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Analysis of the Factors Affecting the Spread of Malaria in White Nile State from a Medical Geography Perspective

Mohammed Amer Ahmed Mohammed[1] & Almahdi Musa Attahir Musa[2]

[1]Bakht Alruda University, Faculty of Education, Department of Geography
[2]Bakht Alruda University, Faculty of Economic and Administrative Science, Department of Econometrics & Social Science

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ABSTRACT

The study aimed to analyze the factors affecting the spread of malaria in the White Nile State from a medical geography perspective, focusing on the relationship between environmental and spatial characteristics and disease infection rates. The study problem was formulated in the following main question: What are the factors affecting the spread of malaria in the White Nile State from a medical geography perspective? The study used the descriptive-analytical method. The study concluded that the state's geographical location places it within the tropical zone where insect-borne diseases, primarily malaria, are prevalent, with an infection rate of approximately 85% of the total population in the areas covered by the study, Geographical and environmental factors such as surface characteristics, climate, population distribution, and poor waste management have a clear impact on increasing infection rates, as accumulated waste in the streets was found to represent about 45% of field observations, this provides a suitable environment for disease-carrying mosquitoes to breed. The study recommended the need to improve drainage networks, especially during the autumn season, and to work on removing ponds, swamps and stagnant water areas that form breeding grounds for mosquitoes, and to implement regular spraying campaigns with pesticides, whether by aircraft or manual spraying, these efforts are intensified during peak seasonal periods of malaria transmission to reduce infection rates and improve the overall health situation in the state.

1. Introduction

Malaria fever is one of the most dangerous epidemic diseases that threaten human health, especially in tropical and subtropical regions. Sudan occupies an advanced position among the countries suffering from the spread of this disease due to climatic, environmental and social factors that create suitable conditions for its spread (UNICEF, 2025). In White Nile State, one of the largest agricultural states in Sudan, diseases constitute a major health problem for the population. Despite the seriousness of these diseases, which claim many lives, there is negligence on the part of both the responsible health authorities and the citizens themselves in taking the necessary measures to combat them, In addition to the numerous agricultural projects in this state, such as the White Nile projects, the Kenana Sugar Project, and the Asalaya Project, these projects rely on irrigation using pumps and canals, which helps spread water over wide areas, leading to mosquito breeding. Consequently, the amount of household waste, refuse, and various types of garbage has increased. Therefore, this study came to clarify the role of medical geography, which represents an effective scientific tool for studying the spatial relationships between disease and environmental and human factors (WHO, 2024). The study attempts to analyze the factors affecting the spread of malaria in the White Nile State in order to treat it and reduce the incidence of the disease from a geographical, economic and medical perspective.

Study Problem

The problem addressed in this study is formulated in the following main question: What are the causes of the spread of malaria in White Nile State? The following sub-questions are then addressed:

- Do geographical and environmental factors play a role in the reproduction and proliferation of mosquitoes that transmit malaria?
- Does environmental degradation caused by the population, due to household waste, garbage, and sewage, contribute to the spread of malaria?

Study Objectives

This study aims to achieve the following objectives:

- To shed light on the geographical and environmental factors affecting human health in White Nile State
- To determine the impact of geographical and environmental factors on the malaria parasite and climatic factors in White Nile State
- To provide practical recommendations that contribute to reducing the spread of the disease

Study hypotheses

The study hypotheses are as follows:

- Geographical environmental factors play a role in the reproduction and spread of malaria-carrying mosquitoes in the state.
- The widespread environmental degradation in the state, resulting from harmful human practices, contributes to the spread of the disease.

Study Methodology

The study employed a regional, descriptive, and analytical approach.

Study Sample

A simple random sample was selected by dividing White Nile State into eight localities, then randomly selecting three localities. From these three localities, eight administrative units were chosen, ensuring differences and spacing between them. A sample of 100 households was then selected from these eight units.

2. Concepts of Medical Geography

The concept of Medical Geography

Medical Geography is a branch of human geography that studies the spatial relationship between health and disease, and the environmental, social, and economic factors that influence them,

Medical geography works to identify patterns of spatial distribution of diseases, study the causes of their spread, and propose appropriate solutions for their prevention and control (May 1950). The World Health Organization (WHO, 1950) defines medical geography as the science that studies the spatial distribution of health and disease and the factors associated with them in order to improve health planning.

The concept of health: (Health)

Is a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity?

The concept of disease: (Disease)

Is a disorder in the function of one or more body systems, leading to symptoms that negatively affect an individual's ability to perform normal functions? Its cause may be genetic, environmental, or infectious factors (Last, J.M., 2001).

The concept of spatial distribution of disease refers to the geographical pattern in which a particular disease spreads across different regions. This is influenced by environmental factors such as climate, soil, and water, as well as social factors such as population density, income level, and health behavior patterns (Meade, 2010). The concept of environmental factors affecting health.

It is the set of natural factors that contribute to the spread or control of diseases, including climate, soil, water sources, air quality, topography, and disease-carrying organisms such as insects (Park, 2021).

Disease Diffusion

Medical geographers divide disease spread into two main categories: the spread of medical discoveries within the scope of providing new medical services, and the spread of infectious diseases. This category includes a number of studies and concepts related to the study of epidemiology and geography.

Global Malaria Situation

Global Malaria Prevalence: Malaria is one of the world's deadliest and most widespread infectious diseases, affecting more than 85 countries and territories, particularly in tropical and subtropical regions where environmental conditions are favorable for the breeding of Anopheles mosquitoes, in 2022, approximately 249 million cases of malaria were recorded worldwide. Africa bears the greatest burden of the global disease, accounting for about 94-95% of all cases and deaths annually (WHO, 2024). Malaria caused approximately 608,000 deaths globally in 2022, the majority of which occurred in sub-Saharan Africa and among children under five years of age (WHO, 2023).

Malaria in Africa

Africa continues to bear the greatest burden of malaria globally in 2023, with approximately 251 million cases in the African Union member states and an estimated 579,000 deaths during the same period. Children under 5 years of age bear the brunt, with approximately 76% of malaria victims being children. Progress in malaria control has experienced some stagnation or slowdown in recent years due to several factors, including drug and pesticide resistance, delays in accessing preventive programs, and conflicts that threaten the continuity of health services (ALMA, 2024).

Malaria in Sudan

According to recent sources, the number of cases and deaths in 2023 showed more than 1.3 million confirmed cases of malaria in Sudan with more than 850 deaths (UNICEF 2023). The Minister of Health stated that Sudan records between 2-3 million cases annually, according to the estimate the star com.my. Children under the age of five were among the most vulnerable to death and illness (UNICEF +3), as were pregnant women and marginalized communities in areas with limited health services (UNICEF +2).

Preventive interventions

A massive campaign was carried out to distribute insecticide-treated mosquito nets, reaching approximately 15.6 million nets covering approximately 28 million people in 14 states. In addition, the anti-malarial vaccine was provided for the first time in Sudan (in the Blue Nile and Al Qadarif states) to children under one year old, starting in November 2024, and then expanding to 129 localities by 2025-2026 (UNICEF+2).

Challenges

a) War has made it difficult to provide health services to many health facilities in the affected areas, rendering them non-functional or with limited capacity.

b) Internal displacement: We find communities living in camps or overcrowded places where prevention and treatment are less effective.

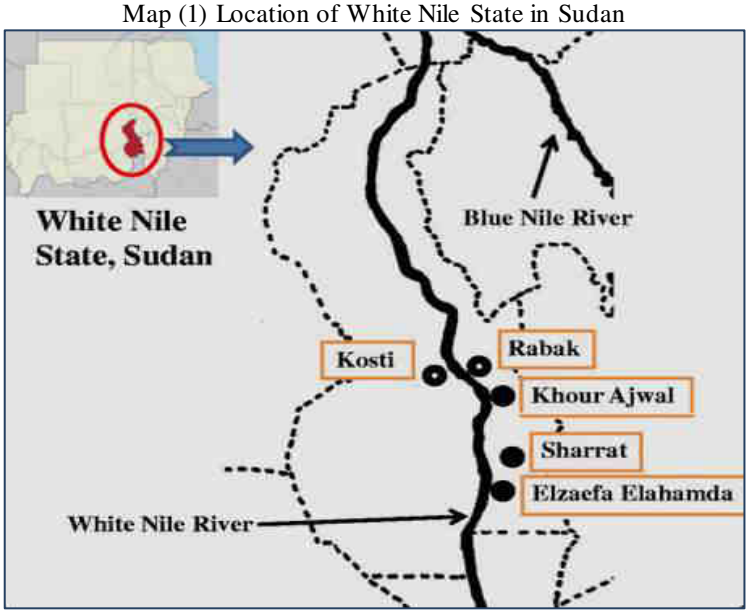
c) The actual use of protective tools such as mosquito nets is much less.

d) Difficulty in conducting a full survey and reporting due to the destruction of infrastructure, poor communications, and limited access to some areas (UNICEF+3).

Malaria in White Nile State

Malaria is one of the health problems in White Nile State, as the World Health Organization confirms the existence of field evidence of an increased risk of malaria transmission in the state due to environmental and human factors, floods and stagnant water, and the accumulation of waste, Lack of water and sanitation services, internal displacement, and overcrowded camps all contribute to increased Anopheles mosquito breeding. Limited field studies have shown high rates of malaria prevalence in areas within the state, including the Al-Darader area, which reported a high prevalence rate among the cases examined %84.5 in the community surveyed. This is a small-scale local study that does not necessarily reflect the entire state, but it does indicate high-risk hotspots.

Map (1) Location of White Nile State in Sudan



Source: White Nile State Atlas

Factors Contributing to Malaria Spread

Malaria is an environmental disease, meaning its spread depends on the availability of suitable natural and human environments. The most important conditions for its spread are:

- The presence of infected individuals or carriers of the parasite.
- The presence of a sufficient number of mosquito vectors, specifically female Anopheles mosquitoes.
- The presence of stagnant water bodies suitable for mosquito breeding and reproduction.
- Warm weather: The disease does not spread in cold regions, so its spread is limited to hot and warm regions or during the season of high heat and humidity.
- Not being too high above sea level: The most suitable areas for its spread are those with an altitude of less than 1500 meters (The Sudan Times 2024)

Natural factors and disease spread in the study area

Location

The state's location in central Sudan and its proximity to the White Nile have encouraged many agricultural projects, which provide a fertile environment for mosquito breeding and reproduction. The location, in terms of longitude and latitude, also has a health impact In terms of its relationship to climate, which has contributed to the distribution of diseases, some, such as cholera,

schistosomiasis, and malaria, are prevalent in tropical regions. Since the state is located in tropical latitudes, its location facilitates the spread of malaria, and this spread is exacerbated by changes in location due to migration.

Topography

It is established that topography has an impact on the distribution of some diseases. For example, it has been shown that the schistosomiasis parasite cannot survive or develop at high altitudes, even if the snails necessary for its development in its various stages are available. It has also been shown that cholera does not usually spread in mountainous regions, even if it is prevalent in the adjacent plains, this also applies to malaria, as the mosquito that transmits it cannot reproduce at high altitudes as readily as it does in lowlands, and malaria is virtually nonexistent in areas above 2,500 meters above sea level. The elevation of White Nile State, at 377 meters above sea level, makes it a suitable breeding ground for the malaria parasite (Reuters, 2024).

Geological composition and soil

The White Nile State consists of sedimentary rocks, clayey and clayey, with a little sand. This has created a climate conducive to mosquito breeding, as it helps to retain water during the rainy season and hinders the drinking process. There are noticeable amounts of ponds and swamps in many localities of the state, and this has helped mosquito breeding.

Climate

Temperature

The climate of White Nile State is conducive to mosquito breeding and reproduction, characterized by high temperatures. However, there is variation in temperature throughout the different months, and consequently, the adaptation or metabolic processes are slow. In winter, the temperature does not exceed 22 degrees Celsius, and therefore, these processes are slow. In the hot, dry season, average temperatures can reach 41 degrees or more, and malaria is often more common in the hot months because warmth helps the eggs hatch and multiply quickly. We can explain the relationship between temperatures and the distribution and spread of malaria fever in the White Nile State by using the test criteria (correlation coefficient) for the infection rate for the year 2024 AD in the most infected months and the temperature for the same year and months.

Table (1) the relationship between temperature and the spread of malaria fever

Months	Average temperatures (°C)	Infection rate
July	30.6	16%
August	29.5	26%
September	29.1	28%
October	30.9	30%

Source: White Nile State Meteorological Department and the researcher's work, 2024. r = 54

In Table (1) shows that the main Searman coefficient was used to illustrate the relationship between the two variables (temperatures are the causative factor in the spread of malaria this year, and it can be said that the temperatures were ideal in those months to a degree that led to an increase and reproduction of mosquitoes, considering that the optimal temperature for their reproduction is 27 degrees Celsius.

Humidity

Its role is in the life and activity of the vector, and it has no role in the presence of the parasite. The relationship between humidity and the spread of malaria fever is clear.

Table (2) the relationship between relative humidity and the spread of malaria fever

Months	Relative humidity	Infection
July	50	16%
August	54	26%
September	52	28%
October	38	30%

Source: White Nile State Meteorological Department and the work of researchers, 2024.

Table (2) shows that, generally, increased humidity reduces the spread of malaria, and vice versa. The table also shows that the highest humidity was recorded in August at 54%, and the highest infection rate was recorded in October when the relative humidity was 38%. This confirms that high humidity shortens the lifespan of mosquitoes, considering that 60% means the absence of malaria transmission, since the relative humidity levels recorded in those months were close to 60%, the spread was slower than in other months. Therefore, it can be concluded that the optimal relative humidity for mosquito breeding ranges between 30% and 40%.

Rainfall

In White Nile State, the rainy season begins in July and ends in mid-October. This is followed by a widespread outbreak of malaria throughout the state, which can reach epidemic levels. This is illustrated by the relationship between rainfall and malaria prevalence, as shown in the table below:

Table (3) Rainfall amount and disease incidence

Months	Rainfall in millimeters	Infection
July	16	16%
August	49.4	26%
September	114	28%
October	15	30%

Source: White Nile State Meteorological Department and the researcher's work, 2024 .r = 40

Table (3) Using the Seyerman coefficient, it became clear that the relationship between the amount of monthly rainfall and malaria infections is high and strong, with the correlation coefficient reaching 4, which confirms that the most significant climatic factor causing the spread of malaria is rainfall, we find that malaria infection does not increase in the rainiest months, which are usually July and August. As noted in the table, infections increased in September and October. This is attributed to the fact that the rain factor was the strongest climatic factor in the spread of malaria fever in the White Nile State for the year 2024.

The external environment of the home contributes to the spread of malaria. Therefore, it must be clean, and the disposal of waste and other refuse must be monitored to prevent it from becoming breeding grounds for disease-carrying insects or causing blockages in drainage systems. This waste includes:

- Household waste: This is considered the richest type of waste in terms of its organic content, consisting of leftover food, vegetables, and fruit.
- Street waste: This is generated from residential activity outside the home and mostly consists of paper and plastic bags, in addition to plant debris from trees lining the streets.

Table (4) Waste Disposal in a Study Area

Method	By way of the wedding stage	Burn it	Bury her in the street	Near the house	Transmitted by health authorities
Number	47	20	10	15	8
Ratio	47%	20%	10%	15%	8%

Source: Fieldwork 2024

From Table (4), we observe that a large percentage of families' dispose of garbage through open dumps (47%), indicating a poor health situation, as this garbage harbors many harmful insects that contribute to mosquito breeding. Meanwhile, we find that 20% of families burn garbage, indicating a higher level of health awareness. The role of health authorities is weak, as they do not effectively contribute to reducing environmental degradation. Additionally, we find that 15%, they dispose of garbage near their homes, which significantly increases the breeding of malaria-carrying mosquitoes, especially when the garbage mixes with water. Observation revealed that most streets in the study area are unclean, with accumulated garbage. This poses a particular risk during the rainy season, as the rain decomposes the garbage, creating a foul odor that attracts mosquitoes. The area outside the homes is also rife with, it contains sewers and pits, especially during the autumn season. These sewers are a permanent habitat for mosquitoes and are not filled in after the rainy season. Many families dispose of the water used for household purposes in the streets, which leads to an increase in the incidence of malaria.

Table (5) Water Disposal and Disease Infection

Malaria infection		Disposing of wastewater used for domestic purposes:	Malaria infection		Total
4	35	Into the sewer system	35	4	39
5	45	Into the street	45	5	50
4	7	Other	7	4	11

Source: Fieldwork 2024

Table (5) shows that, according to the value of chi-squared = 2.70 and the degree of freedom 2, the calculated significance level of 5.991 indicates that there is a correlation between disease infection and the disposal of water used for domestic purposes because the calculated significance level of 5.991 is greater than the tabulated value of 2.70 at the standard level of 0.05. Accordingly, infection with malaria is related to the method of disposing of water used for domestic purposes.

3. Results

- The state's location places it within the area prone to tropical diseases such as malaria, with an infection rate of 85%.
- The climate, with its various elements, clearly contributes to the high incidence of malaria.
- Citizens neglect environmental health; many in the study sample do not maintain the cleanliness of their outdoor environment, resulting in litter in the streets (45%) and numerous potholes and open drains (35%).

4. The state's health services provided by health authorities are inadequate, with a rate of 8%

4. Recommendations

- Pay attention to drainage systems, especially during the autumn season.
- Eliminate wetlands (ponds and swamps).

- Identify and treat mosquito breeding grounds.
- Regularly spray insecticides using aircraft or hand pumps, particularly during the autumn season.
- 5.Strengthen the role of public health education to raise awareness among citizens and promote environmentally responsible behavior.

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