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Local Climate Conditions and Prevalence of Typhoid Fever Disease Patterns in a Vulnerable Community of Ikpoba Okha LGA of Edo State, Nigeria

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ABSTRACT: Climate change presents a significant threat to water resources and public health, with increasing temperature and rainfall variability exacerbating waterborne diseases. Therefore, the objective of this paper is to investigate the relationship between local climate conditions and prevalence of typhoid fever disease patterns in a vulnerable community of Ikpoba Okha LGA of Edo State, Nigeria using appropriate methods. The data shows a persistent increase in typhoid cases, with spikes coinciding with higher temperatures and heavy rainfall, particularly in August and September, when flooding and poor water quality contribute to disease spread. The study highlights the critical need for improved water and sanitation infrastructure and targeted public health interventions to address the growing risks posed by climate change. By enhancing climate adaptation measures and reinforcing healthcare responses during high-risk periods, such as the rainy season, the incidence of typhoid fever can be reduced. These findings emphasize the importance of integrated environmental management and disease surveillance to safeguard vulnerable communities. In conclusion, the observed correlation between climatic factors and typhoid prevalence underscores the urgent need for climate resilience strategies to protect public health in regions like Ikpoba Okha, where climate variability increasingly affects disease patterns.

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Climate change is a global crisis characterized by rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events. These changes significantly impact water resources and public health worldwide. For example, changes in precipitation patterns and higher temperatures can result in water scarcity in some areas and increased flood risks in others, impacting both the availability and quality of freshwater. Regions experiencing prolonged dry spells may face severe water shortages, drinking water supplies, agriculture, and sanitation, while areas with heavy rainfall may suffer from water source contamination with pathogens, chemicals, and other pollutants, posing serious health risks (IPCC, 2022; WHO, 2021). Waterborne diseases are diseases caused by harmful microorganisms transmitted through contaminated water. Health conditions like cholera, typhoid, and dysentery are connected to the quality and accessibility of water. Floods can overwhelm water and sanitation infrastructure, leading to outbreaks of these diseases, while droughts can concentrate contaminants in limited water supplies (Tirado *et al.*, 2020). Several studies have analyzed how climate variables influence the distribution and

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prevalence of waterborne diseases. For instance, Ekwunife *et al.*(2019) found a significant correlation between rainfall patterns and cholera outbreaks in southeastern Nigeria. Okoh *et al.* (2021) reported a similar trend in northern Nigeria, where temperature and rainfall were critical determinants of waterborne disease incidence. Addressing waterborne diseases in Nigeria requires a comprehensive approach to climate change adaptation measures. Improved sanitation, access to clean water, and effective disease surveillance systems are essential for mitigating the impacts of climate change on public health. These dynamics underscore the critical need for adaptive measures to reduce the effects of climate change, particularly in vulnerable communities where the public health infrastructure may be inadequate to handle these challenges. Understanding the relationship between climate-induced changes in disease patterns helps predict and prevent future outbreaks. This knowledge is essential for local communities, enabling them to better prepare and protect themselves against emerging health risks. By identifying the primary climatic factors that contribute to waterborne disease outbreaks, resources, and interventions can be strategically allocated to the most affected areas, thereby enhancing the effectiveness of public health responses**.** Developing effective strategies to mitigate these risks may improve water and sanitation infrastructure, enhance early warning systems for disease outbreaks, and implement public health education campaigns tailored to the local context (Ekpenyong and Akpan, 2023).

The National Bureau of Statistics (NBS, 2020) has emphasized that Nigeria's climate and geography in specific areas heighten the risk of water contamination and the transmission of diseases. In regions like Ikpoaha Okha LGA in Edo State, Nigeria, the intersection of environmental conditions and socio-economic vulnerabilities makes the study of waterborne diseases in the context of climate change particularly urgent. The area already faces challenges related to inadequate water and sanitation infrastructure.

As climate change progresses, these conditions will likely worsen, altering the epidemiology of waterborne diseases. Warmer temperatures could increase the proliferation of pathogens like *Vibrio cholerae*, while increased rainfall and flooding could spread fecal contaminants into drinking water supplies (Levy *et al.*, 2021). These changes necessitate a better understanding of how climate variables such as temperature, rainfall, and humidity correlate with disease outbreaks. Understanding these shifts is crucial for developing effective public health interventions and climate adaptation strategies. Therefore, the objective of this paper is to investigate the relationship between local climate conditions and prevalence of typhoid fever disease patterns in a vulnerable community of Ikpoba Okha LGA of Edo State, Nigeria.

MATERIALS AND METHODS

Study Area: Ikpoba Okha is a Local Government Area in Edo State, Nigeria, located between latitudes 6°15'N and 6°25'N and longitudes 5°30'E and 5°50'E. It is part of the Benin metropolis and includes several towns and villages. Ikpoba Okha experiences a tropical climate with distinct wet and dry seasons. The wet season occurs from April to October, while the dry season lasts from November to March. Temperatures are high year-round, with average temperatures ranging from 25°C to 32°C. Humidity levels are also high, especially during the wet season. The area features a mix of lowlands, plateaus, river valleys, and estuarine regions. The southern part of the region has low-lying plains, while the northern region is mostly occupied by the Edo Plateau. Several rivers cut across the area, including the Ikpe, Ologbo, Ossiomo, Uteh, and Ikpoba rivers. The drainage system in Ikpoba Okha consists of a network of channels, gutters, and stormwater drains. However, inadequate infrastructure and urbanization have led to challenges such as flooding during heavy rainfall. Rivers and streams' natural drainage patterns affect water management. Ikpoba Okha's vegetation varies depending on the region. The southern area is tropical rainforests, while the central and northern features are savanna woodlands. In certain areas, you can find freshwater swamp forests and mangrove forests, which play vital roles in their ecosystems. Grasslands and farmlands are also prevalent, supporting agricultural activities.

Methods: The study employed a retrospective cross-sectional design to assess the prevalence of typhoid fever among children under ten in Ikpoba Okha LGA from 2018 to 2023. A stratified random sampling method was used to select two hospitals one public and one private ensuring a representative sample from different socioeconomic backgrounds across the LGA. Hospital records of children with confirmed typhoid diagnoses were reviewed to assess prevalence. Additionally, meteorological data, including temperature and rainfall from 2010 to 2023, of Edo State were sourced from Nigerian Meteorological Agency (NiMet) station in Abuja to analyze correlations between climatic factors and disease incidence. Ethical approvals were obtained, and patient confidentiality was strictly maintained.

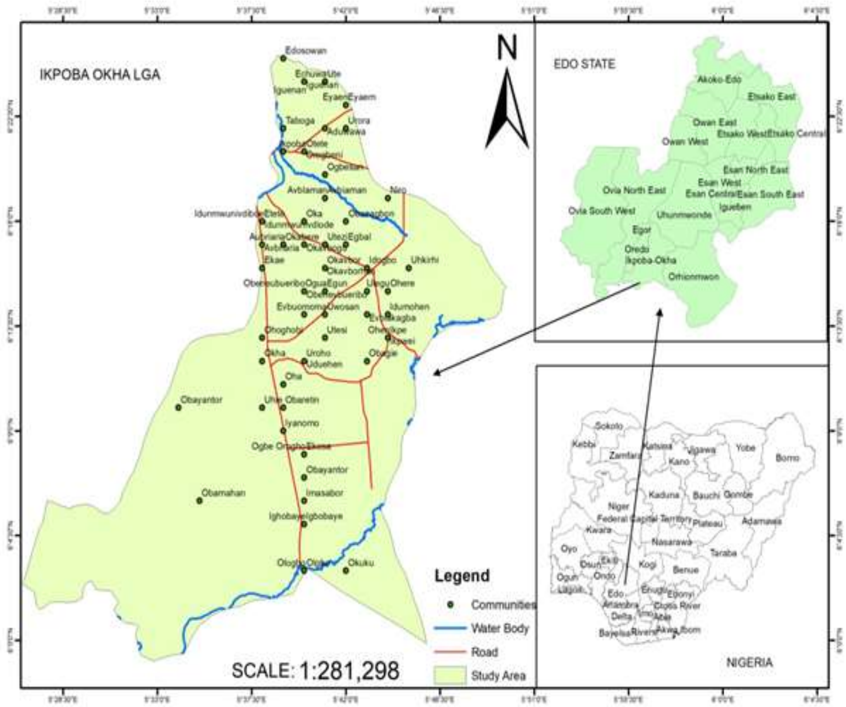

Fig 1: Map of the study Area
Source: Authors GIS map

RESULT AND DISCUSSION

Fig 2 presents the monthly and annual totals of typhoid cases diagnosed and treated at a private hospital in Ikpoba Okha from 2018 to 2023. Over these six years, the total number of cases shows an increasing trend, with annual totals rising from 993 cases in 2018 to a peak of 1,420 cases in 2023. Notably, 2020 recorded a significantly lower total of 781 cases, likely impacted by the COVID-19 pandemic and associated lockdowns, which might have reduced hospital visits or altered reporting and treatment patterns.

Certain months consistently have higher typhoid incidences. For instance, May and June frequently record high numbers, suggesting potential seasonal influences or varying environmental factors that could contribute to typhoid outbreaks. Conversely, the data for some months, such as April and July, shows significant fluctuation due to localized outbreaks or changes in healthcare-seeking behaviour. Fig 3 presents the prevalence of typhoid fever among children under ten years of age at the Ikpoba Okha government hospital from 2018 to 2023. The table demonstrates significant variability and an overall concerning trend. The data indicates that the total number of diagnosed and treated cases of typhoid fever fluctuated over the years, with the highest total number of cases observed in 2021 (1,403) and the lowest in 2018 (321). In 2018, January had 20 cases, and December had 16 cases, contributing to a yearly total of 321 cases.

The monthly distribution shows relatively low numbers and a slight increase in the middle of the year. In 2019, cases ranged from 15 in December to 81 in June, culminating in a yearly total of 755 cases. There was a noticeable spike in the number of cases in March (75) and April (77), suggesting seasonal variations. In 2020, the year started with 25 cases in January and peaked at 61 in September, totaling 382 cases. The absence of data in April and May might have impacted the yearly total. In 2021, the number of cases increased, peaking at 133 in March and hitting its lowest point at 82 in December, resulting in 1,403 cases for the year. The significant jump in cases compared to previous years indicates a potential outbreak or other public health challenges. In 2022, the total number of cases was 1,024, with the highest in March (103) and the lowest in October (63). It represents a slight decline from 2021 but remains significantly high compared to earlier years, while in 2023, the data for this year shows a total of 918 cases, with the highest in August (105) and the lowest in October (32). Although there is a decrease compared to 2022, the numbers remain high, indicating persistent public health issues.

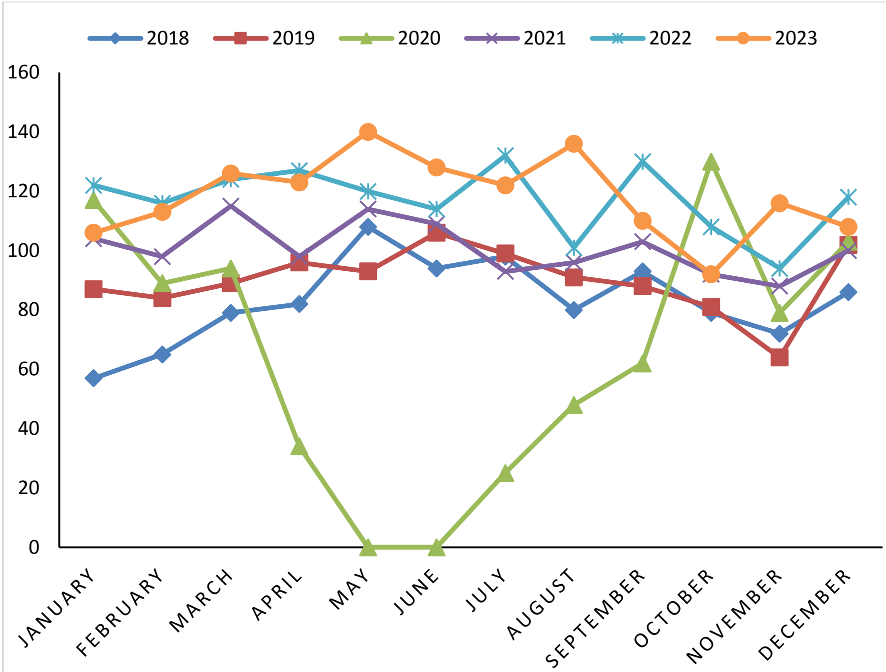

Fig 2: Typhoid Case Diagnosed and Treated from 2018 to 2023 in Private

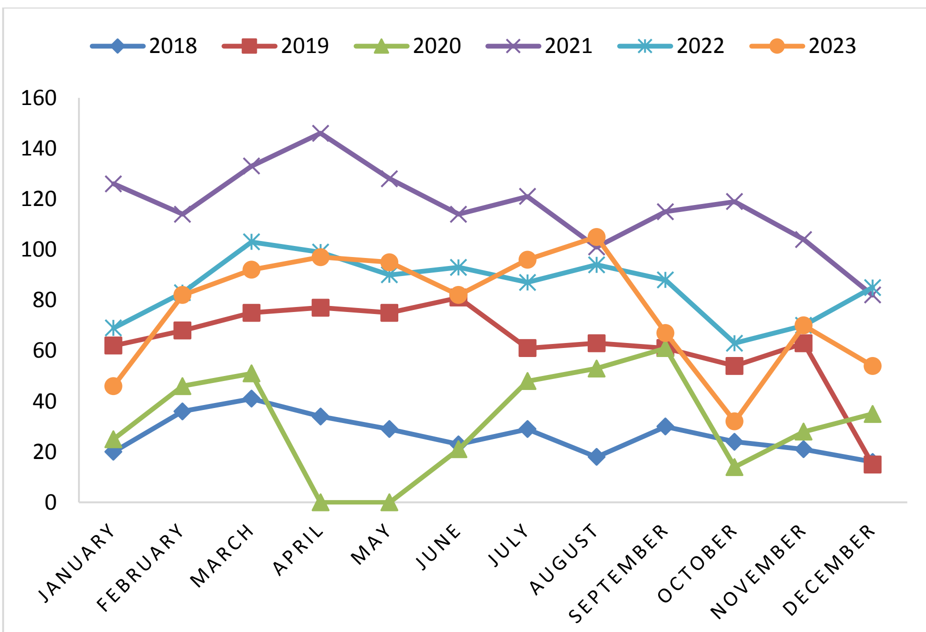

Fig 3: Typhoid Case Diagnosed and Treated from 2018 to 2023 in Government

The table presents monthly temperature data for Benin City in Edo State, Nigeria, from 2010 to 2023. A general trend of temperature fluctuations can be observed throughout the years, with notable patterns across different months and years. Temperatures in Benin tend to be highest during the dry season months of January to April, where values consistently range between 22.0°C and 34.3°C. February often records the highest monthly temperatures, particularly in 2010 (34.3°C) and 2012 (24.1°C), while March also shows high averages, reaching its peak at 34.1°C in 2010 and 2023. During the rainy season, temperatures stabilize around 22°C to 25°C from May to September. July and August are the cooler months, with temperatures averaging between 22.9°C and 24.2°C over the years. These months generally show lower temperatures due to increased rainfall and cloud cover. There is a noticeable variability from year to year.

Table 1: Temperature of Edo State from 2010 to 2023

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
JAN	33.4	22.0	22.3	23.4	24.4	22.3	23.1	24.3	23.2	24.2	22.4	24.5	23.1	23.2
FEB	34.3	24.0	24.1	24.7	24.7	25.1	25.2	25.5	25.3	25.0	24.6	24.1	24.8	24.5
MAR	34.1	24.6	24.9	24.9	24.5	25.0	25.0	25.1	24.9	25.1	25.3	24.6	25.5	23.6
APR	34.1	24.0	24.2	24.5	24.5	25.1	25.5	24.7	24.9	25.5	24.6	24.3	23.9	24.5
MAY	31.5	23.8	23.6	24.1	24.4	24.3	24.3	24.5	24.4	24.6	24.4	24.0	23.7	24.3
JUN	31.2	23.5	22.9	23.5	23.9	24.1	23.6	24.0	24.2	23.7	23.5	23.4	23.5	23.7
JUL	29.3	22.9	22.9	23.0	23.5	23.7	23.6	23.7	23.7	23.3	23.2	23.2	23.3	24.2
AUG	28.5	22.9	23.5	22.6	22.9	23.2	23.5	23.4	23.5	23.1	22.3	23.6	22.9	23.7
SEP	29.0	23.0	23.0	23.0	23.0	23.3	23.5	23.2	23.6	23.3	22.9	23.5	23.3	23.6
OCT	31.1	23.0	22.9	23.4	23.6	23.4	23.8	24.1	24.1	22.8	23.4	23.6	23.2	23.8
NOV	33.6	23.8	23.9	24.4	23.8	17.2	24.5	24.7	25.1	23.9	24.2	24.1	24.4	24.2
DEC	34.2	22.8	23.9	23.2	23.0	20.7	23.4	24.0	23.7	23.0	24.3	23.9	23.5	23.5

Table 2: Rainfall of Edo State from 2010 to 2023

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
JAN	15.5	0	47.7	11.9	82.8	26.5	0	0.6	0	96	0	40.8	3.8	27.5
FEB	99.8	78.2	53.2	61.8	53.3	174.5	2.4	51.1	132.2	117	46.2	70.3	52.9	78.6
MAR	55.3	84.3	74.8	126.2	130.4	182	184.6	153.9	188.4	165.5	264.1	135.4	27.2	311.8
APR	321.5	322.4	157.1	201	212	108.5	104.2	183.7	110.9	104	125.4	212	420.3	52.4
MAY	158.4	76.8	383.7	312.2	252	208.3	232.9	261.9	193	206	111.2	137.2	284.1	371.7
JUN	212.6	139.7	490.4	255.6	244	400.2	312.7	305.3	191	534.9	393	284.6	288.8	472.1
JUL	199.6	188.8	395.3	390.4	274	387.6	325.9	450.8	402.3	428.4	156.6	261.4	350.4	327.6
AUG	532.7	624.7	124.9	168.1	167.5	220.4	256.9	368.5	464.5	335.8	63.7	380.3	154.2	324.6
SEP	608.7	333.2	255.5	564	205.4	340.5	360.2	223.1	305	526.9	381.9	284.4	301.1	431.9
OCT	267.4	105.9	285.2	338.8	90.4	274	184.2	228.2	92	474.1	225.3	217.3	264.7	299.8
NOV	306.5	50.2	189.7	105.8	0	18.8	58.1	113.3	76.9	70.2	145	198.3	73.5	138.5
DEC	49.2	0	7.2	60.1	2	12.1	4.2	7.4	0	48.8	144.1	0.3	19.4	17.3

The rainfall data for Benin, Edo State, from 2010 to 2023 shows significant seasonal and annual variability. Rainfall is typically higher between April and October, with the wettest months usually between June and September. August and September show some of the highest rainfall amounts, peaking in 2010 with 532.7mm and 608.7mm, respectively. The dry season (November to March) exhibits lower rainfall totals, with several months recording negligible rainfall. Notably, rainfall in February 2015 reached 174.5mm, which is unusually high for the dry season, suggesting possible changes in weather patterns. The year 2023 displays irregularities, with extremely high values in March (311.8mm), which stands out compared to other years. This data reflects the region's tropical monsoon climate, where variations in rainfall may influence agriculture, water availability, and overall environmental conditions. Additionally, extreme fluctuations in annual rainfall, like the dry spells in 2011 and higher rainfall years such as 2022, may indicate changing climate trends in the region. The result reveals an increasing trend in typhoid cases from 2018 to 2023, except for the dip in 2020 due to COVID-19 disruptions. The number of typhoid fever cases among children under ten fluctuates, with the highest number occurring in 2021. A key observation is that May and June often record high typhoid cases, coinciding with the transition period from the dry to the rainy season. This period is known for poor water quality and increased contamination risks, possibly due to water stagnation and poor sanitation practices. Okeke and Eze (2021) found that typhoid cases increased during the rainy season in May and June due to water contamination from heavy rainfall, exacerbated by inadequate water treatment, improper waste disposal, and open defecation. The result also shows that typhoid outbreaks are often the relationship between changes in temperature and rainfall. For instance, March to June typically see higher temperatures (22°C to 34°C) before the full onset of the rainy season. This warmer period can lead to increased bacterial activity and higher contamination risks in water sources. According to Nwidu *et al.* (2020), typhoid cases from March to June are linked to warmer temperatures that increase bacterial contamination in water supplies, worsened by poor sanitation and stagnant water during early rains. The result further shows that in the cooler months, July and August, there is a slightly lower typhoid incidence, possibly due to reduced water contamination risks from heavy rainfall washing away contaminants or because lower temperatures reduce bacterial activity. Ogbonna *et al.* (2023) observed that typhoid cases in Enugu peaked in July and August due to rainfall washing contaminants into water sources, with inadequate drainage and poor waste management worsening the contamination risks. Rainfall data indicates that August and September are among the wettest months in Benin City. These months also coincide with peaks in typhoid cases, highlighting the potential link between heavy rainfall and the contamination of water supplies, particularly in communities relying on untreated water sources like boreholes and rivers. Uchegbu *et al.* (2022) found that intense rainfall in August and September in Awka, Anambra State, led to flooding and surface runoff, increasing typhoid cases by contaminating water systems, particularly affecting informal settlements and rural areas reliant on untreated water sources.

Conclusion: This study underscores the significant impact of climate variables, particularly temperature and rainfall, on the prevalence of typhoid fever among children under ten in Ikpoba Okha, Edo State, Nigeria. The findings suggest that higher temperatures and seasonal rainfall contribute to water contamination risks, exacerbated by inadequate sanitation infrastructure and improper waste management. Addressing these vulnerabilities requires prioritizing improvements in water and sanitation facilities, enhancing drainage systems, and implementing community-centered public health education. By strengthening local public health infrastructure and promoting preventive measures, communities can better adapt to climate-induced health risks, reducing the incidence of typhoid fever and improving resilience to future climate variability.

Declaration of Conflict of Interest: The authors declare that there is no conflict of interest

Data Availability Statement: Data are available upon request from the authors

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