ANEMIA AND MALARIA IN A YANOMAMI AMERINDIAN POPULATION FROM THE SOUTHERN VENEZUELAN AMAZON

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Abstract. The prevalence and age distribution of anemia and malaria among Yanomami Amerindians undergoing sociocultural assimilation are described. Anemia and malaria proportions were determined in 103 individuals randomly selected from 515 villagers in Mavaca in the southern Venezuelan Amazon. The age and sex distribution reflected that of the entire village cluster. Anemia (hematocrit less than World Health Organization/Centers for Disease Control and Prevention reference values) was found in 91% of the study population. As a group, adults (>15 years old) had the highest proportion of anemia (P = 0.037). Adult females had lower mean hematocrit values than adult males (P = 0.013). The anemia was predominantly hypochromic and microcytic (62%), a finding that could suggest a diagnosis of iron deficiency in the absence of known hereditary hemoglobinopathies in these Amerindians. Malaria was diagnosed in 14% overall. Children (<10 years old) displayed the highest proportion of Plasmodium falciparum (17%) and P. vivax (14%) parasitemia, splenomegaly (94%), and fever (34%) (P = 0.059, 0.039, 0.005, and 0.008, respectively). The high proportions of anemia and splenomegaly observed in the survey may be used as indicators of inadequately controlled malaria in this community. Further studies to assess the epidemiology of risk factors for the high prevalence of anemia, and predominance of P. falciparum infections in the area are urgently needed.

The cumulative impact of important health problems among Venezuelan Yanomami populations has not been adequately studied. However, these vulnerable Amerindians show a heavy disease load and low productivity. This has become more evident as they establish permanent settlements after contact with national cultures. This process of sociocultural assimilation, leading to relative sedentariness and increasing mission dependency, has resulted in a progressive reduction in the quality, quantity, and variety of food consumption, overcrowding, water contamination, and poorer sanitation. Knowledge of their overall health is fundamental if we hope to improve their living conditions and preserve their culture. However, the burden of disease among remote populations in malaria-endemic areas is infrequently reported.

For the developing regions of the world, anemia is found in about 36%,1,2 ranging from 15% to 40% in tropical South America.1 In Venezuela, the prevalence of anemia seems to be relatively low for a developing country, ranging from 6% in 1989–1990 and 19% in 1992 to 10% in 1994.3,4 In the Brazilian Amazon basin, anemia has been found in 28% of the inhabitants of a malaria-endemic area, ranging from 70% in infants and 38.4% in young children to 44.4% among malaria patients.5

Malaria remains as another important cause of anemia in tropical countries.6,7 One-fourth of all malaria cases detected in the Americas are from Bolivia, Colombia, Ecuador, Peru and Venezuela. In 1992, 29% of these cases were Plasmodium falciparum infections.8 In the northern Venezuelan Amazon, Amerindians have shown a prevalence of antibodies to P. falciparum of 91.2% that are acquired early in life, reflecting the high level of malaria transmission in that region.9

The aim of this study was to ascertain the local prevalence and age distribution of anemia and malaria as a means to investigate the magnitude of the problem in these villages. This was done with a view to determining priorities for preventative health care strategies.

SUBJECTS AND METHODS

Study area and population. In October 1992, a cross-sectional survey of 20% of the population inhabiting Mavaca’s cluster villages of Yanomami Amerindians was conducted. To form the study sample, the number of individuals to be chosen for each age stratum was determined according to the age distribution of the overall population. Individuals were then selected randomly using a table of random numbers. A census update was carried out at mid-year to validate the demographic information. All ages more than eight years are estimates since the Yanomami have no accurate system of recording time. Inclusion criteria were an age of at least six months at entry, and permanent residence in any of Mavaca’s villages. The exclusion criterion was severe illness, as assessed by the author, acting as the local rural physician. All selected adults and parents of selected children consented to participate in the study after having been informed of the purpose of the study. Ethical approval for the study was obtained from the Programa Parima Culebra within the Venezuelan Ministry of Health and Social Welfare.

Mavaca is located in the southern Venezuelan Amazon (02°33’S, 65°12’W), at an altitude of 100–200 meters above sea level. The study area is predominantly rain forest, interrupted only around the villages by land clearance of about 300 m². Its population (n = 515) is distributed in 11 separate small communities, consisting of multifamily dwellings with earthen floors and thatched roofs.10 These communities are scattered along the banks of the Orinoco River and one of its tributaries, the Mavaca River. There is no running water or electricity, and there are no waste disposal systems, mosquito screens, or hammock nets. The average rainfall in the area is 3,500 mm per year, with a major rainy season from April through June, and a dry season from December through March.

Assessment of health status. All data were collected in Mavaca’s rural health clinic and individual villages. A record was compiled for each subject containing name, code number, village, age, sex, and axillary temperature. Spleen size
was measured supine and rated as Hackett class 0–5.\textsuperscript{11} Spleen rates,\textsuperscript{11,12} as indexes of incidence of enlarged spleens in the community, were determined for each age group. Blood samples were collected by earlobe prick for blood slide examination and microhematocrit determination. Heparinized capillary tubes were centrifuged at 8,000 rpm for 5 min (Select-a-Fuge 24, model 0630, powered with solar panels; Bio-Dynamics, Inc., Chatsworth, CA) to determine hematocrit values. Anemia was defined by World Health Organization and Centers for Disease Control and Prevention standards: hematocrit less than 33% for children <5 years of age and pregnant women, less than 36% for children 6–14 years of age and nonpregnant adult females, and less than 39% for adult males.\textsuperscript{1,13} Severe anemia was defined as a hematocrit less than 20%.\textsuperscript{1,13} Blood films were stained with Giemsa. Parasitemia was estimated assuming 0.25 μl per 100 high power fields, and 8,000 leukocytes/mm\(^3\) of blood.\textsuperscript{14} A thick blood film was declared negative after 200 oil-immersion fields were visualized. Malaria species were identified from the thin smear. Blood smear examination of red blood cell morphology for presence of hypochromic microcytes was carried out.\textsuperscript{15}

The data were analyzed using the Fisher’s exact probability test statistics, two-sample \( t \)-test, chi-square test, and one-way analysis of variance test where appropriate. The Wilcoxon rank sum test was applied to the small sample size groups. Statistical significance was considered at a level of \( P \leq 0.05 \).

**RESULTS**

In October 1992, there were 515 indigenous inhabitants in Mavaca in the Upper Orinoco basin of the Venezuelan Amazon; 103 (20%) were surveyed. There were 58 males and 45 females, ages six months through 60 years. Age-specific prevalence proportions of anemia, fever, splenomegaly and malaria parasitemia are shown in Tables 1 and 2. The mean ± SD hematocrit was 29.3 ± 5.1% (range = 15–40%). Adult females (≥ 15 years old) had lower mean hematocrit values than adult males (\( P = 0.013 \)). There were no significant differences between adult groups by sex in anemia and microcytic hypochromic anemia. Likewise, no significant difference in proportions was found across age groups for microcytic hypochromic anemia. Adults (≥ 15 years old) were more anemic than other age groups (\( P = 0.037 \)). Severe anemia was present in three individuals, a 14-year-old woman with acute viral hepatitis and 20 weeks pregnant, a 30 year-old woman 27 weeks pregnant, and a 39-year-old woman with acute viral hepatitis. The highest hematocrit was measured in a 23-year-old man whose diet differed from that of his fellow Amerindians in that it was richer in animal protein and iron content. He took most of his meals at the local mission, where he worked regularly.

The spleen rate (Table 2) was highest among children (<10 years old) (\( P = 0.005 \)). Moderate-to-marked splenomegaly (Hackett class 3 or greater) was present in 46 individuals (44.6%), two of whom were considered to show hyperreactive malarial splenomegaly,\textsuperscript{16} while six others had malaria parasitemia. One-fourth of all children with splenomegaly had malaria parasitemia. The latter was present in only one individual without splenomegaly. Eighty-eight per cent (36 of 41) of the children with splenomegaly had anemia, whereas only three of the six without splenomegaly had anemia (\( P = 0.053 \)).

Children (<10 years old) displayed the highest proportion

**TABLE 1**

Age-specific hematologic indices among Yanomami residents of Mavaca, Upper Orinoco Basin, Amazonas State, Venezuela, October 1992

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>n</th>
<th>Hematocrit (%)</th>
<th>Anemia\textsuperscript{*}</th>
<th>Microcytic hypochromic anemia\textsuperscript{+}</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5–4.9</td>
<td>22</td>
<td>31.4 ± 3.3</td>
<td>16 (72.7) [49.8–89.3]</td>
<td>15 (68.2) [45.1–86.1]</td>
</tr>
<tr>
<td>5–9.9</td>
<td>13</td>
<td>29.5 ± 3.5</td>
<td>13 (100) [75.3–100]</td>
<td>8 (61.5) [31.6–86.1]</td>
</tr>
<tr>
<td>10–14.9</td>
<td>12</td>
<td>28.6 ± 5.7</td>
<td>10 (83.3) [51.6–97.9]</td>
<td>7 (58.3) [27.7–84.8]</td>
</tr>
<tr>
<td>Males ≥ 15</td>
<td>34</td>
<td>30.1 ± 5.6</td>
<td>33 (97.1) [84.7–99.9]</td>
<td>19 (55.9) [37.9–72.8]</td>
</tr>
<tr>
<td>Females ≥ 15</td>
<td>22</td>
<td>26.3 ± 5.1</td>
<td>22 (100) [87.6–100]</td>
<td>15 (68.2) [45.1–86.1]</td>
</tr>
<tr>
<td>All</td>
<td>103</td>
<td>29.3 ± 5.1</td>
<td>94 (91.3) [84.1–95.9]</td>
<td>64 (62.1) [52.1–71.5]</td>
</tr>
</tbody>
</table>

\( ^* \) Values are the number (%) [95% confidence interval] within each age group.

\( ^+ \) Values are the number (%) [95% confidence interval] within each age group.

\( ^\dagger \) As suggested by red blood cell morphology on microscopic examination of peripheral blood smear.\textsuperscript{15}

\( ^\ddagger \) According to World Health Organization and Centers for Disease Control and Prevention norms for age, sex, and pregnancy status.\textsuperscript{1,13}

\( ^\Dagger \) Axillary temperature

\( ^\ddagger \) Spleen size Hackett class

\( ^\dagger \) Fever

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**TABLE 2**

Age-specific malarialometric indices among Yanomami residents of Mavaca, Upper Orinoco Basin, Amazonas State, Venezuela, October 1992

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>n</th>
<th>( P. falciparum \textsuperscript{*} )</th>
<th>( P. vivax \textsuperscript{*} )</th>
<th>Splenomegaly\textsuperscript{+}</th>
<th>Fever\textsuperscript{+}</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5–4.9</td>
<td>35</td>
<td>6 (17.1) ( [6.6–33.8] )</td>
<td>5 (14.3) ( [4.8–30.3] )</td>
<td>33 (94.3) ( [80.8–99.3] )</td>
<td>12 (34.3) ( [19.1–52.2] )</td>
</tr>
<tr>
<td>5–9.9</td>
<td>12</td>
<td>§</td>
<td>§</td>
<td>8 (66.7) ( [34.9–90.1] )</td>
<td>3 (25) ( [5.5–57.2] )</td>
</tr>
<tr>
<td>≥15</td>
<td>56</td>
<td>2 (3.6) ( [0.4–12.3] )</td>
<td>1 (1.8) ( [0.05–9.6] )</td>
<td>38 (67.8) ( [54.0–79.7] )</td>
<td>5 (8.9) ( [3.0–19.6] )</td>
</tr>
<tr>
<td>All</td>
<td>103</td>
<td>8 (7.7) ( [3.4–14.7] )</td>
<td>6 (5.8) ( [2.2–12.2] )</td>
<td>79 (76.7) ( [67.3–84.5] )</td>
<td>20 (19.4) ( [12.3–28.4] )</td>
</tr>
</tbody>
</table>

\( ^* \) Values are the number (%) [95% confidence interval] within each age group.\textsuperscript{3,4}

\( ^+ \) Spleen size Hackett class ≥2.\textsuperscript{2,11}

\( ^\ddagger \) Axillary temperature ≥37.5°C, non-corrected.

\( ^\dagger \) No malaria parasitemia found within this age group.

\( ^\Dagger \) Fever
TABLE 3

Hematocrit values* (%) among Yanomami Amerindians of different malaria parasitemia and fever status in Mavaca, Upper Orinoco Basin, Amazonas State, Venezuela, October 1992

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Fever absent and Malaria parasitemia</th>
<th>Fever present and Malaria parasitemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>None</td>
<td>Any</td>
</tr>
<tr>
<td>&lt;10</td>
<td>35</td>
<td>31.1 ± 2.8</td>
</tr>
<tr>
<td>≥15</td>
<td>56</td>
<td>28.9 ± 5.8</td>
</tr>
</tbody>
</table>

* Values are the mean ± SD.
† No subjects with this parasitologic and clinical status.

of malaria parasitemia for *P. falciparum* (*P = 0.059*) and *P. vivax* (*P = 0.039*), as shown in Table 2. The overall malaria slide positivity rate was 13.6% (95% confidence interval [CI] = 5.6–26.9). *Plasmodium falciparum* was the predominant species (57.1%), followed by *P. vivax* (42.9%). Geometric mean parasite densities were comparable for *P. falciparum* (760/mm³) and *P. vivax* (663/mm³) infections. Table 3 shows that mean hematocrit values were found to be lower in malaria parasitemia and fever cases than in healthy subjects, although this difference was not significant. Anemia was present in 92.8% (13 of 14) of the malaria patients.

Fever is a common complaint among the Yanomami, and children (< 10 years old) showed the highest proportion at the time of the survey (*P = 0.008*). One-fourth of all febrile individuals were parasitic. The remainder had other acute febrile illnesses such as gastroenteritis and lower respiratory infections. High fever (≥ 38.5°C, axillary) was present in three individuals, including two young children with high-density malaria parasitemias (> 2,000/mm³). Overall, only two individuals (1.9%) lacked all indices of infection and disease studied: anemia, fever, splenomegaly, and malaria parasitemia.

**DISCUSSION**

Very few studies on health indices among Yanomami Amerindian populations have been carried out in the Amazon. This is the first community-based morbidity survey of its kind reported on Venezuelan Yanomami Amerindians.

Regional surveys have shown an overall prevalence of anemia as high as 29.7%, with highest proportions found among infants (70%). In contrast, the study population showed a higher overall prevalence of anemia, with adult groups being mostly affected. This represents a particularly severe public health problem.

Sufficient evidence suggests that iron deficiency is the most common cause of nutritional anemia in the world. The high prevalence of hypochromic microcytes found in the study population could suggest a diagnosis of iron deficiency. Other hypochromic microcytic anemias, in particular thalassemias, have not been found in these and other Amazonian Indians. More reliable criteria for diagnosing iron deficiency are needed, such as measurement of serum ferritin and hemoglobin response to iron therapy. The contribution of soil-transmitted helminths in the etiology of anemia in a population such as the one studied should not be discounted, particularly in the face of sustained settlement, and warrants assessment.

 Culturally, all villages in Mavaca are semi-nomadic; however, since being contacted by the mission post for the past four decades, the settlement pattern has become relatively stable. This has led to progressively increased dependency. Richer and more varied indigenous produce has been supplanted by an impoverished and insufficient diet. The impact on nutritional status of these dietary changes needs to be studied.

In 1992, the incidence of malaria in Venezuela was 21,416 cases, with a 6.4% slide-positivity rate. The breakdown of parasitemia forms observed that year was 76% *P. vivax* and 24% *P. falciparum*, which represented an increase in the proportion of *P. falciparum* infections from previous years. In contrast, the study population showed a predominance of *P. falciparum* infections (57.1%), and twice the proportion of slide-confirmed malaria. This is a challenging finding in the face of existing chloroquine-resistant strains of *P. falciparum* in the region and the increased risk of severe malaria and mortality. No strong association was found between malaria (detectable parasitemia at presentation) and anemia in the study population. This could be explained by the small study sample, a relatively low transmission season at the time of the survey, and the fact that almost the entire study population was anemic. Malaria produces anemia by several complex mechanisms: rupture of parasitized erythrocytes, autoimmun e lysis of both parasitized and normal erythrocytes, reticuloendothelial hyperfunction, and dyserythropoiesis. A simple malaria case management protocol in the area could reduce morbidity at an earlier stage as measured by the hemoglobin response to prompt and effective malaria treatment.

The presence of high fever served as a good general indicator of clinical malaria, especially among young children. Relatively low parasite densities were found in most malaria episodes detected, as it would be expected in a community survey. Cases may be surveyed at any stage of the illness and it is therefore unlikely that the parasite density will be at a peak at the time of examination.

Due to the development of malaria immunity acquired early in life, it would be expected that relatively few adults would have splenomegaly in this area. In contrast, high spleen rates were also found among adults. Schistosomiasis, visceral leishmaniasis, brucellosis, and sickle cell disease are not known in the area. Other causes of splenomegaly, such as chronic liver disease with cirrhosis, tuberculosis, systemic mycosis, and chronic infiltrative diseases, need to be excluded in this population. The high proportions of anemia and splenomegaly observed in the survey may be used as indicators of inadequately controlled malaria in this community. The fact that less than 2% of the study population lacked all indices of infection and disease studied strongly suggests a collapse of health in this remote population.

Only continued medical surveillance, and timely institution of other public health measures will permit the survival of this unique Amerindian population as the Yanomami adopt a more sedentary lifestyle and undergo rapid cultural transition. It is hoped that this study will stimulate others to assess the epidemiology of risk factors for the high prevalence of anemia and predominance of *P. falciparum* infections in the area so that control measures that are sustainable, adequate, and applicable to the region can be developed.
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