ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

# Trend and Spatial Geographical Distribution of the Reemergence of Diphtheria in Plateau State, North-Central Nigeria

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**DOI: https://doi.org/10.51244/IJRSI.2025.120800083**

**Received: 23 Aug 2025; Accepted: 30 Aug 2025; Published: 06 September 2025**

## ABSTRACT

**Background**: Diphtheria, an infectious disease caused by Corynebacterium diphtheriae, is a major worldwide health problem due to its high incidence and prevalence, especially among children. Nigeria is among the African countries with the highest reported cases in the North-central geopolitical zone, with Plateau State being particularly affected.

**Objective**: This study aimed to identify Diphtheria trends and spatial geographic distribution in Plateau State, Nigeria.

**Methodology**: The study used a retrospective cross-sectional and ecological design to understand the temporal trends and spatial distribution of diphtheria cases across Plateau State from January 2015 to December 2024. The sample size was determined by the number of diphtheria cases reported by the WHO from 2015 to 2024. Purposive sampling was used based on the location of suspected, confirmed, and death cases in 17 Local Government Areas (LGAs). Data was extracted from WHO databases and visualised using ArcGIS software. The study adhered to ethical guidelines, ensuring unbiased analysis and open disclosure. Data were analysed using SPSS 25.0 and ArcGIS, and the Chi-square test was used to examine the relationship between LGAs and classification and vaccination at a significance level of 0.05.

**Results**: The study revealed that Kenam had the highest incidence of suspected, confirmed, and fatal cases among the 441 LGAs, followed by Barkin-Ladi and Jos-North. The lowest incidence was found in Jos-East, Kanke, and Langtang-South. The most confirmed cases were found in Kenam, followed by Jos-East, Kanke, and Langtang-South. The research also found a significant correlation between local government areas and diphtheria incidences, with 59.2% of Kanam's population vaccinated.

**Conclusion**: There is a significant trend and spread of suspected cases of Diphtheria in Plateau State, with a few confirmed cases. Kanem LGA recorded high suspicion, confirmed, vaccinated, and uncertainty about people's vaccinated status. It is therefore recommended that WHO and PSHMB take prompt action by immunising those who are not afflicted, educating the public about diphtheria symptoms, re-introducing booster shots, identifying symptomatic individuals early, and reducing geographic spread factors.

**Keywords:** Diphtheria, confirmed, Plateau State, suspected, trend, vaccinated, LGAs

## INTRODUCTION

Diphtheria, an infectious disease caused by the bacterium Corynebacterium diphtheriae, is a major worldwide health problem due to its high incidence and prevalence, especially among children (Atete et al., 2024; Harapan et al., 2019; CDCP, 2024). Despite vaccine efforts, the disease remains a concern in areas with limited healthcare facilities and low vaccination coverage (WHO, 2017). Diphtheria creates a potent exotoxin that causes a thick, greyish film in the throat and upper respiratory tract, causing both local tissue destruction and systemic consequences such as myocarditis, neuropathy, and respiratory failure. The disease is highly contagious but preventable. It typically affects the pharynx, tonsils, and nose, but it can also injure essential

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organs such as the heart, kidneys, and nervous system (Adegboye et al., 2023; Bawa, Olumuyiwa & Ibrahim, 2020; Atere et al., 2024).

Diphtheria was a significant cause of infant mortality in the early 20th century, particularly in temperate regions (Ahmed *et al*., 2023). The diphtheria incidence rate in Canada was 98 per 100,000 in 1924 and decreased to approximately 0 per 100,000 by 1969 following the vaccine's introduction in 1926. In 1940, the annual incidence of diphtheria in England and Wales was over 61,000, with 3,283 fatalities. According to the World Health Organisation (WHO, 2020), the annual global incidence was approximately 100,000 in 1980, but it experienced a precipitous decline to 10,000 by 2010. Nevertheless, in the past decade, numerous outbreaks have occurred in Nigeria and South Africa, India, Indonesia, Thailand, Lao PDR, the Philippines, Vietnam, the border between Bangladesh and Myanmar, Brazil, Colombia, Haiti, Venezuela, Madagascar, and Yemen. An attempt to eliminate diphtheria, particularly in Africa, is a significant challenge. This endemic is one of the causes of morbidity and mortality in developing nations (Rintani et al., 2018). As of October 9, 2023, 14,587 instances were documented in four African Union Member States, with Nigeria accounting for more than 90% (CDCP, 2024). The outbreaks have affected people from other countries without prior vaccines, with more than 65% of cases having no vaccination record. Women account for 62% of cases, and socioeconomic differences add to the burden of diphtheria. Outbreaks are frequently related to overcrowded living circumstances, poor hygiene standards, and impediments to healthcare access. Nigeria reported 493 cases of diphtheria in Lagos and Kano due to inadequate pentavalent vaccine coverage, poor sanitation, and surveillance systems (NCDC, 2023). There were 31,129 documented suspected cases of diphtheria in 36 states, encompassing 318 local government areas (LGAs). Out of them, 18,250 (59%) were verified, resulting in 863 fatalities. Of the verified instances, 369 (2%) were identified by laboratory testing, 515 (3%) through epidemiological linkage, and 17,366 (95%) through clinical compatibility (WHO, 2023; NCDC, 2024). The national trend is declining. The case fatality ratio (CFR) for suspected patients was 8%. There were 7,086 suspected cases, with 4,185 (59%) confirmed and 76 fatalities. Nearly 99% of known cases originated from Kano, Yobe, Borno, Bauchi, and Katsina; 60% of the confirmed patients are female, and 26% are completely vaccinated (WHO, 2023, and NCDC, 2024).

Diphtheria cases worldwide have declined since 2000, with the highest total recorded in 2017 at 8,819 (Harapan et al., 2019; CDCP, 2024; Aborode *et al.,* 2023). The global average of yearly cases during the last 5-year interval was 6,582, reflecting a 37% rise from the preceding 5-year average of 4,809 cases between 2008 and 2012 (WHO, 2020). The Southeast Asia region consistently reports the majority of worldwide diphtheria cases annually. In the European Region, the incidence dropped by 95%, from 1.82 cases per million people in 2000 to 0.07 cases per million population in 2009. 85% of cases originated from Russia and Ukraine. However, Latvia, with a population of under two million, recorded the highest yearly incidence from 2000 to 2009 (Wagner, 2015). Diphtheria has been recorded at 29.9% of cases in the African region from 2013 to 2022 (WHO, 2024). The majority of African nations have inadequate DTP3 vaccination coverage. Starting in July 2023, at least five African countries (Guinea, Mauritania, Niger, Nigeria, and South Africa) have reported an atypical surge in diphtheria cases and are now facing active epidemics. Nigeria experienced a diphtheria epidemic in 2019, with over 20,000 cases, despite the World Health Organisation's prediction of a decrease in infections from 100,000 in 1980 to fewer than 10,000 in 2021. The Nigerian Centre for Disease Control reported a diphtheria epidemic in four of Nigeria's 36 states, with 128 confirmed cases and 38 deaths (NCDC, 2023). This outbreak occurred within 18 days of 189 fatalities attributed to Lassa fever and 63 instances of Lassa fever among healthcare practitioners in 2022 (WHO, 2023). As of February 14, there were 216 reported instances of diphtheria, resulting in 40 fatalities in less than a month (WHO, 2024). The NCDC reported 523 suspected cases across Kano, Yobe, Katsina, Lagos, and Osun states. Kano had the highest number of suspected cases (396), followed by Yobe with 78 and Katsina with 34 (Ikejezie et al., 2023). The World Health Organisation rated Nigeria's 2020-2024 data as the fourth highest, indicating a diphtheria reemergence in the country (WHO, 2024).

**Table 1: Nigeria Reported Cases of Diphtheria from 1975-2024 (WHO)**

| Period | Confirmed Cases |
|---|---|

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| | |
|---|---|
| 2020-2024 | 5341 |
| 2015-2019 | 4159 |
| 2010-2014 | 0 |
| 2005-2009 | 312 |
| 2000-2004 | 7253 |
| 1995-1999 | 2753 |
| 1990-1994 | 9479 |
| 1985-1989 | 11551 |
| 1980-1984 | 2144 |
| 1975-1979 | 2144 |

Source: extracted from the WHO report 2024

**Table 2: Distribution of diphtheria cases and deaths in Nigeria, epi-week 19 2022 - epi-Week 48 2023**

| North-Central State | Suspected Cases | Confirmed Cases | Death among Confirmed Cases |
|---|---|---|---|
| Plateau | 66 | 31 | 15 |
| Nasarawa | 7 | 1 | 1 |
| Niger | 11 | 2 | 0 |
| Benue | 0 | 0 | 0 |
| Kogi | 36 | 0 | 0 |
| Kwara | 1 | 0 | 0 |
| | | | |

Source: Extracted from the WHO report 2024

The WHO report (2024) revealed the distribution of diphtheria in North-Central Nigeria from epi-week 19, 2022, to epi-week 48, 2023. Plateau State had the highest suspected cases, 66, the highest confirmed cases, and the highest deaths among confirmed cases. This necessitated the observation of each LGA in the state to understand the trend of diphtheria.

Plateau State, located in north-central Nigeria, has a history of vaccine-preventable diseases due to socio-political difficulties, inadequate healthcare infrastructure, and restricted vaccination coverage. The World Health Organisation attributes diphtheria epidemics in Nigeria and Plateau to inadequate vaccination rates, especially in northern and rural areas. In these areas, diphtheria cases are frequently underreported due to insufficient monitoring and diagnostic facilities, complicating the determination of correct prevalence estimates. Research by Ibrahim et al. (2022) revealed that diphtheria incidence in Plateau State predominantly affects children under 15 years old, who are particularly susceptible to inadequate vaccination regimens. The research identified a link between outbreaks and population migrations, especially among internally displaced persons (IDPs) escaping conflict, which has hindered vaccination initiatives (Ibrahim et al., 2022). The Case

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Fatality Rate (CFR) of diphtheria in Plateau State is increasing due to treatment delays, inadequate healthcare infrastructure, and the absence of diphtheria antitoxin (DAT), which is essential for efficient disease management (Olulaja et al., 2023). A study from the Nigeria Centre for Disease Control (NCDC) (2020) indicated that Plateau State had a fatality rate of roughly 10% for recorded diphtheria cases, underscoring the necessity for further public health interventions and vaccination initiatives. This serves as the basis for undertaking a diphtheria trend and spatial geographic study in Plateau State.

# METHODOLOGY

## Study area

Plateau State is situated in the North Central Region of Nigeria, positioned between latitudes 8.371° N and 10.301° N and longitudes 7.401° E and 8.371° E. Plateau State was delineated from Benue-Plateau State in 1979. A subsequent division occurred in 1996 when Nassarawa State was established, after forming other states in Nigeria. The state borders Bauchi State to the north, Taraba State to the east, Nassarawa State to the south, and Kaduna State to the west. The state encompasses an area of 26,901 square kilometres (Timothy, 2006). Plateau State has 17 Local Government Areas: Barkin Ladi, Bassa, Bokkos, Jos East, Jos North, Jos South, Kanam, Kanke, Langtang North, Langtang South, Mangu, Mikang, Pankshin, Qu'an-Pan, Riyom, Shendam, and Wase (see Figure 1).

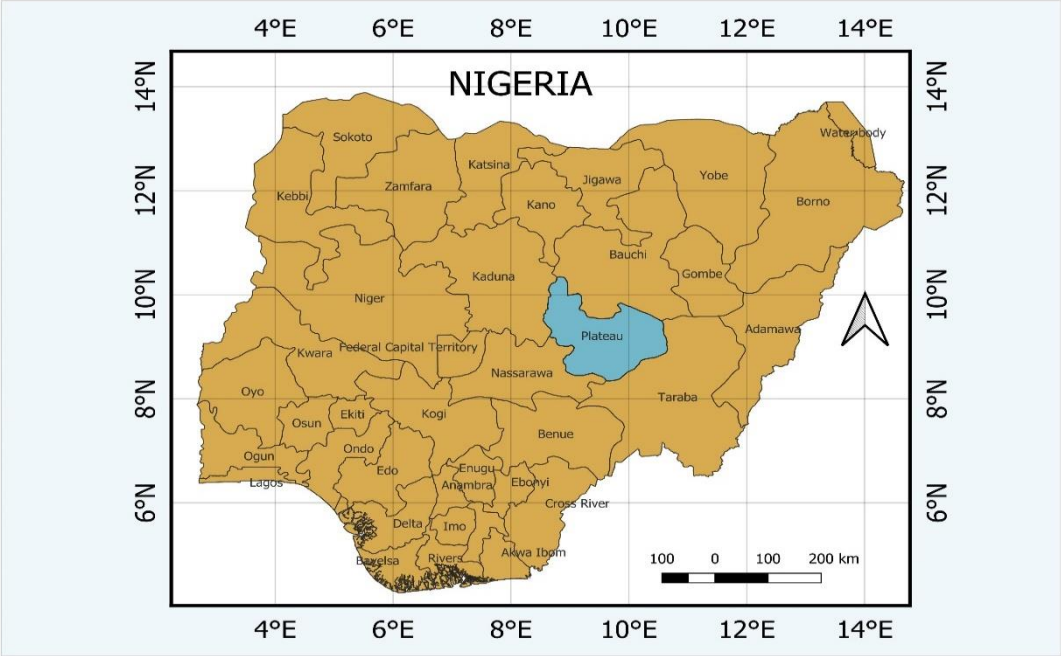


Figure 1: Nigeria showing Plateau State

## Study Design

The study employed a retrospective cross-sectional and ecological design using secondary data from the World Health Organisation (WHO) surveillance reports. The design was suitable for understanding the temporal trends and spatial distribution pattern of diphtheria cases across Plateau State, from January 2015 to December 2024.

## Study Population/Inclusion and Exclusion Criteria

The population of the study is the precise and target population considered for the research. For this study, all suspected and confirmed diphtheria cases reported in Plateau State at the time of investigation were included with the following inclusion criteria:

i. Cases reported between 2015 and 2024

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ii. Suspected and confirmed diphtheria cases from WHO (clinical and laboratory confirmed)

iii. Vaccinated and unvaccinated persons' records

iv. Geographic locations

While exclusion includes

i. Cases outside the geographical location of Plateau State

ii. Missing demographic information

iii. Cases outside Diphtheria

**Sample size**

The study was based on secondary data; therefore, the sample size was determined by the number of diphtheria cases reported by the WHO from 2015 to 2024. A record of 441 suspected, confirmed, and fatal cases was considered the sample size.

**Sampling Technique**

The study used purposeful sampling based on the geographical location of suspected, confirmed, and death cases of diphtheria in the 17 LGAs.

**Instrument and Method of Data Collection**

Data was extracted from the WHO databases of the Plateau State office between 2015 and 2024 based on a design template using Microsoft Excel for weekly epidemiological records, outbreaks of diseases, and disease surveillance (IDSR). Secondly, ArcGIS (GIS) software was used to visualise the spatial distribution of diphtheria cases in the state. Data were retrieved on suspected and confirmed death cases, as well as vaccination coverage areas, afterwards.

**Ethics**

The study adheres to ethical guidelines by relying on pre-approved WHO data, respecting anonymity, and ensuring unbiased analysis. However, open disclosure of limits, accurate data attribution, and avoiding damaging misunderstandings that can influence public health regulations or opinion are all necessary for ethical rigour.

**Data analysis and measurement of variables**

The data collected were analysed using SPSS 25.0 and the ArcGIS application to study the trend and spatial distribution of diphtheria in Plateau State. Simple descriptive statistics were used, and the results were presented in tabular form and maps. Chi-square was used to test the relationship among LGAs against classification and vaccination at 0.05.

## RESULTS AND DISCUSSION

According to Table 3, the distribution of diphtheria cases among LGAs shows that Kenam has the highest number of suspected cases, with approximately 155 cases, followed by Barkin-Ladi with 62 cases, and Jos-North with 38 cases. The least were found in Jos-East, Kanke and Langtang-South with only three reported cases. Cases reported to be confirmed after laboratory examination were found to have 99 cases in Kanam and only 3 in Jos-North, while death cases among all the LGAs were found to have 7 in Kanam, 6 in Jos-North, 5 in Barkin-Ladi and 2 in Langtang-South, with only 1 in Kanke and Langtang-North, respectively.

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Table 3: Distribution of Suspected, Confirmed and Death Cases of Diphtheria in Plateau State LGAs 2023-2024

| **Local Government Area**<br><br>**LGAs** | **Suspected Cases** | **Confirmed Cases** | **Death Cases among Suspected & Confirmed Cases** |
|---|---|---|---|
| Barkin-Ladi | 62 | - | 5 |
| Bassa | 7 | - | |
| Bokkos | 20 | - | |
| Jos-East | 3 | - | |
| Jos-North | 38 | 3 | 6 |
| Jos-South | 11 | - | |
| Kenam | 155 | 99 | 7 |
| Kanke | 3 | - | 1 |
| Langtang North | 17 | - | 1 |
| Langtang South | 3 | - | 2 |
| Mangu | 28 | - | - |
| Mikang | 9 | - | - |
| Pankshin | 17 | - | - |
| Riyom | 15 | - | - |
| Shendam | 29 | - | - |
| Wase | 24 | - | - |
| Total | 441 | 102 | 22 |

Source: WHO (2024)

It is diagrammatically represented through ArcGIS in the Maps below

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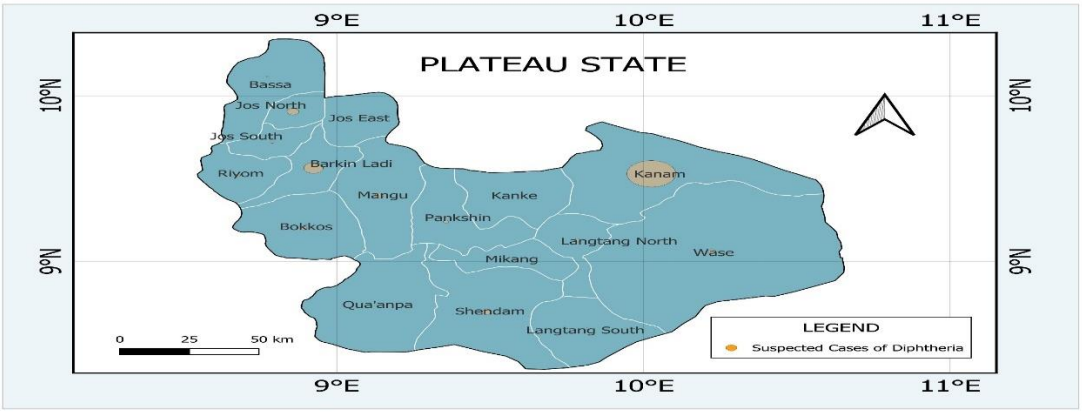


Figure 2: Diphtheria Suspected Cases in LGAs of Plateau State

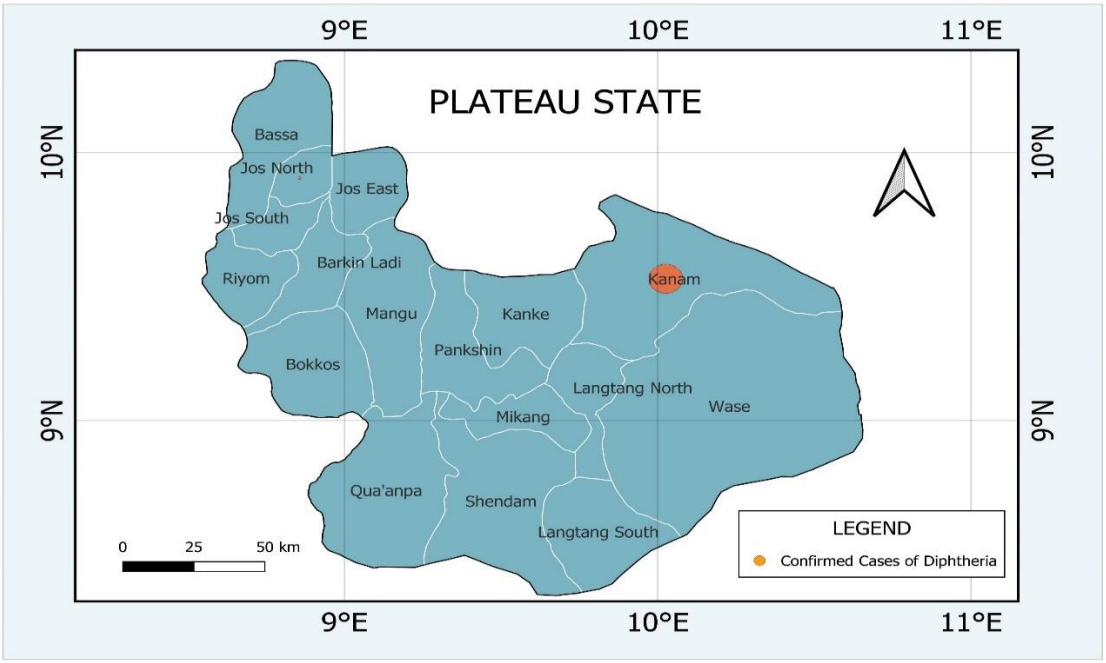


Figure 3: Diphtheria Confirmed Cases in LGAs of Plateau State

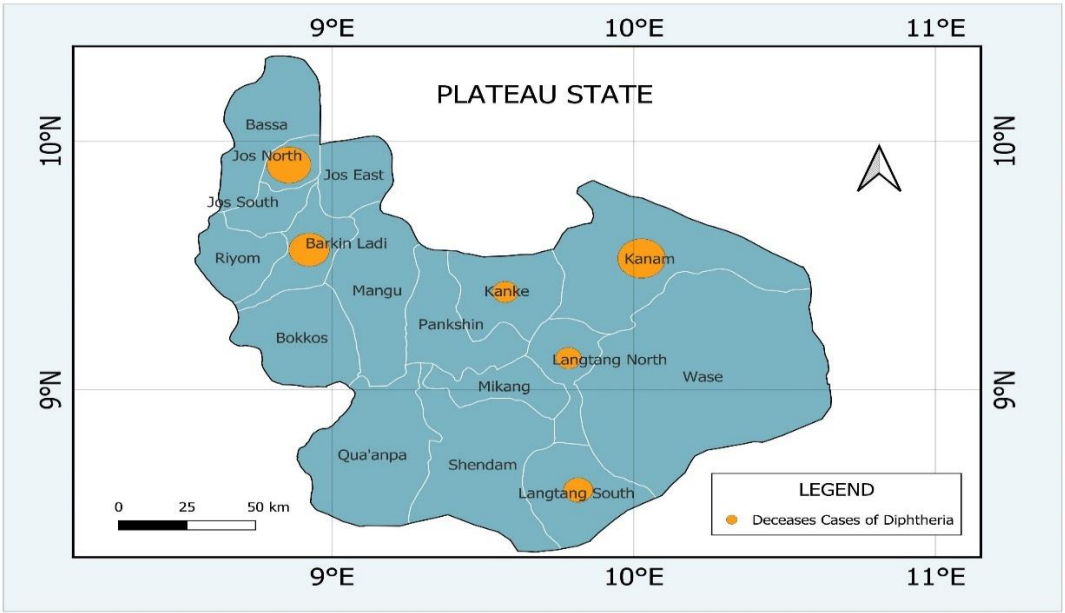


Figure 4: Diphtheria Cases of Death among the LGAs of Plateau State.

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Diphtheria classification cases based on LGAs in Table 4 reveal the following: 14.1% of suspected cases in Barkin-Ladi, 1.6% not yet classified, 14.3% not a case, and 1.6% suspected cases in Bassa. Additionally, there are 4.5% suspected cases against 21.4%, and 1.9% not a case, as well as confirmed cases in Bokkos. However, 35.1% of suspected cases in Kanam were recorded, the highest, followed by 14.1% suspected cases in Barkin-Ladi and 6.6% suspected cases in Shendam. At the same time, the least were Jos-East, Kanke, and Langtang-South, with 0.7%. The confirmed cases were only in Kanam, with 95.2%; Jos-North, 2.9%; and Bokkos, 1.9%. Jos-South has the highest non-case rate, with 42.9%, followed by Bokkos, 21.4%, and Bassa and Jos-North, 14.3%. For the not yet classified, Pankshin has the highest with 79.7%, then Jos-North with 12.5%, and Langtang-North with 4.7%. Of the probable cases, only Jos-North has 100%, while the others have none. This indicates that a high number of suspected and confirmed cases were found in Kenam, with no cases in Jos-South, no cases yet classified in Pankshin, and a probable case in Jos-North. This also shows the relationship between LGAs and cases of diphtheria in the study, with a chi-square result revealing a strong significance at 0.05 ($\chi 2 = 0.000; 500.112$).

Table 4: Distribution of Diphtheria Classification Cases and LGAs in Plateau State

| | | | | | | **Total** |
|---|---|---|---|---|---|---|
| | **Confirmed Cases** | **Not a case** | **Not yet classified** | **Probable case** | **Suspect case** | |
| Barkin-Ladi | 0 | 0 | 1 | 0 | 62 | 63 |
| | 0.0% | 0.0% | 1.6% | 0.0% | 14.1% | 10.1% |
| Bassa | 0 | 2 | 0 | 0 | 7 | 9 |
| | 0.0% | 14.3% | 0.0% | 0.0% | 1.6% | 1.4% |
| Bokkos | 2 | 3 | 0 | 0 | 20 | 25 |
| | 1.9% | 21.4% | 0.0% | 0.0% | 4.5% | 4.0% |
| Jos-East | 0 | 0 | 0 | 0 | 3 | 3 |
| | 0.0% | 0.0% | 0.0% | 0.0% | 0.7% | 0.5% |
| Jos-North | 3 | 2 | 8 | 2 | 38 | 53 |
| | 2.9% | 14.3% | 12.5% | 100.0% | 8.6% | 8.5% |
| Jos-South | 0 | 6 | 0 | 0 | 11 | 17 |
| | 0.0% | 42.9% | 0.0% | 0.0% | 2.5% | 2.7% |
| Kenam | 99 | 0 | 0 | 0 | 155 | 254 |
| | 95.2% | 0.0% | 0.0% | 0.0% | 35.1% | 40.6% |
| Kanke | 0 | 0 | 0 | 0 | 3 | 3 |
| | 0.0% | 0.0% | 0.0% | 0.0% | 0.7% | 0.5% |
| Langtang-North | 0 | 0 | 3 | 0 | 17 | 20 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | 0.0% | 0.0% | 4.7% | 0.0% | 3.9% | 3.2% |
| Langtang-South | 0 | 0 | 1 | 0 | 3 | 4 |
| | 0.0% | 0.0% | 1.6% | 0.0% | 0.7% | 0.6% |
| Mangu | 0 | 1 | 0 | 0 | 28 | 29 |
| | 0.0% | 7.1% | 0.0% | 0.0% | 6.3% | 4.6% |
| Mikang | 0 | 0 | 0 | 0 | 9 | 9 |
| | 0.0% | 0.0% | 0.0% | 0.0% | 2.0% | 1.4% |
| Pankshin | 0 | 0 | 51 | 0 | 17 | 68 |
| | 0.0% | 0.0% | 79.7% | 0.0% | 3.9% | 10.9% |
| Riyom | 0 | 0 | 0 | 0 | 15 | 15 |
| | 0.0% | 0.0% | 0.0% | 0.0% | 3.4% | 2.4% |
| Shendam | 0 | 0 | 0 | 0 | 29 | 29 |
| | 0.0% | 0.0% | 0.0% | 0.0% | 6.6% | 4.6% |
| Wase | 0 | 0 | 0 | 0 | 24 | 24 |
| | 0.0% | 0.0% | 0.0% | 0.0% | 5.4% | 3.8% |
| Total | 104 | 14 | 64 | 2 | 441 | 625 |
| | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Source: WHO (2024) X2= 0.000; (645.388)

Table 5 presents the diphtheria cases against vaccination in LGAs of Plateau State. The vaccination rates were 59.2% in Kanam, 9.6% in Shendam, and 8.8% in Barkin-Ladi, out of a total of 260 individuals in the study. In contrast, Kanam had 45% for the unvaccinated, followed by Wase with 30% and Langtang-North with 11.7%. The unknown category represented individuals who did not know whether they were vaccinated, with Kenem reported to have the highest rate at 71.4%, followed by Barkin-Ladi at 17.9%. This indicates that Kanam has the highest number of individuals who are either vaccinated, unvaccinated, or uncertain about their vaccination status. However, the chi-square result is statistically significant at 0.05 ($\chi 2 = 0.000$; df = 1).

Table 5: Distribution of Diphtheria Cases in LGAs against Vaccination in Plateau State

| | LGAs | Unknown | Unvaccinated | Vaccinated | Total |
|---|---|---|---|---|---|
| | Barkin Ladi | 15 | 3 | 23 | 41 |
| | | 17.9% | 5.0% | 8.8% | 10.1% |
| | Bassa | 0 | 0 | 3 | 3 |

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| | | | | | |
|---|---|---|---|---|---|
| | | 0.0% | 0.0% | 1.2% | 1.4% |
| | Bokkos | 0 | 2 | 8 | 10 |
| | | 0.0% | 3.3% | 3.1% | 4.0% |
| | Jos East | 0 | 0 | 3 | 3 |
| | | 0.0% | 0.0% | 1.2% | 0.5% |
| | Jos North | 0 | 0 | 5 | 5 |
| | | 0.0% | 0.0% | 1.9% | 8.5% |
| | Jos South | 1 | 1 | 9 | 11 |
| | | 1.2% | 1.7% | 3.5% | 2.7% |
| | Kanam | 60 | 27 | 154 | 241 |
| | | 71.4% | 45.0% | 59.2% | 40.6% |
| | Kanke | 0 | 0 | 3 | 3 |
| | | 0.0% | 0.0% | 1.2% | 0.5% |
| | Langtang North | 4 | 7 | 2 | 13 |
| | | 4.8% | 11.7% | 0.8% | 3.2% |
| | Langtang South | 0 | 0 | 3 | 3 |
| | | 0.0% | 0.0% | 1.2% | 0.6% |
| | Mangu | 0 | 2 | 7 | 8 |
| | | 0.0% | 3.3% | 2.7% | 4.6% |
| | Mikang | 0 | 0 | 7 | 7 |
| | | 0.0% | 0.0% | 2.7% | 1.4% |
| | Pankshin | 0 | 0 | 5 | 5 |
| | | 0.0% | 0.0% | 1.9% | 10.9% |
| | Riyom | 4 | 0 | 3 | 7 |
| | | 4.8% | 0.0% | 1.2% | 2.4% |
| | Shendam | 0 | 0 | 25 | 25 |
| | | 0.0% | 0.0% | 9.6% | 4.6% |
| | Wase | 0 | 18 | 0 | 18 |

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| | | | | | |
|---|---|---|---|---|---|
| | | 0.0% | 30.0% | 0.0% | 3.8% |
| Total | | 84 | 60 | 260 | 403 |
| | | 100.0% | 100.0% | 100.0% | 100.0% |

Source: WHO (2024) $\chi 2 = 0.000; 500.112$

## CONCLUSION

The study indicates that among the 17 LGAs, Kenam had the highest incidence of suspected, confirmed, and fatal cases, followed by Barkin-Ladi with 62 cases and Jos-North with 38 instances. The lowest incidence was recorded in Jos-East, Kanke, and Langtang-South, each reporting only 3 cases. The most confirmed cases were identified in Kenam, followed by Jos-East, Kanke, and Langtang-South. Diphtheria cases were classified in many LGAs, and the most confirmed cases were recorded in Kanam, Jos-North, and Bokkos. Jos-South recorded one of the highest percentages of non-cases. The research revealed a significant correlation between local government areas and diphtheria incidences, with 59.2% of the population in Kanam vaccinated.

In comparison, the highest rates of unvaccinated persons were observed in Kanam (45%), Wase (30%), and Langtang-North (11.7%). A strong positive significance at 0.05 was observed among the LGAs. Since diphtheria is contagious and the outbreak is intensifying, immediate intervention through vaccination of those unaffected was suggested to the WHO and PSHMB to curtail the spread of diphtheria in Plateau State, Nigeria, Africa, and the world. Furthermore, public enlightenment about the signs and symptoms of diphtheria, re-introducing booster vaccinations through door-to-door immunisation for immunocompromised individuals, facilitating early identification of symptomatic individuals, and enhancing contact tracing are crucial measures. Additionally, the government, global partners, and individuals should mitigate factors contributing to the geographical spread of diphtheria.

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ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

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