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Identifying the Factors Contributing to Dengue Fever: An Analytical Study from a Medical Geography Perspective, White Nile State, Sudan (2021-2025)

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Abstract

This study aimed to analyze the epidemiological situation of dengue fever in White Nile State, Sudan, focusing on environmental and social factors and their role in disease spread. The study problem was formulated in the following main question: What factors influence the spread of dengue fever in White Nile State? The study was based on the following main hypothesis: there was a statistical significant relationship between climate elements and the spread of dengue fever. The study used a descriptive-analytical approach's, collecting data from health facilities, conducting field surveys, and interviewing patients and healthcare workers. The study found that infection rates are higher in densely populated areas, with poor sanitation and stagnant water, in addition to the effect of hot and humid climates on increasing the density of disease-carrying mosquitoes. The study recommended strengthening health awareness programs, improving the environment, and intensifying efforts to combat dengue fever vectors to reduce its spread in the state and other states.

Keywords: Dengue fever, White Nile State, environmental and climatic factors, mosquito vector, public health.

Introduction

Dengue fever is a prominent mosquito-borne viral disease, posing a growing health challenge in many developing countries, particularly in tropical and subtropical regions where environmental conditions are favorable for vector breeding. The world has witnessed a significant increase in the prevalence of this disease in recent decades, due to a confluence of factors including climate change, unregulated urbanization, and weak healthcare infrastructure. In Sudan, dengue fever is an emerging health problem that has been expanding geographically, several states, including White Nile State, have recorded an increase in infection rates in recent years. This is attributed to a combination of environmental and social factors, such as rising temperatures, fluctuating rainfall, poor waste management, and the practice of storing water inside homes, which provides a breeding ground for the mosquito vector. The interaction between humans and the environment in these areas clearly highlights the importance of employing a medical geography perspective to study the spatial and temporal patterns of diseases and analyze the factors influencing their spread, several states, including White Nile State, have recorded an increase in infection rates in recent years. This is attributed to a combination of environmental and social factors, such as rising temperatures, fluctuating rainfall, poor waste management, and the practice of storing water inside homes, which provides a breeding ground for the mosquito vector. The interaction between humans and the environment in these areas clearly highlights the importance of employing a medical

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geography perspective to study the spatial and temporal patterns of diseases and analyze the factors influencing their spread.

The importance of the study

The importance of the study stems from the increasing rates of dengue fever infection in the White Nile State during recent years, the scarcity of epidemiological studies that have dealt with the disease in this state specifically, contributing to supporting health decision-makers with scientific information that helps in planning preventive interventions and highlighting the role of environmental and social factors in the spread of vector-borne diseases.

The Problem of the Study

The study observed a rise in dengue fever cases in White Nile State, under environmental and social conditions conducive to the spread of the mosquito vector, coupled with limited preventive measures and weak environmental and health awareness within the local community.

Objectives of the Study: The study aims to achieve the following objectives:

1**)** To analyze the spread of dengue fever in White Nile State and identify the environmental and social factors influencing it.

2) To identify the epidemiological characteristics of dengue fever cases in the state.

3) To identify the environmental and climatic factors associated with the spread of the disease.

4) Identifying social factors and their role in the spread of dengue fever.

Study hypotheses: The study was based on the following hypotheses:

1)There is a statistically significant relationship between climatic elements (temperature, humidity, rainfall) and the spread of dengue fever.

2) Weak environmental and health awareness increases the spread of dengue fever in White Nile State.

Study Population and Sample:

The study population included the residents of the White Nile State, focusing on nine localities (Rabak, Kosti, Al-Duwaim, AlQutaynah, AlJabalayn, Tendelti, AlSalam, Umm Ramta and Quli). A purposive random sample of (100) respondents was used, and the localities were divided into three ranges: localities with high population density, localities with medium population density, and localities with low population density, in order to ensure fair geographical and demographic representation of the study population.

Table (1) Study Sample by Population Density in White Nile State

High population density			Average population density			Low population density		
Edduiem	Kosti	Rabak	Tendelti	AlJabalayn	AlJabalayn	Quli	Umm rimta	Alsalam
15%	15%	15%	10%	10%	10%	8%	8%	8%

Source: From the researcher's work using fieldwork data, 2025

Study Methodology

The study employed a descriptive-analytical approach, collecting secondary data from health records and official reports, and primary data through a field survey. The data were then analyzed using descriptive statistical methods.

Previous Studies

A study by Mohammed (2018) aimed to identify the factors influencing the spread of dengue fever in eastern Sudan. This study utilized a descriptive-analytical methodology. It concluded that there is a

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strong correlation between disease spread and stagnant water. The study recommended strengthening awareness programs to reduce the spread of the disease.

Ahmed et al., (2020) the study aimed to investigate the impact of climate change on the spread of mosquito-borne diseases in Africa. The study employed a descriptive-analytical approach and a regional methodology. It found an increase in disease outbreaks across the African continent during the autumn season. The study recommended adequate preparation for the autumn season to mitigate disease spread.

Morin et al., (2013) the study aimed to determine the impact of environmental and climatic factors on the spread of dengue fever in Alexandria, Egypt. It concluded that temperature fluctuations not only affect the survival rates of the mosquito vector but also accelerate the external incubation period (EIP) of the virus, making the mosquitoes infectious in a shorter timeframe.

Bhatt et al. (2013): This study aimed to model global dengue fever distribution maps. It concluded that heavy rainfall followed by high relative humidity provides an ideal environment for the sustainability of breeding sites, particularly in tropical and subtropical regions.

Wilder-Smith (2021): This study aimed to determine the role of unplanned urbanization in exacerbating dengue fever spread in Asia. It found a direct correlation between population density, poor solid waste management, and increased larval detection indicators.

Messina et al. (2019): This study discussed the impact of long-term climate change on dengue fever spread. It concluded that the disease's geographic range will expand to include areas in Europe and North America by 2050 as a result of rising global temperatures, posing an unprecedented environmental and health challenge to the world.

Seidahmed et al., (2022) This study aimed to investigate the relationship between rapid urban expansion in Sudanese cities (such as Port Sudan and Kassala) and the availability of artificial breeding sites for some dengue fever vectors, particularly domestic water storage tanks necessitated by the ongoing water scarcity.

Hamed et al., (2020) the study aimed to demonstrate the impact of the recent unprecedented floods in Sudan on the spread of dengue fever. This study concluded that the prolonged presence of stagnant water pools in populated areas creates an ideal ecosystem for sustaining the life cycle of the dengue fever vector.

Local, regional, and international studies align with the current study and the global trend that the fragility of urban ecosystems and poor sanitation are the most significant factors contributing to the endemic nature of the disease and its transformation from sporadic cases to recurring epidemics in various Sudanese states. This necessitates updating integrated vector control strategies. These studies also generally agree that sanitation-based interventions are the cornerstone of reducing disease spread in the absence of universally effective vaccines for all serotypes. At the local level in Sudan, epidemiological studies have indicated a worrying increase in the rate of dengue fever transmission.

Dengue Fever

Dengue fever is an acute viral disease transmitted to humans through the bite of the Aedes aegypti mosquito. Humans are the primary host for the virus, and repeated exposure to different strains increases

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the risk of developing dengue hemorrhagic fever, the most severe form of the disease (Mohammed, 2018, p. 12).

Epidemiological Characteristics of Dengue Fever: Dengue fever is characterized by several key epidemiological features, including:

1. Rapid spread in urban and semi-urban areas.
2. Its strong association with rainy seasons.
3. High incidence among young adults and adults.
4. Potential for seasonal epidemics (Ahmed, 2020, p. 23).

The mosquito vector and its life cycle:

The Aedes aegypti mosquito is the primary vector of dengue fever and is characterized by the following:

1) It breeds in clean, stagnant water in and around homes.
2) It is active during the day, especially in the early morning and before sunset.
3) It has a high capacity for adapting to urban environments.

The mosquito life cycle consists of four stages: egg, larva, pupa, and adult. This cycle accelerates at higher temperatures, which explains the increased incidence of dengue fever in hot climates (WHO, 2019, p34).

Factors Affecting the Spread of Dengue Fever

1) Climatic Factors (Main Driver): Climate is the primary regulator of mosquito activity, and its most important effects include:

Temperature: High temperatures (between 25 and 32 degrees Celsius) accelerate the mosquito life cycle and the virus's incubation period. When the temperature rises, the virus requires a lower temperature to multiply inside the mosquito and reach its salivary glands to become infectious.

Rain and Humidity: Rain provides natural breeding grounds, such as water pools, for egg-laying, while high humidity increases the mosquito's lifespan, giving it more opportunities to bite a larger number of people.

2) Urban Environment and Urban Planning: Dengue fever is often classified as an urban disease, as it thrives in cities due to:

Population Density: Living in densely populated areas facilitates the transmission of the virus from person to person via mosquitoes, which do not typically fly long distances.

Poor Waste Management: Accumulation of old tires, plastic containers, and empty cans provides an ideal environment for rainwater to collect, which are preferred breeding grounds for mosquitoes.

Water Storage Systems: In areas suffering from water shortages, residents resort to storing water in open tanks, creating an artificial breeding environment inside or around homes. (Ibrahim, 2021, p14).

Discussion and Analysis:

Table (2) illustrates the relationship between temperature and the spread of dengue fever In White Nile State.(2025-2021)

Year	Injury	Temperature
2021	455	45.1
2022	773	46
2023	816	48

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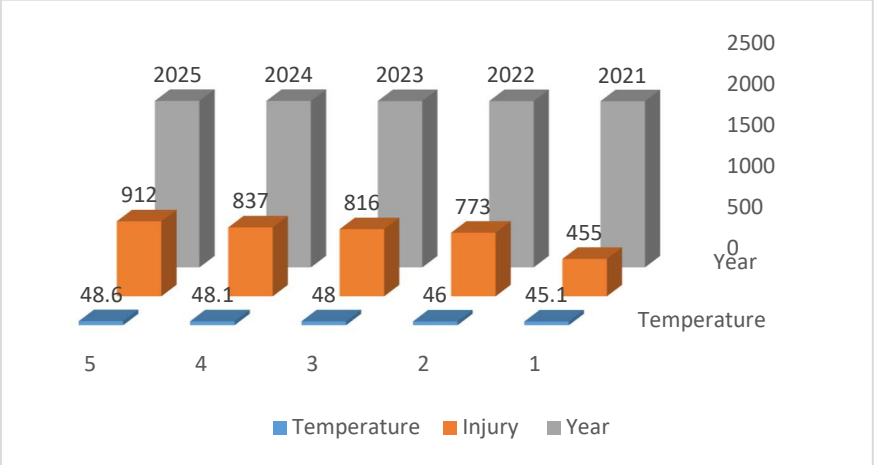
2024	837	48.1
2025	912	48.6

R= (0.9)

Source: State Meteorological Service and Ministry of Health, 2025

Figure (1) the relationship between temperatures and the spread of dengue fever in White Nile State (2021-2025)



From Table (2) and Figure (1), and using Spearman's rank correlation coefficient to illustrate the relationship between dengue fever cases and temperature, it became clear that the relationship is direct; the higher the temperature, the higher the incidence of dengue fever. This means that the years with the most favorable biological temperature increase the reproduction of the mosquitoes that transmit dengue fever.

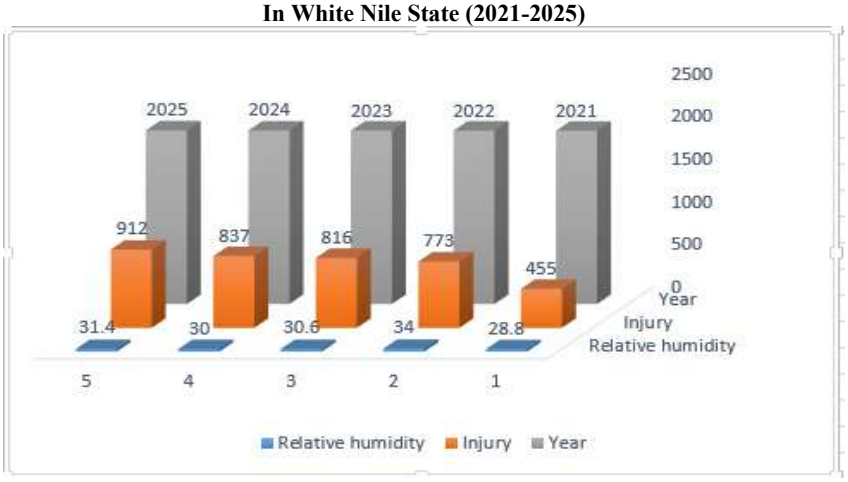
Table (3) illustrates the relationship between relative humidity and the spread of dengue fever In White Nile State.(2025-2021)

Year	Injury	Relative humidity
2021	455	28.8
2022	773	34
2023	816	30.6
2024	837	30
2025	912	31.4

R= (0.5)

Source: State Meteorological Service and Ministry of Health, 2025

Figure (2) the relationship between relative humidity and the spread of dengue fever In White Nile State (2021-2025)



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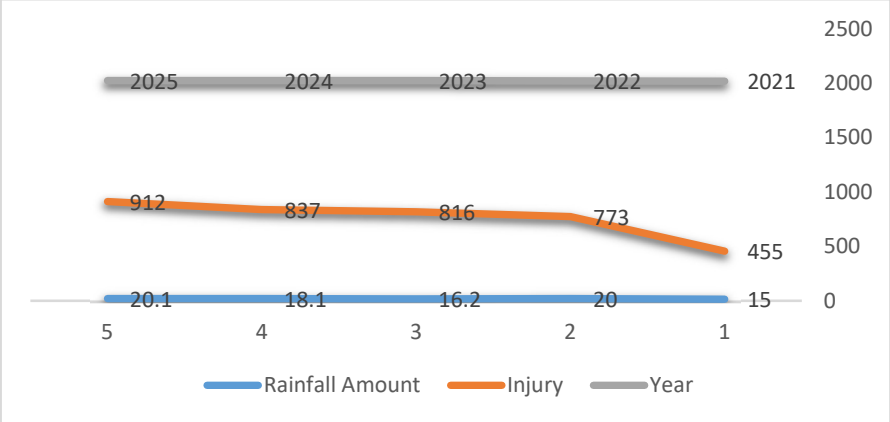
From Table (3) and Figure (2), and using Spearman's rank correlation coefficient to determine the relationship between dengue fever incidence and relative humidity in the state, it became clear that the relationship is real and that the relative humidity in those years was conducive to the spread of dengue fever.

Table (4) illustrates the relationship between rainfall and the spread of dengue fever in White Nile State.(2025-2021)

Year	Injury	Rainfall Amount
2021	455	15
2022	773	20
2023	816	16.2
2024	837	18.1
2025	912	20.1

R= (0.3)
Source: State Meteorological Service and Ministry of Health, 2025

Figure (3) the relationship between the amount of rainfall and the spread of dengue Fever in the White Nile State (2021-2025)



From Table (4) and Figure (3), and using Spearman's rank correlation coefficient, it became clear that the relationship between the two variables was weak and that rainfall was low in those years. We note that the highest recorded dengue fever case occurred in 2025, the same year that recorded the highest rainfall in the state. This indicates that rainfall plays a role in the spread of dengue fever, but other contributing factors also played a significant role in its spread during those years. From Tables (2), (3), and (4), we observe that relative humidity has a significant impact on the rate of spread, with the highest percentage recorded in 2025, the year with the highest rainfall. The same applies to temperatures in the same year. This type of spread is considered expansive and contagious, and the role played by these three climatic elements contributes to the rapid spread of the disease, and that it is the main reason for the presence of mosquitoes that transmit dengue fever in the state, and this confirms the initial hypothesis which states: (There is a statistically significant relationship between climate elements (temperature, humidity, rainfall) and the spread of dengue fever).

Environmental Aspects

The outdoor environment of the home contributes to the spread of dengue fever. Therefore, the environment must be clean, and the disposal of waste and other refuse must be monitored to prevent it

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from becoming breeding grounds for disease-carrying insects or causing blockages in drainage systems. This waste includes:

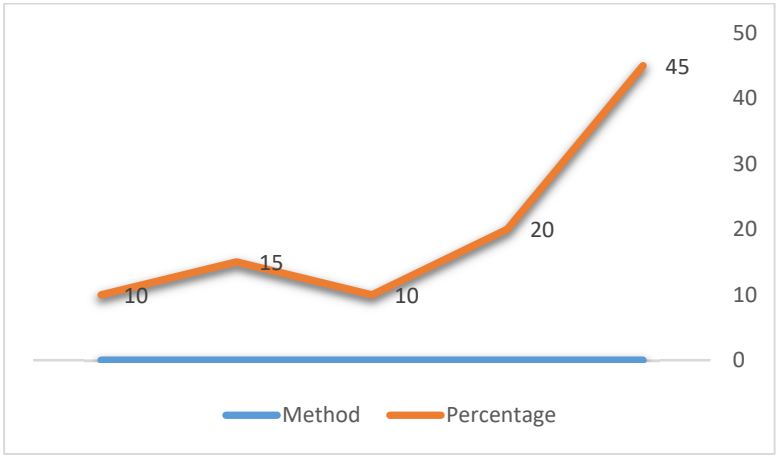
Household waste: This is considered the richest type of waste in terms of its organic content, consisting of leftover food, vegetables, and fruit.

Table (5) Methods of waste disposal in White Nile State 2025

Method	Percentage
By the oven	45
Burning it	20
Burying it in the street	10
Near the house	15
Transferred by health authorities	10

Source: Prepared by the researcher from field data, 2025

Figure (4) Methods of waste disposal in White Nile State, 2025



From Table (5) and Figure (4), we observe that a large percentage of families' dispose of garbage through the garbage bin, reaching 45%, which indicates a poor health situation, as garbage harbors many harmful insects that help mosquitoes multiply. Families who burn garbage are found to be living in good health conditions, and this is an indication that these families have health awareness, although their percentage is small, 20%. Meanwhile, we find that health authorities do not contribute effectively to reducing environmental degradation. Through observation, it was found that most of the streets in the study community are unclean, and dirt accumulates in the street, which increases its danger to humans and the environment, especially during the rainy season, because the rain helps ferment this garbage and it becomes foul-smelling, which further helps the spread of mosquitoes that transmit dengue fever.

Table (6) Water storage methods in the White Nile State

Method	Percentage
Refrigerator	30
Zeer	35
Barrel	20
Tank	10
Other	5

Source: Prepared by the researcher from field data, 2025

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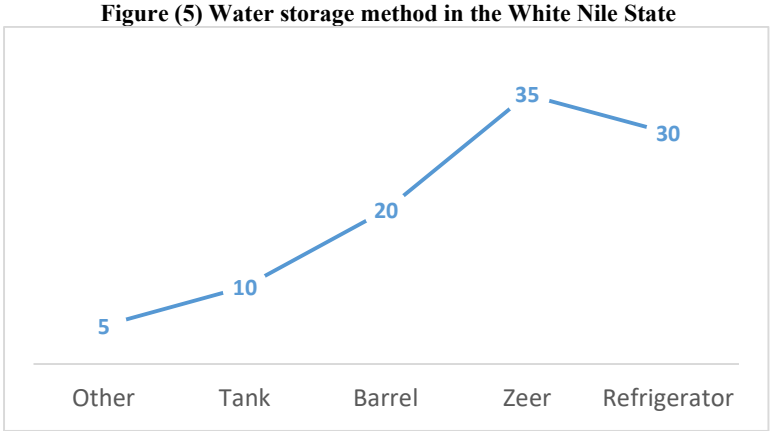
Figure (5) Water storage method in the White Nile State



From Table (6), we observe that the respondents mentioned more than one method of water storage. A large percentage (35%) store drinking water in earthen jars, followed by refrigerators (30%), barrels (20%), tanks (10%), and other methods (5%). We find that earthen jars, barrels, and tanks are suitable breeding grounds for mosquitoes in homes. Based on the results in Tables (5) and (6), the second hypothesis is confirmed: (Weak environmental and health awareness increases the spread of dengue fever in White Nile State).

Results

1/ the incidence of dengue fever in the state is steadily increasing year after year.

2/ There is a strong correlation between climatic elements (temperature, humidity, and rainfall) and the spread of dengue fever.

3/ There is a lack of environmental and health awareness, as 45% of the state's population disposes of garbage in open dumps and 35% store water in earthenware jars.

4/ The spread of dengue fever in White Nile State is the result of a complex interaction between environmental, social, and health factors, requiring an integrated intervention that combines awareness campaigns, environmental improvement, and enhanced public health services.

Recommendations

1/ Intensify health awareness campaigns on dengue fever prevention.

2/ Improve sanitation and water management systems.

3/ Strengthen mosquito control programs.

4/ Support epidemiological surveillance systems in the state.

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