

## Original Article

## A clinico-epidemiological study of falciparum malaria in a cluster of villages in the eastern bank of the River Nile in Northern Sudan

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### Abstract

*A cross sectional descriptive study was conducted during the period from September 1997 to February 1998 in Tragma area; a part of an irrigation scheme located on the Eastern bank of the River Nile, 200 km North of Khartoum, in order to determine point prevalence and clinical characteristics of malaria in the area. The study consisted of two household surveys followed by a hospital-based study. Prevalence of malaria was 0.09% (1/1053) during September and 16.7% (119/711) during December survey. Plasmodium falciparum was detected in 120 (9.2%) of 1300 patients who reported to hospital during the study period. Both infection rate and mean parasite count/ $\mu$ l of Plasmodium falciparum decreased significantly with age ( $P < 0.05$ ).*

*Fever and low haemoglobin were found to be associated with Plasmodium falciparum infection ( $P < 0.05$ ). No associations were observed between Plasmodium falciparum and digestive system symptoms or leucocyte count.*

**Keywords:** Plasmodium falciparum, irrigation scheme, transmission, Sudan.

### Introduction

Malaria is one of the major contributors to morbidity and mortality in the world, particularly, in sub-Saharan Africa <sup>(1)</sup>. It is an acute febrile illness whose severity and course of infection depends on the species and strain of infecting parasite; on the age, genetic constitution, and state of immunity <sup>(2)</sup>.

The epidemiology of malaria is governed by the characteristics of transmission, which can be described in terms of intensity, stability, and seasonal variation. In areas of stable transmission, the pattern of transmission remains roughly unchanged from year to year, whereas areas with unstable malaria are characterised by considerable variation in the intensity of transmission between years <sup>(3)</sup>. All age groups are vulnerable to malaria in areas of unstable malaria transmission and it is

generally believed that under such conditions new infection tends to be followed by clinical disease <sup>(4)</sup>.

The severity of a clinical attack of malaria can vary from an illness characterized by only a few hours of fever to one that kills within 24 hours of the first appearance of symptoms <sup>(5)</sup>. Falciparum malaria is known for its severity and complications that are extremely serious <sup>(6-8)</sup>.

In Sudan, malaria ranges from hypo-endemic in the north to holoendemic in the South. Annual number of malaria cases is around 7 millions with 30000 malaria deaths. Moreover, malaria accounts for 25.7% of the total hospital admissions and 15.9% of the total deaths <sup>(9)</sup>.

Incidence, clinical characteristics and mortality due to malaria have not been previously described in a systematic way in the northern Sudan. So, the aim of the present study is to determine the burden of

malaria in the area and to describe disease-related characteristics in the study area.

## Methods

*Study Area:* This study took place during September 1997 to February 1998 in El Tragma area, River Nile State, Sudan. El Tragma area is located on the east bank of the River Nile, 200 km north of Khartoum. It consists of a number of small villages and is a part of Kaboshiya Agricultural Scheme, which was established in the year 1978. The total area is 1500 feddan (acres) divided into 300 farms. The population of the area is about 4000, the majority of whom are farmers. Irrigation depends mainly on a pump system and the climate of the area is semi-desert. There is a short discontinuous rainy season from July to September with an average rainfall of 136 mm and temperature varies from 25°C to 43°C.

The area is characterized by seasonal malaria transmission (November-January), which coincides with the irrigation of the wheat which is considered as the main cash crop in the area.

The study consisted of two parts: household surveys during September and December 1997, followed by a hospital-based study during February 1998.

Prior to this study meetings were held with the village leaders and the purpose of the study was explained and their consent was obtained.

*Household survey:* A stratified, systematic, random sampling was used for selection of houses. A total of 1053 individuals were included during September 1997 and 711 individuals during December 1997.

After obtaining informed consent, from each household member, data were collected using a questionnaire then thick and thin blood smears were prepared. Later on, blood smears were stained with 10% Giemsa stain and examined microscopically.

*Hospital-based study:* This was conducted in El Sadier hospital. After obtaining informed consent of the patient or caregiver; patients who presented with symptoms commonly attributed to malaria were selected. They were interviewed and clinically examined by a clinician. Further, from each patient thick and thin blood smears were prepared and stained with 10% Giemsa stain.

The total white blood cells for each patient was counted separately using a Neubauer counting chamber and haemoglobin was measured using Sahli's acid haematin method.

Microscopic examination of blood smears was carried out for the presence of malaria parasites and number of parasites was counted against 200 white blood cells. Parasite count per  $\mu\text{l}$  was calculated using measured total white blood cell count applying the following formula

$$\text{Number of parasites counted} \times \text{TWBCc}/200 = \text{parasites per } \mu\text{l}$$

Individuals/patients with microscopically confirmed malaria were treated with Chloroquine in standard dose (25mg/kg body weight).

Simultaneously, 128 patients presenting with symptoms commonly attributed to malaria but with negative blood films for malaria were included as a control group.

*Data analysis:* Data were analysed using the Statistical Package for Social Science (SPSS) version 10 for windows. Chi-square test was used for comparison of proportions. Mean parasite counts were compared using Mann-Whitney test and mean or Kruskal-Wallis. The difference was considered significant when P-value was < 0.05.

This study was approved by the Ethical Review Committee (Federal Ministry of Health, Sudan).

## Results

*Household surveys:* Prevalence of *Plasmodium falciparum* varied greatly between the two cross-sectional surveys carried out in the study area. Of

1053 individuals examined during September 1997 *Plasmodium falciparum* was detected in only 1 individual (0.09%) of the study subjects examined. Whereas, during December 1997, out of 711 blood smears examined *Plasmodium falciparum* was identified in 119 (16.7%).

*Hospital based study:* Out of 1300 patients reported to the hospital with complains of fever or other malaria symptoms, malaria parasites were detected

in 120 individuals (9.2%). Of these 103 were included as study group after informed consent.

The infection rate was 52% in males compared to 38.8% in females, whereas density of infection expressed as mean parasite count/ $\mu$ l was comparable between males and females (Table 1). Both infection rate and mean parasite count/ $\mu$ l of *Plasmodium falciparum* decreased significantly with age (Table 1).

**Table1: Number included, number and percentage infected with *Plasmodium falciparum* and parasite density/ $\mu$ l according to sex and age group**

Characteristics	Number included (n=231)	Number (%) infected	Mean parasite count/ $\mu$ l ( $\pm$ SD)
<b>Sex</b>			
Males	102	53 (52.0)	15226 (31053)
Females	129	50 (38.8)	10826 (22286)
P-value		< 0.05*	0.81**
<b>Age group</b>			
0-5	30	24 (80.0)	27869 (41853)
$\geq$ 5	201	79 (39.3)	8600 (18898)
P- value		< 0.001*	< 0.05**

\* Chi-square test

\*\* Mann-Whitney Test

*Association between Plasmodium falciparum infection and symptoms:* Headache, joint pain and rigors showed positive association with *Plasmodium falciparum*. No associations were observed between *Plasmodium falciparum* and anorexia, nausea, vomiting and diarrhea (data not shown).

Both history of fever and mean body temperature in the control group was significantly lower than among falciparum malaria patients ( $P < 0.001$ ), and they tended to increase significantly with increase in parasite density (table 2).

The mean haemoglobin concentration in the control group was statistically significantly increased

compare to falciparum malaria patients ( $P < 0.01$ ). Furthermore, there was a tendency of decrease in haemoglobin concentration with the increase of parasitaemia although; this was not statistically significant (table 2).

Regarding total white blood cells count; the mean leucocyte count of 5098 in the control group was comparable with 5259 in falciparum malaria patients. Although, there was increase in the mean leucocyte count with increase in density of *Plasmodium falciparum* infection, but it remained comparable and within normal limits. (Table 2).

**Table 2. Clinical characteristics according to Plasmodium falciparum infection and parasite count categories.**

Characteristics	<i>Plasmodium falciparum</i>		P-value	Parasite count categories			P-value
	Control (n=128)	Patients (n=103)		< 1000	1000-4999	$\geq$ 5000	
History of fever (CI)	73.4%	94.2%	0.001*	87.2%	96.4%	100%	0.001*
Mean body temperature ( $\pm$ SD)	37.6 (0.8)	38.1 (1.1)	0.001**	37.6 (0.7)	38.1 (1.2)	38.7 (1.1)	0.001***
Mean haemoglobin concentration ( $\pm$ SD)	11.7 (1.8)	11.0 (1.9)	0.01**	11.3 (1.9)	11.1 (2.2)	10.6 (1.7)	0.30***
Mean leucocyte count ( $\pm$ SD)	5098 (2150)	5259 (2299)	0.48**	4647 (1419)	5406 (1931)	5782 (3063)	0.22***

\* Chi-square Test

\*\* Mann-Whitney Test

\*\*\* Kruskal-Wallis

**Discussion:**

Irrigation schemes for economic development have always been associated with the spread of water-related diseases, as there was always a lack of planned intervention for reducing this impact.

Point prevalence of malaria in the present study was low (0.09%) during the rainy season then it increased to reach 16.7% in December. The increase in malaria transmission during the dry season (winter) coincided with intensive irrigation of the winter crop (Wheat) which is considered as the main cash crop in the area. During this period the temperature remains within the optimum range that provides suitable breeding environment for *Anopheles arabiensis*, the main malaria vector in the area<sup>(10)</sup> and for sporogonic cycle of malaria parasites inside the vector.

The effect of gender on malaria susceptibility varied from area to area and from season to season<sup>(11)</sup>. In this context, statistically significant difference in infection rate between males and females was observed. Females had lower infection rate than that of males. This is likely to be due to the fact that women in this area as part of their traditional and social practice apply local cosmetic ointments on their skins and they have a tendency to expose their bodies to smoke for cosmetic purposes and cover their bodies before sleeping. These factors might act as repellents and consequently reduce their contact with mosquitoes. The development of clinical malaria in endemic areas is governed by the transmission pattern. Adults in stable transmission areas acquire specific immunity to malaria, and the disease affects mainly children, in contrast to areas where malaria endemicity is seasonal and unstable, where the disease affects all age groups<sup>(4)</sup>.

Although, the transmission in the study area is seasonal and less intense, yet, both infection rate and density of infection decrease significantly with

increasing age. Biard et al in 1993 described age-dependent immunity to malaria in non immune transmigrates after 2 years of their settlement in a highly endemic malaria area in Iran<sup>(12)</sup>. This type of immunity might be attributed to recent heavy exposure and/or physiological effect of age rather than being the cumulative product of many exposures to parasites<sup>(12)</sup>.

In this study, both history of fever and mean body temperature were significantly higher ( $P < 0.01$ ) in individuals infected with *Plasmodium falciparum* compared with uninfected group of the study population. Furthermore, comparison of history of fever, body temperature with stratified parasitaemia revealed a significant increase with increase in parasitaemia (i.e. density of malaria parasites is responsible for fever). This signifies that fever is a core symptom of malaria. Fever as predominating symptom of malaria has been shown in previous studies<sup>(13,14)</sup>.

The study showed a significantly lower mean haemoglobin concentration in malaria patients. This is an expected result due to the destruction of infected and uninfected red blood cells by the parasites as well as the immune system<sup>(15)</sup>; the trends for the decrease of haemoglobin concentration with the increase in density of infection have been reported by Kitua et al. in a previous study<sup>(16)</sup>. Moreover, Warrell and Gilles found that the severity of anaemia correlates with parasitaemia<sup>(2)</sup>.

The mean leucocyte count in individually infected with *Plasmodium falciparum* was comparable with uninfected individuals. In 1987 Jandl claimed that during infection by any of the malarial species, the leucocyte count is usually normal or slightly higher<sup>(17)</sup>.

Regression analysis showed (data not shown) that decrease in haemoglobin concentration was age dependent and not density dependent. This is

partially supported by the findings of Premjiz et al. in 1995, who found that fever and parasitaemia were effective in predicting anaemia and that the anaemia was age dependent<sup>(18)</sup>.

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