis experienced by the Yanomami people in their territory, violated by illegal gold mining. Removed from their Indigenous lands for hospital admission in Boa Vista, dozens of Yanomami children require blood transfusion in a clinical context marked by chronic malaria, severe anemia, respiratory infections, diarrhea, and severe acute malnutrition—conditions that potentially result in fatal outcomes. Transfusion is hindered by the patients' immunological environment, which leads to the emergence of unexpected antibodies capable of compromising the identification of compatible blood units. The pathophysiological mechanisms of malaria-related anemia, with particular emphasis on immune-mediated hemolytic processes are addressed.

Keywords

Malaria, Anemia, Blood Transfusion, Yanomami People, Roraima

The State of Roraima and Its Socio-Environmental Characteristics

The state of Roraima, with approximately 636,000 inhabitants – about two-thirds of whom living in the capital Boa Vista – covers an area of 224,300 km² sharing international borders with Venezuela and Guyana. With a population density of only about 2.8 inhabitants per km², Roraima presents unique socio-environmental features, as 45% of its territory is covered by demarcated Indigenous lands and around 15% of its population self-identifies as Indigenous. ⁽¹⁻³⁾ Roraima is the main home to the Yanomami Indigenous Territory, which spans more than 9.6 million hectares and extends across the border into Venezuela, beyond a frontier not recognized by the Yanomami people themselves. In addition, Roraima encompasses the Raposa Serra do Sol Indigenous Territory. Alongside these, Roraima hosts a remarkable ethnic diversity that includes the Macuxi, Wapichana, Ye'kwana, Ingarikó, Taurepang, and other Indigenous peoples. ⁽¹⁻³⁾

Roraima has also been a stage for the development of large-scale agricultural projects being increasingly occupied by mechanized monocultures, especially soybeans, corn, and rice, largely oriented toward export. Today, agribusiness represents a growing vector of economic expansion in Roraima making the state a critical arena for discussions on the balance between economic development and socio-environmental sustainability in the Amazon. ⁽⁴⁾ In recent years, a substantial increase in gold-mining activity has affected Indigenous populations, making the interface between this economic activity and Indigenous societies—particularly the Yanomami—deeply troubling. ⁽⁵⁾

Malaria in Roraima

In the state of Roraima, malaria exhibits a very high incidence, disproportionately affecting Indigenous populations. Data from the Malaria Surveillance System (available at <https://public.tableau.com/app/profile/mal.ria.brasil/vizzes>) show that between 2020 and 2024, a total of 146,817 malaria cases were reported in the state, corresponding to an average Annual Parasite Incidence (API) of 45.04 cases per 1,000 inhabitants per year—considerably higher than in other Brazilian Amazon states, as shown in Table 1. Among the malaria cases recorded in Roraima, 94,959 (64.7%) occurred in Indigenous areas, a proportion that has displayed a consistent upward trend. Given the low population density of Indigenous territories, malaria incidence in these areas is extraordinarily high. Furthermore, from 2020 to 2024, in Roraima, the proportion of reported malaria among children under 9 years of age also increased, reaching 37.5% in 2024, as illustrated in Figure 1.

Persistent Health Risks in Indigenous Territories and the Yanomami Public Health Emergency

Despite the recognition of Indigenous territories as legally protected areas, persistent health risks remain a pressing concern for their populations. ⁽⁶⁾ In Roraima and other Amazonian states, Indigenous peoples face a complex epidemiological scenario shaped by geographic isolation, logistical challenges in health care, and the constant threat of infectious diseases, such as malaria. ⁽⁷⁾ Similarly, tuberculosis presents disproportionately high incidence rates among Indigenous communities, often aggravated by food insecurity, and barriers to diagnosis and treatment adherence. In addition, outbreaks of acute respiratory infections and

diarrheal diseases persist. ⁽⁸⁾ In January 2023, the Brazilian Ministry of Health declared a Public Health Emergency of National Importance and created the Yanomami Emergency Operations Centre (COE-Yanomami) to coordinate actions. ⁽⁹⁾ The crisis, marked by high rates of malaria, malnutrition, and preventable child mortality, was compounded by illegal gold mining and insufficient healthcare provision. ⁽¹⁰⁾

Malaria, Malnutrition and Other Conditions Requiring Hospitalization and Blood Transfusion

According to Report 07 on the activities of the Working Groups of the Yanomami Emergency Coordination, covering the period from January 1 to December 31, 2024, in a population of 33,355 Yanomami people, there were 428 deaths in 2023 and 337 deaths in 2024. The leading underlying causes of death were acute respiratory infections (89 in 2023 and 47 in 2024), malnutrition (44 in 2023 and 35 in 2024), and malaria (26 in 2023 and 15 in 2024). ⁽¹¹⁾ Although not stated in the official document, most of these deaths occurred in children. According to the Yanomami Emergency Operations Centre and the Indigenous Health Care Information System (SIASI), a total of 538 deaths among children under 5 years of age were recorded in the Yanomami Territory between 2019 and 2022. ⁽¹²⁾ In 2022, there were 703 hospitalizations of Yanomami Indigenous people at Hospital da Criança Santo Antônio, the pediatric referral unit in the state. ⁽¹³⁾ The main causes of hospitalization were acute diarrhea, severe malnutrition, respiratory infections, snakebite envenomation, and malaria ⁽¹³⁾ with a recurrent need for blood transfusion. The HEMO-BR Observatory, accessible at <https://www.hemobr.com/> provides data on blood transfusions in Brazil for the year 2021, twenty-four months before the declaration of the Public Health Emergency of National Importance. In that year, in Roraima, there were reports of 74 blood units transfused in patients whose indication for transfusion was malaria, of which 59 cases were attributed to *Plasmodium vivax* and 15 to *Plasmodium falciparum*. These data make it possible to calculate the rate of blood units transfused due to malaria per population of Roraima, which—when compared with those of other malaria-endemic states—is substantially higher, as shown in Table 1. This finding indicates that the population of Roraima is more severely affected by the disease, which in the state is frequently associated with severe anemia requiring blood transfusion.

Malaria contributes to the onset of anemia in Yanomami through multiple mechanisms, including immunologically mediated hemolysis

Malaria is one of the leading causes of anemia among Indigenous children in the Brazilian Amazon, particularly in Roraima. Studies conducted in the Yanomami Indigenous Territory in 2022 found that approximately 25% of the children assessed presented anemia. ⁽¹⁴⁾ Anemia in malaria results from multiple pathophysiological mechanisms and, in endemic areas, besides hemolysis and bone marrow suppression, it is often compounded by co-morbid conditions such as enteric infections, deficiencies of iron, folate, vitamin B12, and other essential nutrients. ^(15,16) The condition may be further exacerbated using antimalarial drugs, which can contribute to anemia through both immune-mediated and non-immune pathways ^(14,15), with emphasis on individuals with low glucose-6-phosphate dehydrogenase enzymatic activity and the use of primaquine and, more recently, tafenoquine. In a cross-sectional study

conducted among the Yanomami, the prevalence of chronic malaria, anemia, and splenomegaly reached 80.8%, 18.2%, and 85.4%, respectively, and the mean hemoglobin concentration was 10 g/dL among individuals without regular access to healthcare services. ⁽¹⁷⁾ Hyperreactive malarial splenomegaly, a condition associated with chronic malaria characterized by lymphocytic hyperplasia, polyclonal IgM overproduction, and hypersplenism, is frequently observed among Yanomami children and results in hemolytic anemia, leukopenia, and thrombocytopenia. ⁽¹⁸⁻¹⁹⁾ According to Torres et al. (2003), in a cluster of cases of hyperreactive malarial splenomegaly with severe acute hemolysis among an isolated Yanomami population, the majority of the 13 sera investigated—but only one of 14 control sera—contained elevated titres of complement-fixing IgM cold agglutinins. These cold agglutinins displayed specificity for both the I and i blood-group antigens (with a relative predominance of anti-I) and showed wide thermal stability. This finding suggests that, in at least some cases, the acute severe hemolytic episodes occasionally observed in hyperreactive malarial splenomegaly are associated with an autoimmune, cold-agglutinin-mediated response triggered by non-patent parasitaemias. ⁽²⁰⁾ Still considering the loss of uninfected red blood cells in malaria, Rivera-Correa and Rodriguez (2020), in a recent review, explored the role of autoimmune antibodies against the membrane lipid phosphatidylserine in promoting the clearance of uninfected erythrocytes after binding to exposed phosphatidylserine on their surface. The authors point out that in human malaria there is a strong correlation between anemia and anti-phosphatidylserine antibodies. During malaria, these antibodies are produced by atypical B cells, and their levels correlate with the development and severity of anemia. ⁽²¹⁾ In India, Taneja & Agarwal (2019) reported a case of severe anemia following the use of artesunate, highlighting the difficulty of blood transfusion as cross-matching showed major incompatibility; group O negative blood was transfused under steroid cover. ⁽²²⁾

Transfusion Challenges in Roraima: Unexpected Antibodies as a Cause of Incompatibility in the Recipient

From the mechanisms exemplified above, it can be inferred that malaria generates an immunological environment in which both autoantibodies (directed against self-antigens, often cold agglutinins with specificity for the I/i blood group system) and alloantibodies may appear. These antibodies can interfere with standard serologic compatibility testing. The mandatory pre-transfusion tests are patient blood typing, re-typing of the red blood cell concentrate, screening for irregular antibodies with the indirect Coombs test, and crossmatching. ⁽²³⁻²⁵⁾ Antibodies produced in the context of malarial infection may interfere with all of these, including additional tests such as the direct antiglobulin test (direct Coombs test), irregular antibody identification, and autoantibody detection. Although interference does not occur in every case, in Roraima they are frequently observed. Such interferences prevent from reliably determining whether alloantibodies are present in the patient, since pan agglutination often occurs in all test tubes, and the presence of autoantibodies prevents the safe exclusion of alloantibodies, thereby increasing transfusion risks. Pan agglutination may interfere with procedures ranging from ABO/Rh typing to obtaining compatible crossmatches, ultimately delaying or even cancelling transfusion.

It is generally recommended that malaria be treated first so that hemoglobin levels may increase naturally following parasite clearance. However, it is not always possible to wait for this improvement, as patients often present with hemodynamic decompensation, making

transfusion both necessary and urgent. In cases of incompatible crossmatches, it becomes necessary for the attending physician to sign a consent form taking responsibility for the transfusion of an incompatible blood unit, requiring a careful assessment of the risk-benefit ratio. The risk assumed is that clinically significant alloantibodies may be masked by autoantibodies binding to potential blood group antigens, which may or may not be present in the transfused red cell units. The requirement for a signed responsibility statement may create insecurity among less experienced physicians, who sometimes choose not to proceed with the transfusion.

Concluding remarks

In addition to impacting donor selection—having stayed within the past 30 days in an area of active transmission is the main cause of deferral for blood donation in Roraima ⁽²⁶⁾—and making malaria nucleic acid testing (NAT) screening crucial in donated blood, malaria also interferes with the routine work of hemotherapy professionals, hindering the release of transfusions due to incompatibility mediated by unexpected antibodies and possibly contributing to morbidity and mortality among the Yanomami. This illustrates the less obvious effects of an endemic disease whose control must be intensified, particularly through effective and applicable interventions among Indigenous populations—an ongoing challenge within the framework of Indigenous health.

Ethics

This is an opinion article that presents publicly accessible data obtained from Internet sources; therefore, it does not involve human subjects, either directly or indirectly, and is exempt from approval by a Research Ethics Committee.

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Authors' Contribution

DRR organised the dataset and designed the study; FG supervised the study; FACC was responsible for data analysis and preparation of the manuscript.

Disclosure

The authors declare that they have no competing interests in this work.

Data availability statement

Data presented in this perspective paper are available from the corresponding author on reasonable request

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Table 1. Malaria cases and Annual Parasite Incidence (per 1,000 inhabitants) in states of the Brazilian Amazon region in 2021; information on blood transfusions in patients for whom malaria was the underlying cause of blood demand; rate of blood unit utilization and hospitalization with transfusion (per 100,000 inhabitants); average Annual Parasite Incidence for the period 2002–2024. Prepared based on public information collected from <https://public.tableau.com/app/profile/malaria.brasil/vizzes> and <https://www.hemobr.com/>.

State	Malária cases 2021	API* (2021))	Blood units transfused in patients with malaria (2021)			Malaria-related hospitalizations requiring blood transfusion (n; 2021)	Malaria-related hospitalizations requiring blood transfusion / population**	Blood unities / population***	Average API* (2020-2024)
			Total (n)	Atributed to <i>P. vivax</i> (n)	Atributed to <i>P. falciparum</i> (n)				
Roraima	26070	39.94	74	59	15	26	3.98	11.34	45.05
Amapá	4066	4.63	0	0	0	0	0.00	0.00	4.60
Amazonas	61258	14.35	31	18	2	18	0.42	0.73	13.99
Pará	20331	2.32	10	6	1	6	0.07	0.11	2.66
Rondônia	14403	7.93	64	41	8	22	1.21	3.53	6.42
Acre	8464	9.33	13	5	1	11	1.21	1.43	8.15
Mato Grosso	4303	1.21	40	17	12	15	0.42	1.12	0.66

* Annual Parasite Incidence (API); ** Number of hospitalizations requiring blood transfusion due to malaria / state population × 100,000; *** Number of blood units transfused for malaria / state population × 100,000

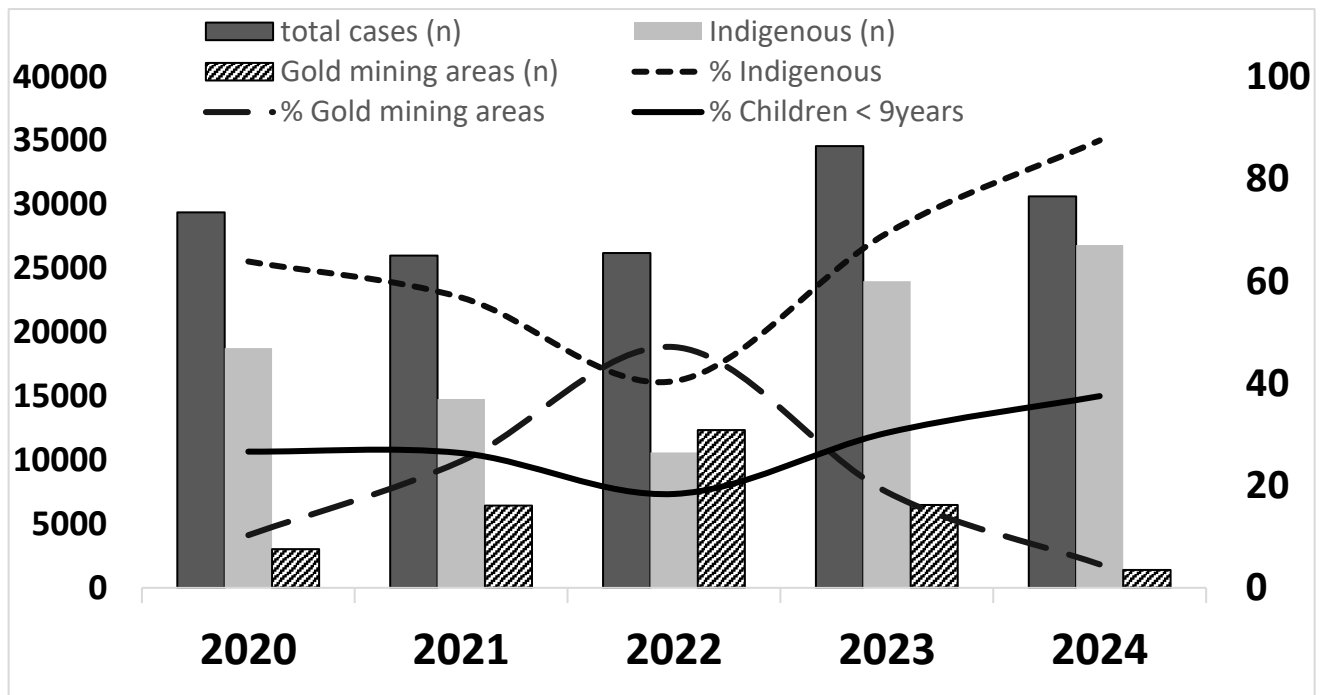


Figure 1. Malaria in Roraima from 2020 to 2024: total number of cases, number and proportion of cases reported in Indigenous areas, number and proportion of cases reported in gold mining zones, and the proportion of cases reported in children under 9 years of age. Based on data obtained from: <https://public.tableau.com/app/profile/malaria.brasil/vizzes>

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