Epidemiology, Prevalence, Clinical Manifestations, and Severity of Plasmodium vivax Among Adults at Merowe City, November 2021 to September 2022

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ABSTRACT

BACKGROUND Plasmodium vivax is the most frequent cause of recurring malaria. It is less virulent than Plasmodium falciparum, but it can also lead to severe disease and death. Classic clinical signs and symptoms of malaria include fever, headache, nausea, vomiting, body aches, anemia, and jaundice. The present study investigated the epidemiology, prevalence, manifestations, and severity of Plasmodium vivax among adults at two sites in Merowe City, Sudan, between November 2021 and September 2022.

METHODS A retrospective cross-sectional study was conducted at two sites (Al-Gawda Medical Clinic and Al-Ehsan Medical Clinic) in Merowe City, Northern State, Sudan. Malaria records from November 2021 to September 2022 were reviewed. Complete blood count, blood film for malaria, and immunochromatographic testing for detection of Plasmodium falciparum and Plasmodium vivax were collected for all infected participants' records. Collected data were analyzed using SPSS 16.0.

RESULTS There were 149 recorded malaria cases during the study period, of which 49 were Plasmodium vivax infected. Of these 49 patients, 43% were female and 57% were male, and 36.7% were in the 31–40-year age group. The most common single presentation was fever (18%), followed by headache (10%), while the most common combined symptoms were fever and headache (16%). In this study, Plasmodium vivax was associated with several findings considered in the manuscript as features of severe malaria, including hypoglycemia, cerebral manifestations, hypotension, and hyperparasitaemia.

CONCLUSIONS Plasmodium vivax accounted for 32.9% of malaria cases recorded at Al-Ehsan and Al-Gawda Medical Clinics during the study period. It presented with clinical features including fever and headache, and the study recorded hypoglycemia, cerebral manifestations, hypotension, and hyperparasitaemia. Further investigation with a larger sample size is needed to better understand the occurrence and spread of Plasmodium vivax in Merowe City, the locality, and Northern State.

Keywords: Malaria, Plasmodium vivax, Merowe, Northern Sudan.

I. INTRODUCTION

Malaria is a significant health problem worldwide. In 2019, there were approximately 229 million cases of malaria, responsible for about 409,000 deaths, most of them in Africa [1].

Malaria is a common disease in Sudan. The annual reported number of cases in 2019 was 3,568,941, with 1,663 deaths [2]. In 2020, Sudan carried the heaviest malaria burden in the Eastern Mediterranean Region, accounting for 56% of cases and 61% of malaria deaths, followed by Somalia, Yemen, Pakistan, Afghanistan, and Djibouti [3].

Malaria is a parasitic disease spread through bites of female Anopheles mosquitoes. It is caused by Plasmodium species [4]. Five species of Plasmodium are known to cause disease in humans: P. falciparum, P. vivax, P. ovale, P. malariae, and P. knowlesi. The majority of cases are caused by Plasmodium falciparum and Plasmodium vivax [4].

Plasmodium falciparum is the deadliest species of Plasmodium that causes malaria in humans. It is also associated with the development of Burkitt's lymphoma and is classified as a carcinogen [5]. Plasmodium vivax is the most frequent cause of recurring malaria [6]. It is less virulent than Plasmodium falciparum, but it can lead to severe disease and death [6]. Classic clinical signs and symptoms of malaria include fever, headache, nausea, vomiting, body aches, anemia, and jaundice [4].

Plasmodium vivax is found mainly in Asia, Latin America, and some parts of Africa. P. vivax is believed to have originated in Asia, but studies have shown that wild chimpanzees and gorillas throughout central Africa are endemically infected with parasites closely related to human P. vivax. These findings indicate that human P. vivax is of African origin [7].

P. vivax invades erythrocytes; infected red blood cells appear larger than uninfected cells. Trophozoites may appear as thick, large, amoeboid rings, about one half the diameter of the red blood cell, and Schüffner's dots are present [4]. The typical incubation period for vivax malaria is 12 to 17 days, but relapses may occur up to 2 years later from dormant hypnozoites [4].

Sporozoites inoculated into the skin by female Anopheles mosquitoes reach the bloodstream and enter hepatocytes in the liver. Here, P. vivax can either differentiate into tissue schizonts that, after thousands of mitotic replications in individual hepatocytes, release merozoites into the bloodstream, or differentiate into a dormant stage called a hypnozoite that, upon activation after weeks, months, or years, causes clinical relapse. The merosome has so far only been described in malaria in rodents but is predicted to be present in late-stage liver infections with P. vivax. The merozoites of P. vivax mainly invade reticulocytes. Some P. vivax parasites can differentiate into mature gametocytes, which are infective to anopheline mosquitoes before a clinical infection and illness develops. On uptake in the blood meal of Anopheles mosquitoes, gametocytes begin the sexual cycle, which includes release of male and female gametes, fertilization, and formation of a motile ookinete that crosses the midgut epithelium of the mosquito. Differentiation into a new replicative form known as the oocyst, release of sporozoites, migration, and invasion of the salivary glands end this complex life cycle. In all, the parasite undergoes more than 10 stages of cellular differentiation and invades at least four types of cells within two different hosts [8].

The spectrum of disease associated with P. vivax infection ranges from asymptomatic parasitaemia and uncomplicated febrile illness to severe and fatal malaria [8]. In non-immune individuals, P. vivax malaria gives rise to a well-defined paroxysmal fever with a periodicity of 24 or 48 hours, usually preceded by chills with rigour. Other symptoms and signs include headache, anorexia, myalgia, abdominal pain, cough, diarrhoea, restlessness, delirium, and anaemia [8].

Clinical manifestations of severe P. vivax malaria include severe anaemia (<5 mg hemoglobin/dL), thrombocytopenia, acute pulmonary oedema and, less commonly, cerebral malaria, pancytopenia, jaundice, splenic rupture, haemoglobinuria, acute renal failure, and shock [8].

II. MATERIALS AND METHODS

Study Design, Area, and Period

This retrospective study was performed at two sites (Al-Gawda Medical Clinic and Al-Ehsan Medical Clinic) in Merowe City. The manuscript states that Merowe City is about 400 kilometers north of Khartoum, the capital city of Sudan. The study was carried out from November 2021 to September 2022. A total of 149 recorded malaria cases during the mentioned period were reported in the study.

Sample Size Determination and Sampling Technique

The sample size for this study was total coverage of all records of attending patients diagnosed with malaria. The study population was all adult patient records (above 18 years old) who had been confirmed to have malaria. Individuals with a travel history to Eastern Sudan were excluded from the study due to epidemics of dengue fever.

Data Collection and Analysis

Authorization for the use of medical records for research and publication purposes was obtained from the two clinics. Socio-demographic information, medical history, laboratory results (complete blood count, blood film for malaria, and immunochromatographic testing for detection of Plasmodium falciparum and Plasmodium vivax), and clinical findings were collected and analyzed using SPSS 16.0.

III. RESULTS

There were 149 malaria cases during the study period. Of these, 49 patients were infected with Plasmodium vivax. Thus, Plasmodium vivax accounted for 32.9% of the recorded malaria cases.

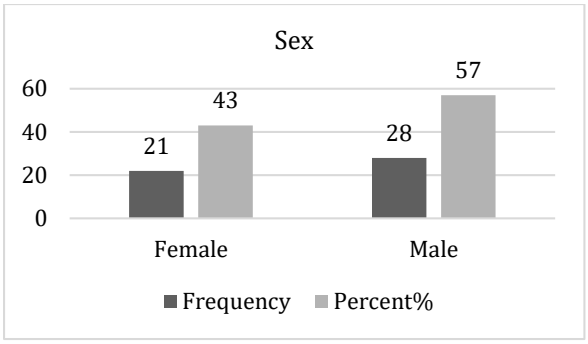

Figure 1: Gender distribution in Plasmodium vivax infected patients.

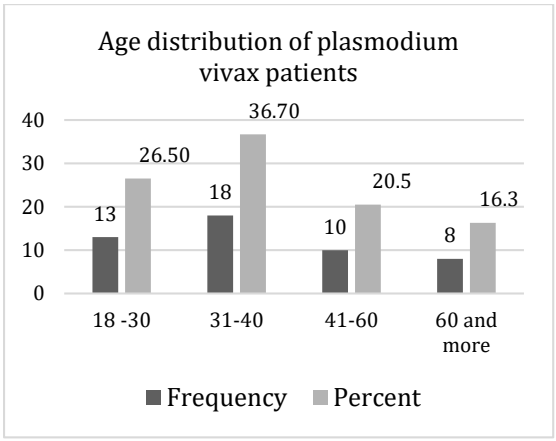

Figure 2: Age distribution of Plasmodium vivax patients.

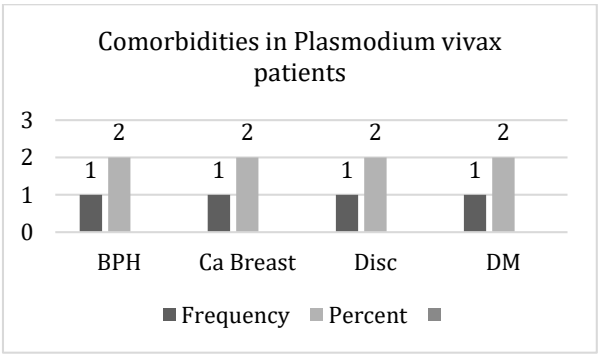

Figure 3: Comorbidities in Plasmodium vivax patients.

The study found that 36.7% of Plasmodium vivax infected patients were in the age group of 31 to 40 years.
The study showed that most patients had no comorbidities.

Table 1: Prevalence of Plasmodium vivax patients

Species	Frequency	Percentage
Plasmodium falciparum	100	67.1%
Plasmodium vivax	49	32.9%
Total	149	100%

The most common combined symptoms in Plasmodium vivax were fever and headache (16%), and the most common single presentation was fever (18%), followed by headache (10%). Seventeen patients did not mention fever as a presenting symptom.

Table 2: Manifestations of Plasmodium vivax

Manifestation	Frequency	Percent
Abdominal pain	1	2.0
Abdominal pain, Diarrhoea	1	2.0
Abdominal pain, Diarrhoea, Vomiting	1	2.0
Fever	9	18.0
Fever, Abdominal pain	1	2.0
Fever, Confusion	1	2.0
Fever, Confusion, Loss of appetite	1	2.0
Fever, Diarrhoea, Vomiting	1	2.0
Fever, Headache	8	16.0
Fever, Headache, Loss of appetite	3	6.0
Fever, Headache, Vomiting	2	4.0
Fever, Headache, Vomiting, Loss of appetite	1	2.0
Fever, Rigors	1	2.0
Fever, Rigors, Abdominal pain, Vomiting	1	2.0
Fever, Rigors, Headache	2	4.0
Fever, Vomiting, Loss of appetite	1	2.0
Headache	5	10.0
Headache, Diarrhoea	1	2.0
Headache, Loss of appetite	1	2.0
Loss of appetite	4	8.0
Rigors, Abdominal pain	1	2.0
Rigors, Vomiting	1	2.0
Vomiting	1	2.0
Total	49	100.0

Hypotension was documented in 4% of Plasmodium vivax patients. Six patients had blood pressure of 90–120/60–80 mmHg, two had blood pressure below 90/60 mmHg, and 41 had blood pressure above 120/80 mmHg.

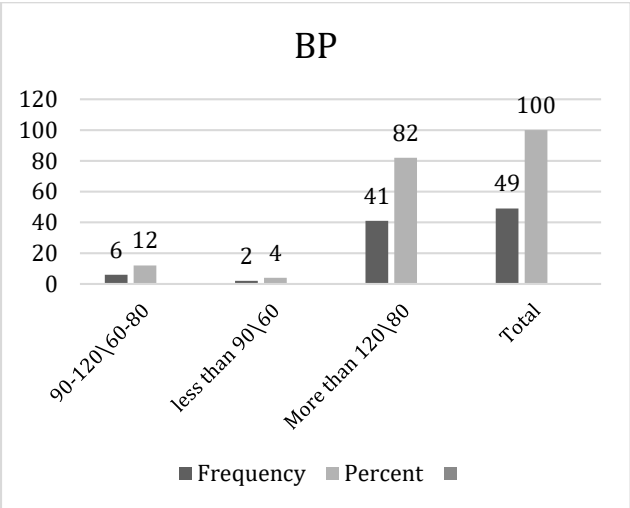

Figure 4: Blood pressure (BP) measurement in Plasmodium vivax.

Ninety-six percent of Plasmodium vivax patients had a normal Glasgow Coma Scale (GCS), while 4% were confused.

Table 3: Neck stiffness in Plasmodium vivax

Neck stiffness	Frequency	Percent
No	48	96.0
Yes	1	2.0
Total	49	100.0

The manuscript text reports neck stiffness in 4% of Plasmodium vivax patients; however, Table 3 records one patient (2.0%). The table value is retained here and the discrepancy is flagged for author verification.

The study found that about 85% of patients had low-density parasites, while hyperparasitaemia was found in 6% of Plasmodium vivax patients.

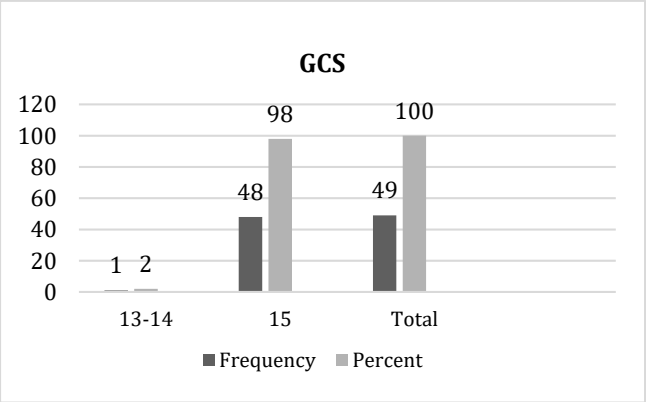

Figure 5: Parasitaemia in Plasmodium vivax.

Most Plasmodium vivax patients had a normal platelet count, while 10.2% had thrombocytopenia.

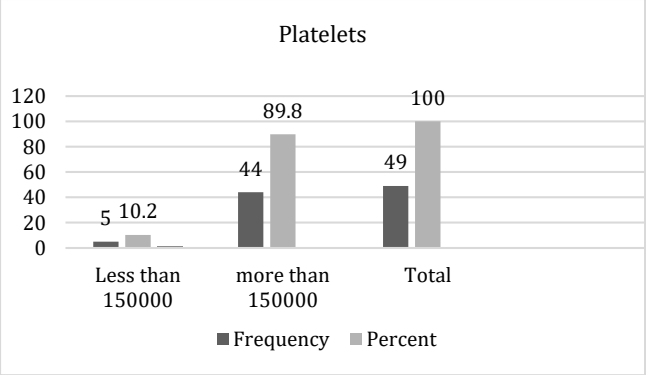

Figure 6: Platelet count in Plasmodium vivax.

Table 4: Blood glucose level in Plasmodium vivax

Blood glucose level	Frequency	Percent
Less than 70 mg/dL	1	2.0
More than 70 mg/dL	48	98.0
Total	49	100.0

IV. DISCUSSION

The present study shows that 32.9% of malaria cases were due to Plasmodium vivax, which is consistent with the finding of Makarim M. Adam Suliman et al. [9], who found Plasmodium vivax in about 36% of malaria cases in the central area of Sudan, but higher than the 20% reported by the same study in Aljabaleen in White Nile.

This study revealed that 57% of Plasmodium vivax infected patients were male and 43% were female, and most patients (36.7%) were aged 31 to 40 years. In addition, 80% of patients had no comorbidity.

The proportion of Plasmodium vivax in this study was also higher than that documented by Samwal Haj Osman Osman et al. [10], who reported Plasmodium vivax in about 2% of malaria cases in the Elhajyosife area of Khartoum State, but lower than the proportions reported by K. Saravu et al. [11], in which 46% of malaria patients were due to Plasmodium vivax, and Narendra Kumar Gupta et al. [12], in which 56% of malaria cases were due to Plasmodium vivax.

In this study, Plasmodium vivax had various manifestations. The most common combined symptoms were fever and headache (16%), and the most common single presentation was fever (18%), followed by headache (10%). Seventeen patients did not mention fever as a presenting symptom.

In this study, the manuscript identified several findings as features of severe malaria: neck stiffness and confusion as cerebral manifestations were reported in 4% in the text, hypoglycemia in 2%, thrombocytopenia in 10%, hypotension in 4%, and hyperparasitaemia in 6%. The neck-stiffness table records 1 patient (2.0%), while the text reports 4%; this discrepancy should be resolved before submission.

The findings are discussed in relation to Maowia M. Mukhtar et al. [13], who reported a case of cerebral malaria and hyperparasitaemia due to Plasmodium vivax in Al Kuwaiti Hospital in Khartoum. They are also discussed in relation to Catalina Tovar-Acero et al. [14], who reported that thrombocytopenia, hypoglycemia, and liver and kidney problems were common P. vivax malaria complications, and to Bilal Ahmad Rahimi et al. [15], who reported a systematic review of 77 studies of severe Plasmodium vivax.

The manifestations of severe malaria in this study had lower incidence than that reported by Tajeldin M. Abdallah et al. [16], who found severe Plasmodium vivax in about 26% of 139 malaria patients admitted to Kassala Hospital, eastern Sudan.

V. LIMITATIONS AND RECOMMENDATIONS

The study limitation was the small sample size. We recommend performing a study with a larger population and involving more centres for data collection. We recommend a larger sample and the inclusion of sepsis parameters.

VI. CONCLUSION

Plasmodium vivax was identified among malaria cases in Merowe City during the study period and accounted for 32.9% of the recorded malaria cases at Al-Ehsan and Al-Gawda Medical Clinics. The study recorded clinical manifestations including fever and headache, as well as hypoglycemia, cerebral manifestations, hypotension, thrombocytopenia, and hyperparasitaemia. Further studies and surveillance are needed to investigate these findings in larger populations and additional centres.

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DECLARATIONS

Ethics approval and consent to participate

Permissions for access to data records, analysis, and publication were obtained from Al-Gawda and Al-Ehsan Medical Centres.

Consent for publication

Permissions for access to data records, analysis, and publication were obtained from Al-Gawda and Al-Ehsan Medical Centres.

Availability of data and materials

The data that support the findings of this study are available from Al-Gawda and Al-Ehsan Medical Centres, but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. Data are, however, available from the authors upon reasonable request and with the permission of Al-Gawda and Al-Ehsan Medical Centres.

Competing interests

The authors declare that they have no competing interests.

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This research was self-financed by the authors.

Authors' contributions

Alamin analyzed all patient data and partially contributed to the literature review. Makkawi performed data collection and interpretation, partially contributed to the literature review, and was a major contributor to the writing of the manuscript. All the authors have read and approved the final manuscript.

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