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Original Article

Prevalence of Malaria Among Children Attending AlFaw Teaching Hospital, El-Gedaref State, Sudan

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Abstract

Introduction: In Sudan, malaria is still a major cause of death and the primary cause of death for children. A strategy for reducing and eradicating malaria may be developed with the help of knowledge regarding the prevalence of the disease among children. The goal of this study was to examine the prevalence of malaria in children at the AlFaw Teaching Hospital, as well as the risk factors and contributing factors.

Methods: In this study, questionnaires were used to gather socioeconomic, demographic, and vector control data from the families of children aged 1 day to 17 years in order to detect *Plasmodium falciparum* and other spp. Age, gender, place of residence, usage of a vector control intervention, and mother's educational degree are all associated with malaria positivity.

Results: During June through July 2022, 400 children who visited AlFaw teaching hospital participated in a facility-based cross-sectional survey. *P. falciparum* species made up 279 of the *Plasmodium* species (70%), and other species consisted of 121 (30%). Children who regularly spend the night outside and those who live in homes with stagnant water in the complex had higher probabilities of contracting malaria than those who regularly sleep under long-lasting insecticide-treated nets. Malaria diagnoses were more common in children of mothers with no formal education than in children of mothers with secondary education.

Conclusion: Children who were patients at AlFaw teaching hospital had a significant malaria prevalence. In this study, a higher proportion of moderate parasitemia was also detected, and those with the highest prevalence of malaria were in the age group of 0–17 years. The main correlations with malaria were irregular usage of bed nets, night-out times, and parents not receiving malaria health education. To reduce the impact of malaria, the local government and other concerned organizations should put more emphasis on routine insecticide-treated net (ITN) use, infections linked to nighttime exposure to the outdoors, environmental management, and modification of attitudes toward malaria prevention and control through health education. Other actions that can be taken to decrease this impact include improving health management and planning, redistributing resources (including consultants) at the central and regional levels, and implementing appropriate training programs on the management of severe malaria at all levels.

Keywords: Malaria infection, Prevalence, Risk factors, Children, ITN

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Introduction

One of the most important public health issues is malaria, a parasitic disease that can be fatal and is brought on by members of the *Plasmodium* genus (1). In underdeveloped nations, malaria is the leading cause of death for children and pregnant mothers (2-4). Children are among the most at-risk group because they lack the necessary immune system to fight off malaria parasites. Around the world, malaria may be to blame for up to 10% of all child fatalities. Children with severe malaria frequently experience sequelae such as cerebral malaria, severe anemia, and respiratory distress (5). Infectious diseases continue to be the most serious danger to public health in sub-Saharan Africa (6). One of the most widespread illnesses, malaria disproportionately affects children and pregnant mothers. An estimated 409 000 people died from malaria in 2019. About 94% of infections and fatalities involved young children (274 000), and 94% of these incidents happened in Africa (7). Although there are several *Plasmodium* species, only a few of them are

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responsible for the majority of infections. The World Health Organization (WHO) estimates that in 2018, *Plasmodium falciparum* was responsible for 99.7%, 50%, 71%, and 65% of all malaria cases in the African region, the South-East Asian region, the Eastern Mediterranean, and the Western Pacific, respectively. Around 75% of malaria cases in the WHO region of the Americas are caused by *P. vivax* (8). *P. falciparum* and *P. vivax* are the two predominant malaria parasites and primarily attack young children (9,10). One of the most vulnerable age groups to malaria is children under five. The symptoms of severe malaria, such as severe anemia, hypoglycemia, and cerebral malaria, are more frequently observed in children than in adults (11). The vulnerability of children to diarrhea, respiratory infections, and other ailments rises when they experience recurrent malaria infections (12). As a result of the brain damage brought on by the infection, around 2% of children who recover from cerebral malaria acquire learning problems and impairments, including epilepsy and spasticity (13). Malaria generally has the potential to harm children severely in three different ways: First, since children typically lack acquired immunity, they are more likely to get cerebral malaria, a severe form of malaria that can result in an emergency death and is characterized by convulsions or coma; Second, through side effects, including anemia linked to recurrent infections; Third, malaria raises the chance of death in the first month of life when it occurs during pregnancy and results in low birth weight (9). Prior studies were solely concerned with the adult population and were conducted in places where malaria transmission is endemic, despite the fact that malaria is one of the primary causes of morbidity and mortality for children. Even though it could pose a hazard in areas where it is not endemic (10), information on the epidemiology of malaria among children who reside in areas with low malaria transmission is scarce (14). By analyzing the prevalence and determinants of malaria in children who reside in areas with low malaria transmission, the results of this study will guide clinical and public health decisions and spark additional research. In Alfaw-Sudan, a number of intervention actions have been taken to prevent and reduce malaria infections, including the distribution of insecticide-treated nets (ITNs), indoor residual spraying (IRS), artemisinin-based combination therapy, and health information dissemination. Despite these initiatives, malaria continues to pose a severe public health risk in places where it is endemic (15). By 2030, Sudan hopes to eradicate malaria (16) through the implementation of a program. The prevalence and causes of malaria among at-risk groups should be examined throughout time and in various locations in order to standardize the success of the program. Children are the most susceptible populations because they lack adequate immune systems to fight off malaria parasites. They experience severe clinical symptoms when infected with *P. falciparum*. Up to 10% of all child fatalities could be attributed to it (17). Anemia, cerebral malaria, coma, respiratory distress, and a reduction in cognitive and behavioral progress are complications that can affect children with malaria infection (18). Despite the potentially fatal side effects of malaria on children, there is little information concerning this issue in Sudan. Accordingly, this study aimed to investigate the incidence of malaria in children, along with its risk factors and contributing factors, in the AlFaw teaching hospital.

Materials and Methods

Study Design

This retrospective and cross-sectional study included children aged 1 day to 17 years old who were admitted to AlFaw teaching hospital between June and July 2022. This hospital is located in the city of Alfaw. Children from all across the city are admitted to the hospital. General outpatient and inpatient medical treatments, an extended vaccination program, and management of children with severe acute malnutrition with medical complications are only a few of the services provided.

Study Area

Alfaw, a city in the Sudanese state of Gedaref, is situated at an elevation of 439 m (1443 feet) above sea level. It is 62 km (39 miles) from Gedaref, the state capital, and 251 km (165 miles) from Khartoum, the country's capital. Rashad's agricultural initiative is progressing.

Sample Size

Totally, 400 samples were gathered for the of the purpose study.

Study Participants

The source population consisted of all children between the ages of 1 day and 17 years who visited the AlFaw teaching hospital during the study period.

Inclusion Criteria

Children aged 1 day to 17 years (information was retrieved from the age variable in the MIS dataset), children who had their malaria levels checked, and children who had their anemia levels checked in the field were the only ones who were qualified for inclusion in this study.

Exclusion Criteria

Small communication reports, reviews, posters, and studies that exclusively employed clinical signs and symptoms to report malaria prevalence were disqualified, as were studies that used rapid *diagnostic tests* as a laboratory test. Children who tested negative for malaria and those whose anemia was not assessed were excluded from the study.

Data Collection

An English-language standard questionnaire was created to gather information on socio-demographics, malarial signs and symptoms, and associated risk factors. When interviewing their parents or careers, trained data collectors utilized standardized and tested questionnaires to collect sociodemographic and environmental data.

Laboratory Data Collection

Blood Sample Collection, Processing, and Examination

Capillary blood was extracted aseptically from the kids' fingertips in a laboratory at AlFaw teaching hospital using a blood lancet. The blood films of various thicknesses were produced and dried by air. The thin blood film was then fixed with 100% methanol and let to dry by air. Giemsa stain 10% was applied for 10 minutes, staining both thin and thick blood films. The slides were air-dried after being washed with distilled water. Finally, the dyed slides were evaluated by laboratory technologists at the medical facilities. Thin smears were utilized to identify the species of the parasite using an oil immersion objective, while thick smears were used to detect *Plasmodium* infections. A tally counter was employed to manually count the asexual forms of the parasites, such as trophozoites and schizonts, until 200 white blood cells (WBCs) were present in a thick smear. The formula below was applied to get the parasite count per microliter of blood, assuming that the patient's total leukocyte count was 8000/L. The parasite count multiplied by 8000 WBC per liter of blood is the parasite burden. Then, the parasitemia (5000 parasites per microliter of blood) was categorized as low (19).

Data Quality Assurance

The investigators gave two days of training to the data gatherers. The slides of known positive and negative malaria were utilized to evaluate the Giemsa stain. A slide was deemed to be negative during the microscopic examination after 200 fields at each site had been checked by two laboratory technicians for the presence of the *Plasmodium* parasite. The microscopic analysis was conducted using a color atlas. All positive slides and 10% of the negative slides were re-examined by a third reader to eliminate any discrepant findings in order to ensure the accuracy of the microscopic exams.

Data Processing and Analysis

After data collection, the information was input and examined with SPSS, version 22. Descriptive statistics were used to determine the prevalence rate and contributing factors.

Results

The results of this study about the prevalence of malaria among children attending AlFaw Teaching Hospital, El-Gedaref State, Sudan, are provided in Tables 1–5.

Discussion

To better understand the many socio-demographic factors linked to poor child health in AlFaw, this study assessed the prevalence of and risk factors related to malaria infection among children ages 1 day to 17 years. Due to the interaction between the anthropogenic environment (people density, movement patterns, and human settlements) and climate variability (rainfall, temperature, and humidity), malaria endemicity in Sudan demonstrates seasonal, inter-annual, and regional variety. The main malaria transmission peak for *P. falciparum* occurs in July and early November, just after the rainy season, and a second, less severe peak occurs in December to early February. Contrarily, *P. vivax* transmission peaks primarily between March and May, following the *P. falciparum* winter peak. During the rainy season, *P. vivax* transmission experiences a second intense peak that lasts less time than the comparable peak in *P. falciparum*. There are six distinct malaria epidemiological strata in Sudan, according to the Ministry of Health. These include malaria in seasonal, riverine, irrigated, urban, emergency, and conflict zones (20). In the city of Alfaw, *P. falciparum* transmission is persistently high year-round. This city is located in a Sudanese agricultural area with extensive irrigation infrastructure that offers favorable Anopheles breeding grounds. Out of 400 children assessed, 220 (55%) were males and 180 (45%) were females, according to the infection prevalence among males and females. It seemed that male children had a higher prevalence of malaria. This supports Mbanugo and Ejim's (21) conclusion that

Table 1. Demographic Data of Children Aged 1 Day to 17 Years, AlFaw 2022

Variable	Characteristics	Frequency	Percent
Gender	Male	220	55
	Female	180	45
	Total	400	100
Age	1 day - 30 days	18	4.5
	1 month - 11 month	95	23.7
	1 year - 12 years	238	59.5
	13 years - 17 years	49	12.3
	Total	400	100
Residence	Rural	88	22
	Urban	312	78
	Total	400	100
Mother education level	Primary	103	25.7
	Secondary	20	5
	Non-educated	277	69.3
	Total	400	100

Table 2. Clinical Features of Malaria in Hospitalized Children, AlFaw 2022

Clinical Manifestations	Yes No. (%)	No No. (%)
Fever	395 (98.8)	5 (1.2)
Headache	287 (71.7)	113 (28.3)
Chills	371 (92.7)	29 (7.3)
Fatigue	390 (97.5)	10 (2.5)
Worry	396 (99)	4 (1)
Vomiting	292 (73)	108 (27)
Diarrhea	371 (93)	29 (7)
Joint pain	318 (79.5)	82 (20.5)
Abdominal pain	243 (61)	157 (39)
Convulsion	246 (61.5)	154 (38.5)
Loss of conscious	272 (68)	128 (32)
Loss of appetite	248 (62)	152 (38)
Nausea	303 (75.7)	97 (24.3)
Anemia	74 (18.5)	326 (81.5)

Table 3. IRS, LLIN, and Environmental Characteristics of Study Participants, Alfaw, 2022

Variables	Yes No. (%)	No No. (%)
Uses of insecticide	361 (90.3)	39 (9.7)
Sleeping under nets	209 (52.3)	191 (47.7)
Uses of fans	198 (49.5)	202 (50.5)
Uses of replant	46 (11.5)	354 (88.5)
Close windows and doors	195 (48.7)	205 (51.3)
Smoldering	347 (86.7)	53 (13.3)
Trees	343 (85.7)	57 (14.3)
Water pool	201 (50.3)	199 (49.7)
Uses of mosquito creams	51 (13)	349 (87)
Uses of natural oil	253 (63.3)	147 (36.7)
Living near an agricultural scheme	294 (73.5)	106 (26.5)
Living near the water channel	291 (72.7)	109 (27.3)

Note. IRS: Indoor residual spraying; LLIN**:** Long-lasting insecticide-treated net.

Table 4. IRS, LLIN, and Environmental Characteristics of Study Participants, Alfaw, 2022

Type of *Plasmodium*	Frequency	Percent
Plasmodium falciparum	279	70
Other spp.	121	30
Total	400	100

Note. IRS: Indoor residual spraying; LLIN**:** Long-lasting insecticide-treated net.

Table 5. Frequency of Malaria During the Year, Type of Treatments, and Hyperparasitemia, Alfaw, 2022

Type	Variable	Frequency	Percent
Frequency of malaria during year	Once	131	32.8
	Twice	195	48.7
	Three times	68	17
	More three times	6	1.5
	Total	400	100
Treatment	Quinine	62	15.5
	Coartem	19	4.7
	Artesunate + Quinine	9	2.2
	Artesunate + Coartem	5	1.3
	Artesunate	212	53
	None	93	23.3
	Total	400	100
Hyperparasitemia	Yes	79	20
	No	321	80
	Total	400	100

sex has no bearing on the prevalence among youngsters. Children who are refugees or internally displaced people are particularly susceptible to malaria. Since the 1990s, malaria has been a significant issue in refugee camps. The likelihood of a malaria parasitemia test being positive was higher in the offspring of mothers with only an elementary education or no education at all. Lower levels of education have been linked to an increased incidence of malaria parasitemia in other investigations (22). Mothers with less education are potentially less knowledgeable about how to protect their children from malaria and are more likely to engage in activities that expose them to mosquito bites (23). Additionally, there is a higher likelihood of finding precarious homes in rural locations, making it easier for mosquitoes to enter (24). The discovery that having a low wealth index and living in rural areas increase the prevalence of malaria shows that malaria control interventions cannot be isolated and must involve raising the socioeconomic standing of the population, such as improving environmental sanitation to prevent mosquito breeding and improving living conditions to prevent biting (25). In this study, there were 74 cases of malaria-related anemia (18.5%). Studies in low-resource mining environments have been conducted in the Luangwa District in Zambia, the Bonikro mining region in central Cote d'Ivoire, and Okada in Nigeria (26-28). Recent research also suggests that bone marrow suppression and inefficient erythropoiesis are potential mechanisms for malarial anemia (29,30). Erythrocyte lysis, phagocytosis, and sequestration of parasitized red blood cells have also been proposed as potential reasons for malarial anemia. Older children had a higher chance of contracting malaria than newborns, according to studies conducted in Tanzania and Uganda (31,32). This might be explained by the fact that newborns receive their mothers' immunity from breastfeeding and other passive antibody transfers. Children are more susceptible to contracting malaria before they start to build up immunity after multiple infections since this immunity begins to decline with advancing age (33,34). However, the current study demonstrated no discernible difference

in the prevalence of malaria infections between children under the age of 11 months and those above the age of 12 months. This is in line with the results of earlier research, indicating that the prevalence of malaria rises with children's age (35,36). This could be because younger children in AlFaw are more likely to be appropriately covered by a blanket or mosquito net than older children and share a bed with their moms. Studies conducted in Uganda and other African nations have shown that children who sleep in the same bed as their mothers are more likely to use a mosquito net to protect themselves from insects (37,38). Another possibility is that most kids in AlFaw are weaned from breastfeeding at age 2, implying they get less attention from their parents and are more likely to be exposed to malaria vectors (39). A further finding of this study was that children of mothers with no formal education had a higher risk of contracting malaria than children whose mothers had a secondary education. This is in line with the findings of regional research in SSA, discovering that households with mothers who had completed the sixth grade or higher had a reduced risk of having a malarial infection than those with mothers who had less education (40). According to a study conducted in Alfaw, women with higher levels of education were more aware of the symptoms and prevention of malaria than mothers with lower levels of education, and as a result, they were more proactive and reactive in their prevention efforts (41). Malaria protection was supposed to come from sleeping under a long-lasting insecticide-treated net (LLIN). Other comparable investigations performed in East Shewa (42), Amhara, Oromia, SNNRP (43), Dilla (44), Ethiopia (45), Ghana (46), and Uganda (47) all support this evidence. It was clear that properly using ITN reduced mosquito bites, which in turn reduced malaria infection. Overall, 209 respondents (52.3%) used ITNs as a malaria prevention method, while 361 of them (90.3%) selected IRS. ITNs and IRS for malaria prevention were less commonly known than they were in research conducted in Damot Gale, Ethiopia (48). The WHO's malaria control and elimination strategies state that access to all interventions, such as improved case management, increased ITN use, IRS, early diagnosis and treatment, and environmental management, helps reduce malaria (49). Low and moderate parasite densities predominated in infected children, followed by high densities, which were responsible for 321 (80%) and 79 (20%) of malaria-positive children, respectively. This is in line with a prior investigation performed in South Gondar, Ethiopia (50). However, Sanja Town was found to have a large proportion of low parasite density, while East Central Tanzania had a high proportion of high parasite density (51,52). To find health promotion measures that can lower the risk of malaria in children, health practitioners should think about involving parents. Children's developmental phases, geographic location, and the hours of day and night that make them more vulnerable to malarial vectors should all be taken into account while designing interventions. Children can avoid mosquito bites both indoors and outdoors, for instance, by using insect repellents. More study is necessary before this intervention is implemented, as there is currently conflicting information about the efficiency of repellents in preventing malaria in developing countries (53-56). Our findings suggest that AlFaw has a high malaria incidence. Spatial and species-specific variation at sub-national and local scales typically reflects underlying topological, climatic, and socioeconomic issues, such as population displacement and migration. In low-endemic states such as those in the Northern Hemisphere and the Red Sea, where the elimination of malaria is possible shortly, we advise smart and targeted treatments. Other places could use our endemicity maps as a resource to direct intervention plans and spot gaps in malaria surveillance. We strongly advise the scaling up of all available interventions, particularly during and after the rainy season, in regions with hyperendemicity.

Conclusion

Children who were patients at AlFaw Teaching Hospital had a significant malaria prevalence. In this study, a higher proportion of moderate parasitemia was also detected, and those in the age range of 0–17 years demonstrated the highest prevalence of malaria. The main correlations with malaria were irregular usage of bed nets, night-out times, and parents not receiving malaria health education. To reduce the impact of malaria, the local government and other concerned organizations should put more emphasis on routine ITN use, environmental management, infections linked to nighttime exposure to the outdoors, and alterations of attitudes toward malaria prevention and control through health education. It can be argued that this impact can be reduced by enhancing health management and planning, redistributing resources (including consultants) at the regional and central levels, and performing appropriate training programs on the management of severe malaria at all levels.

Authors' Contribution

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Competing Interests

The author has affirmed that there are no conflicting interests.

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