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Original Research Article

CURRENT RABIES EPIDEMIOLOGY IN NIGERIA (2015-2024): A SPATIOTEMPORAL AND VACCINATION COVERAGE ANALYSIS FROM THE WORLD ANIMAL HEALTH INFORMATION SYSTEM

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ABSTRACT

Rabies remains a fatal viral zoonosis affecting all warm-blooded animals. This study analyzed temporal trends, spatial distribution, and vaccination coverage of rabies in Nigeria from 2015 to 2024. Using open-access records, a retrospective study was conducted to evaluate the number of Rabies cases in Nigeria in the last decade (January 2015-December 2024). Secondary epidemiological data, extracted from the World Animal Health Information System, were analyzed using Quantum Geographic Information System, while the computation for attack rates, case fatality rates, and vaccination coverage were done using SPSS version 26. Descriptive statistics was used to summarize temporal trends, geographic disparities, and species-specific burdens. A total of 1,037 cases and 408 deaths were reported, giving an overall CFR of 39.3%. The highest attack rate occurred in 2016 (20,000/100,000), while 2020–2024 recorded the lowest. In 2024, cases peaked (n = 191) despite a lower CFR (11.0%). Vaccination coverage was poor (19.7%), with a peak in 2017 and most states recording zero coverage; Kaduna achieved the highest (380.2%). Plateau State reported the most cases (n = 555) and deaths (n = 244), while Anambra had the fewest. Dogs accounted for 95.2% of cases, though rabbits (100.0%) and cattle (50.0%) had the highest CFRs. Our findings revealed a persistent rabies burden across the country, and critical vaccination gaps among dogs and other domestic species. Strengthening prevention strategies will require sustained vaccination campaigns, improved surveillance and disease reporting system, and integrated One Health approaches to reduce incidence and mortality associated with rabies.

Keywords: Epidemiology, Rabies, Vaccination, Zoonosis

INTRODUCTION

Rabies is a zoonotic, fatal and progressive neurotropic infection caused by the rabies virus of the genus *Lyssavirus* and family Rhabdoviridae (Wunner, 2019; Arif *et al*., 2023). It affects all warm-blooded animals, and the disease is prevalent throughout the world and endemic in many countries except in Islands like Australia and Antarctica (Kumar *et al*., 2023; Singh *et al*., 2017). It is a major public and veterinary health concern, particularly in developing countries like Nigeria, and is seen as a neglected disease worldwide (Adesola *et al*., 2023; Eugene *et al*., 2025; Khan *et al*., 2025). Domestic dog is the primary reservoir host responsible for the maintenance and transmission of rabies, contributing to 99% of human rabies in endemic regions (Kalthoum *et al*., 2021; Lushasi *et al*., 2021). Canine rabies is endemic and appropriate facilities are often not available for intensive medical care (Kipanyula, 2015). The burden of rabies is disproportionately high due to several factors, including large populations of free-roaming dogs, limited access to post-exposure prophylaxis, and inadequate public awareness (Changalucha *et al*., 2019; Walwa *et al*., 2024).

The World Organisation for Animal Health (WOAH), formerly OIE, classifies rabies as a notifiable disease, hence it has a mandatory reporting status in member countries,

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including Nigeria. The World Animal Health Information System (WAHIS) is an open-source, internationally standardized web-based disease reporting system portal, and managed by WOAH (WOAH, 2025). It provided the template on which the Nigerian-based National Animal Disease Information System (NADIS) was developed. NADIS is the official conduit through which Nigeria submits disease data to the global platform, via the office of the Chief Veterinary Officer of Nigeria (FRN, 2019). WAHIS is recognized by the Global Alliance for Rabies Control (GARC), which partners collaboratively with the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organisation for Animal Health (WOAH), amongst others. This partnership developed a global strategic plan which birthed the 'United Against Rabies' forum targeted at achieving zero human death from dog-mediated rabies by 2030 (GARC, 2018).

Globally, over 60,000 people die every year due to rabies, while approximately 15 million people receive rabies Post-Exposure Prophylaxis (PEP) annually (Hampson *et al*., 2019; Holzbauer *et al*., 2023). Apart from the direct health implication, rabies also has significant socioeconomic impacts in Nigeria. One of these is the high costs of post-exposure prophylaxis (PEP) in human cases, which can be quite unaffordable for many families in low-resource settings (Adetayo *et al*., 2021). In livestock farming, losses due to rabies can also severely affect rural livelihoods in developing nations, where animals are vital for economic stability (Knobel *et al*., 2005; Azalu *et al*., 2025). Furthermore, psychological trauma, and sometimes stigma, associated with rabies exposure is palpable within affected communities (Bashir *et al*., 2022).

Effective control of rabies relies on sustained monitoring of animal cases and strategic vaccination of susceptible populations (Rattanavipapong *et al*., 2019; Aborode *et al*., 2025; Mwanyalu *et al*., 2025). However, routine documentation and analysis of animal rabies cases in Nigeria have been fragmented, limiting the capacity for evidence-based interventions (Mshelbwala *et al*., 2021). Poor countries in Africa often fail to obtain the necessary immunization coverage, making it difficult to undertake a state-wide vaccination campaign. According to a recent assessment, understanding rabies epidemiology is essential for launching more focused and successful immunization campaigns (Wobessi *et al*., 2021). To implement a global rabies elimination strategy tailored to the Nigerian setting, it would be crucial to have a general understanding of the epidemiology of rabies in Nigeria. This study therefore evaluated the epidemiological trends and geographic distribution of rabies in animals across Nigeria over a ten-year period (2015–2024), and assess the extent of vaccination coverage among susceptible animal species.

MATERIALS AND METHODS

This study conducted a retrospective study of open-access records to evaluate the number of rabies cases in Nigeria over the last ten years (January 2015-December 2024). The data were extracted from the World Animal Health Information System (WAHIS; https://wahis.woah.org) maintained by the World Organization for Animal Health (WOAH). The following variables were extracted from the database: 1. Yearly and immediate reports of Rabies outbreaks in Nigeria; 2. Number of Rabies cases, deaths, susceptible, and slaughtered animal population; 3. Geographical location (state/region); 4. Species affected (dogs), and 5. Control measures applied (vaccination, movement control, etc.). Our data focused on officially reported rabies outbreaks in Nigeria. Map visualization was performed using Quantum Geographic Information System (QGIS; Version 3.38.3), a free and open-source GIS platform. Administrative boundary data were obtained from the publicly accessible Global Administrative Areas (GADM) database (University of California, Berkeley), with boundaries at the state level incorporated into the spatial analyses.

The rabies epidemiological data (2015–2024) were analyzed using SPSS version 26 to compute attack rates (AR), case fatality rates (CFR), and vaccination coverage nationally and stratified by year, state, and species. AR was calculated as (Cases/Susceptible Animals) ×100,000; CFR as (Deaths/Cases) ×100, and vaccination coverage as (Vaccinated Animals/Susceptible Animals) × 100. ‘Susceptible Animals’, in this context, refer to unvaccinated domestic animal species capable of contracting and transmitting rabies, related to a specific documented rabies cases at a specific period and location, while “Vaccinated animals” are the susceptible animals recorded by competent veterinary authorities as having received anti-rabies vaccination during the reporting period (WOAH, 2025). Descriptive statistics (frequencies and percentages) was used to summarize temporal trends, geographic disparities, and species-specific burdens.

RESULTS

Over the ten-year period, a total of 1,037 rabies cases were recorded across Nigeria, with 408 deaths, resulting in an overall case fatality rate (CFR) of 39.3%. The attack rate (AR) varied widely by year, with the highest in 2016 (20,000.0 per 100,000) despite low case numbers, indicating very few susceptible animals that year. The lowest ARs were seen from 2020–2024, reflecting broader animal surveillance. Rabies deaths peaked in 2018 (84 deaths) and 2019 (73 deaths). Interestingly, the highest number of cases occurred in 2024 (191 cases), yet the CFR had significantly dropped to 11.0%, possibly due to better case management or underreporting of fatalities. Vaccination coverage remained poor across most years, with only 19.7% of susceptible animals vaccinated over the decade. The highest vaccination effort was in 2017 (3,000 animals vaccinated), while multiple years such as 2015, 2016, 2020, and 2022 had zero recorded vaccinations (Figure I; Table I).

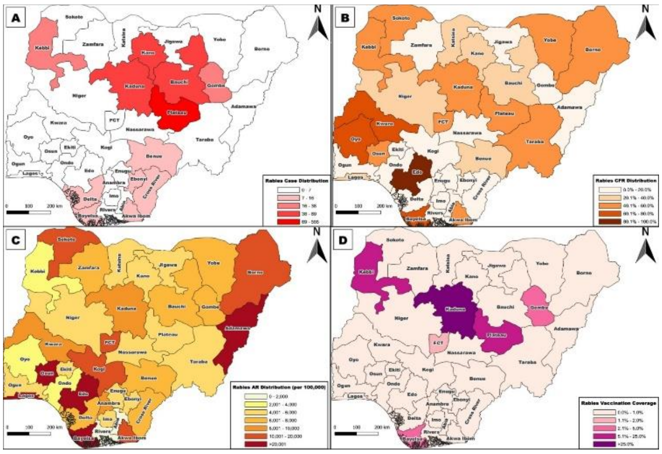

Figure I: Distribution of Rabies in Nigeria (2015- 2024): A. Total reported cases B. Case fatality rate (CFR) C. Attack rate (AR) D. Vaccination coverage

Figure II illustrates the evolving epidemiological dynamics of rabies in Nigeria from 2015 to 2024 by comparing total cases, attack rates (AR), and case fatality rates (CFR). Over this decade, total reported cases of rabies increased substantially—from just 5 cases in 2015 and a single case in 2016 to a peak of 191 cases in 2024. This steady rise, particularly from 2017 onward, suggests either a worsening rabies burden, improved case detection, or broader surveillance efforts.

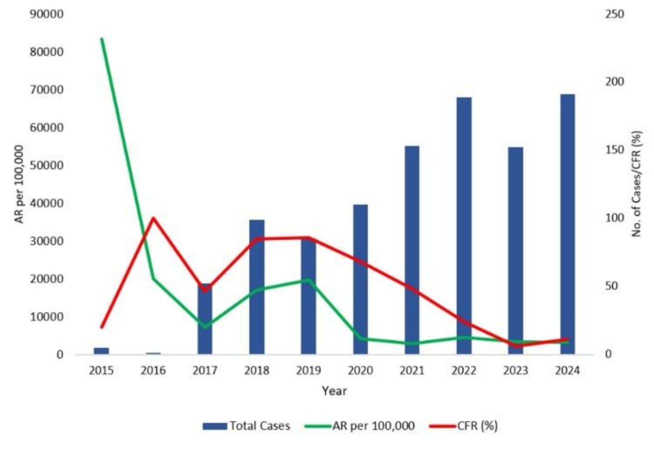

Figure II: Temporal Trends in Rabies Incidence, Attack Rates, and Case Fatality in Nigeria, 2015-2024

In contrast, the attack rate showed a reverse trend, starting with extremely high values in the early years—most notably 83,333.3 per 100,000 in 2015 and 20,000.0 in 2016—despite very few cases. These inflated AR values are likely due to the small number of documented susceptible animals at the time, highlighting underestimation in denominator data. As reporting systems improved, the AR declined and stabilized in later years, ranging between 2,819.5 and 4,590.4 from 2020 to 2024. This shift reflects more realistic estimations of at-risk populations and suggests more reliable epidemiological monitoring in recent years.

The CFR exhibited a marked decline over the study period. It was extremely high in the early and middle years—reaching 100% in 2016 and remaining above 80% in 2018 and 2019—indicating high mortality among confirmed cases and possibly poor access to timely treatment. However, from 2020 onward, CFR dropped steadily, reaching just 5.9% in 2023 and 11.0% in 2024. This downward trend may reflect improved awareness, quicker access to post-exposure prophylaxis, and better case management practices.

Table I: Annual Rabies Epidemiological Summary in Nigeria (2015–2024)

Year	Total Cases	Susceptible Animals	AR per 100,000	Deaths	CFR (%)	Vaccinated Animals	Vaccination Coverage (%)
2015	5	6	83,333.3	1	20.0	0	0.0
2016	1	5	20,000.0	1	100.0	0	0.0
2017	52	717	7,252.1	24	46.2	3,000	418.5
2018	99	579	17,094.0	84	84.8	80	13.8
2019	85	431	19,720.4	73	85.9	208	48.3
2020	110	2,651	4,148.4	75	68.2	0	0.0
2021	153	5,426	2,819.5	74	48.4	10	0.2
2022	189	4,117	4,590.4	46	24.3	0	0.0
2023	152	4,563	3,329.5	9	5.9	22	0.5
2024	191	5,935	3,218.1	21	11.0	1,500	25.3
Total	**1,037**	**24,430**	**4244.8**	**408**	**39.3**	**4,820**	**19.7**

Note: AR= Attack Rate; CFR = Case Fatality Rate

Rabies burden varied markedly by state. Plateau State accounted for the highest number of cases (555 cases) and deaths (244 deaths), but its attack rate (AR) of 4,586.6 per 100,000 was surpassed by states like Bayelsa (AR = 23,333.3) and Lagos (AR = 60,000.0) due to lower numbers of susceptible animals. Kaduna reported a high AR (9,964.4) and remarkably high vaccination coverage (380.2%), likely due to overestimated vaccinations or undercounted susceptible animals.

Several states—Akwa Ibom, Adamawa, Osun, Lagos, and Edo—had extremely high ARs, with Edo recording an AR of 33,333.3 from just one case, reflecting very low denominators. Notably, many states had no vaccinated animals despite high rabies risk, highlighting a concerning gap in prevention. The national average AR across states was 5,463.9 per 100,000, with a CFR of 39.3% and overall vaccination coverage of 25.4% (Table II).

Table II: State-Level Rabies Indicators in Nigeria (2015–2024)

State	Cases	Susceptible Animals	AR per 100,000	Deaths	CFR (%)	Vaccinated	Vaccination Coverage (%)
Plateau	555	12,103	4,586.6	244	44.0	1,509	12.5
Bauchi	89	1,133	7,855.3	31	34.8	0	0.0
Kaduna	84	843	9,964.4	39	46.4	3,205	380.2
Kano	78	1,434	5,439.3	24	30.8	0	0.0
Gombe	38	509	7,465.6	3	7.9	22	4.3
Kebbi	27	716	3,771.0	16	59.3	81	11.3
Akwa Ibom	16	109	14,678.9	9	56.3	0	0.0
Bayelsa	14	60	23,333.3	9	64.3	2	3.3
Delta	14	216	6,481.5	2	14.3	0	0.0
Benue	13	167	7,784.4	3	23.1	0	0.0
Ebonyi	13	277	4,693.1	1	7.7	0	0.0
Cross River	11	156	7,051.3	0	0.0	0	0.0
FCT	7	52	13,461.5	3	42.9	1	1.9
Osun	6	13	46,153.8	3	50.0	0	0.0
Adamawa	6	16	37,500.0	1	16.7	0	0.0
Katsina	6	124	4,838.7	2	33.3	0	0.0
Yobe	6	78	7,692.3	3	50.0	0	0.0
Ogun	6	123	4,878.0	1	16.7	0	0.0
Oyo	6	196	3,061.2	4	66.7	0	0.0
Niger	6	125	4,800.0	2	33.3	0	0.0
Ekiti	5	98	5,102.0	0	0.0	0	0.0
Jigawa	5	92	5,434.8	0	0.0	0	0.0
Zamfara	5	82	6,097.6	0	0.0	0	0.0
Kwara	4	49	8,163.3	3	75.0	0	0.0
Lagos	3	5	60,000.0	1	33.3	0	0.0
Sokoto	2	17	11,764.7	1	50.0	0	0.0
Borno	2	11	18,181.8	1	50.0	0	0.0
Nassarawa	2	40	5,000.0	0	0.0	0	0.0
Taraba	2	37	5,405.4	1	50.0	0	0.0
Edo	1	3	33,333.3	1	100.0	0	0.0
Imo	1	19	5,263.2	0	0.0	0	0.0
Enugu	1	17	5,882.4	0	0.0	0	0.0
Kogi	1	9	11,111.1	0	0.0	0	0.0
Ondo	1	39	2,564.1	0	0.0	0	0.0
Anambra	1	11	9,090.9	0	0.0	0	0.0
Total	**1037**	**18979**	**5463.9**	**408**	**39.3**	**4820**	**25.4**

Note: AR= Attack Rate; CFR = Case Fatality Rate

Table III: Species-Specific Rabies Indicators in Nigeria (2015–2024)

Species	Cases	Susceptible Animals	AR per 100,000	Deaths	CFR (%)	Vaccinated	Vaccination Coverage (%)
Dogs	987	23,088	4,275.9	398	40.3	4,820	20.9
Cats	28	235	11,914.9	4	14.3	0	0.0
Cattle	8	415	1,927.7	4	50.0	0	0.0
Swine	4	53	7,547.2	1	25.0	0	0.0
Sheep	4	90	4,444.4	0	0.0	0	0.0
Goats	4	95	4,210.5	0	0.0	0	0.0
Rabbits	1	20	5,000.0	1	100.0	0	0.0
Equidae	1	20	5,000.0	0	0.0	0	0.0
Total	1,037	24,430	4319	408	39.3	4,820	19.7

Note: AR= Attack Rate; CFR = Case Fatality Rate

Dogs were the primary species affected, responsible for 95.2% (987/1,037) of total cases, with an AR of 4,275.9 per 100,000 and a CFR of 40.3%. All rabies vaccinations recorded during the study period were administered to dogs, giving them a vaccination coverage of 20.9%.

Cats followed distantly with 28 cases but had a strikingly high AR (11,914.9) due to the small number of cats considered at risk. Other affected species included cattle, swine, sheep, goats, rabbits, and equids, though in very low numbers. Rabbits had a CFR of 100%, while cattle showed a 50% fatality rate. No vaccinations were recorded for non-canine species, indicating a narrow vaccination strategy focused only on dogs (Table III).

DISCUSSION

Our study revealed that the total number of reported cases increased significantly from 2015 to 2024, with some fluctuations across the years. This finding aligns with previous studies which reported that the rising trends of reported cases indicate either increased transmission dynamics or enhanced surveillance, while also suggesting not only improvements in disease surveillance systems, but also indicating lapses in preventive measures like vaccination or biosecurity (Li *et al*., 2021; Naïssengar *et al*., 2021; and Kahariri *et al*., 2025). However, enhanced surveillance systems often lead to increased case detection rather than actual surges in disease prevalence (Hampson *et al*., 2015).

Plateau State recorded the highest number of cases, aligning with previous report of the State being a hotspot for animal diseases due to its dense livestock population and intensive animal movement (Braam *et al*., 2024). Despite recording the most cases, its AR was lower than several other states, suggesting a broader susceptible population. States like Akwa Ibom, Lagos, and Bayelsa had extremely high ARs, possibly reflecting outbreaks in smaller susceptible populations. Such outbreaks in states with smaller livestock numbers have been highlighted in studies as high-risk scenarios because they can go unnoticed until mortality increases (Adedeji *et al*., 2010)

Due to a very low number of susceptible animals, the highest AR was reported in 2015, thereby indicating a localized outbreak in a small population. The AR generally fluctuated, reducing after 2015 but remaining significant in 2018 and 2019 before stabilizing in later years. These findings align with Varela *et al*. (2022) where it was reported that high AR in years with fewer susceptible animals suggests intense localized transmission, while lower AR in later years with higher susceptible populations may reflect dilution of risk or underreporting. Similarly, descriptive analyses of the epidemiological data showed the number of reported canine rabies cases greatly underestimates the true incidence of the disease. Underreporting subsequently affects the coherence of its spatial distribution (Khayli *et al*., 2021)

The highest rabies-linked deaths were recorded in 2018 and 2019. The CFR peaked in 2016 at 100%, resulting from a single death out of one reported case. The declining trend noticed with the CFR from 2019 to 2023 agrees with the report from a recent surveillance data from 2014–2023 which showed increased detection of canine rabies outbreaks through improved mechanisms, although geographic coverage remains patchy (Williams *et al*., 2025). Enhanced detection means that milder or earlier-stage cases were identified—often before progression—lowering apparent CFR. This implies that improved detection of mild cases can artificially lower CFR. The overall CFR (39.3%) falls within the range documented in similar Nigerian outbreaks of the disease (Mshelbwala *et al*., 2021). However, considering rabies being an extreme fatal disease, more extensive research, incorporating active surveillance and multiple data sources, would be needed to further investigate this.

Southern States, like Edo, Oyo, and Bayelsa, with alarmingly high CFRs indicate delayed detection or poor access to veterinary interventions, consistent with findings from Nyasulu *et al*. (2021), who documented high mortality in regions with poor veterinary outreach. Other southern states like Lagos, Bayelsa, and Akwa Ibom, despite low total numbers, showed high AR and CFR, underscoring the vulnerability of smaller animal populations with minimal preventive healthcare. Meanwhile, northern states such as Plateau, Kaduna, and Bauchi contributed substantially to the total case count, mirroring previous epidemiological trends where high livestock density and cross-border movement fuel recurrent outbreaks (Braam *et al*., 2024).

Our study also revealed that vaccination efforts were inconsistent; with no vaccination reports made in some years (2015, 2016, 2020, 2022). The unnatural coverage peak in 2017 was possibly due to post-outbreak emergency vaccination, thus, overshooting the estimated susceptible population. Generally, vaccination coverage remained poor and far below the FAO-OIE recommended threshold of 70–80% required to achieve herd immunity (WHO *et al*., 2018). Additionally, it has been demonstrated in developed countries that multi-annual vaccination campaigns with vaccination coverage of at least 70% of the domestic dog population should be effective in order to achieve rabies control and elimination (Wobessi *et al*., 2021)

Several states had zero vaccination coverage reports despite high AR and CFR (e.g., Akwa Ibom, Kano, Bayelsa), suggesting underreporting or gaps in routine preventive programs. This aligns with previous findings indicating inadequate veterinary infrastructure and poor vaccine distribution logistics in many Nigerian states (Al-Mustapha *et al*., 2021). Only Kaduna recorded a high apparent vaccination coverage (380.2%), potentially due to recent mass vaccination campaigns, though this figure exceeding 100% suggests data inaccuracies, possibly due to underestimation of susceptible populations or inclusion of previous years' cumulative vaccinations (WHO *et al*., 2018)

This study also reported species-specific distribution of rabies cases and vaccination coverage across multiple domestic and livestock species. The dominant involvement of domestic dogs in the total rabies cases concurs with extensive epidemiological literature underscoring the central role of domestic dogs as the principal reservoir and transmitter of rabies in Nigeria and across Africa (Adedeji *et al*., 2010; Mshelbwala *et al*., 2021). In addition, we noticed a high attack rate in cats despite their lower case number, but a total absence of reports of vaccination coverage in cats. This underscores a significant gap in rabies control efforts and its reporting. Fehlner-Gardiner *et al*. (2024) reiterated that cats, especially free-roaming and feral populations, can serve as secondary reservoirs of rabies, contributing to sporadic transmission events to humans and other animals. Therefore, the neglect of cats in rabies vaccination campaigns presents a hidden threat to effective rabies elimination strategies, particularly in urban and peri-urban settings.

The detection of rabies cases among livestock species, particularly cattle, sheep, and goats, further reflects the disease's broader ecological impact. This is consistent with earlier reports of Rahman *et al*. (2020) who identified frequent spill over infections from rabid dogs to livestock in Nigeria, resulting in significant economic losses to pastoralist communities. Although livestock cases were relatively few, the CFR in cattle was notably high. The lack of vaccination in livestock populations, coupled with the fatal nature of rabies upon clinical manifestation, emphasizes the disease's direct and indirect impact on animal health and rural livelihoods (Carpenter *et al*., 2022). The isolated case of rabies in rabbits, with 100% CFR, though may be sporadic, further reinforce the classical understanding that rabies remains invariably fatal in virtually all warm-blooded mammals once clinical signs appear (Oyda & Megersa, 2017). Literatures from endemic areas confirm that such cases, while less frequent, indicate broader zoonotic risks and highlight potential routes of transmission to humans, especially in mixed farming systems (Acharya *et al*., 2020; Gado *et al*., 2023; Islam *et al*., 2025)

In general, our findings reflect systemic weaknesses in the implementation of rabies control programs, exacerbated by low vaccination coverage, poor animal population disease surveillance and reporting systems, and other evidence, such as limited community awareness (Broban *et al*., 2018; Mogano *et al*., 2024; Omuse *et al*., 2025), contributing to the persistent endemicity of rabies in Nigeria and other parts of sub-Saharan Africa.

CONCLUSION

Our study draws on a decade of data to provide a comprehensive epidemiological overview of rabies cases across states and among animals in Nigeria. It also spotlighted the continued burden of rabies in domestic and livestock species in Nigeria, driven predominantly by low vaccination coverage among dogs and secondary gaps in the vaccination of other species. Addressing these challenges through comprehensive One Health strategies, sustained political commitment, and strengthened veterinary public health infrastructure is essential to disrupt rabies transmission and achieve the 2030 global elimination target. We have also provided information on salient gaps which will provide guidance in putting in place modalities to curb the spread of the disease and strengthen already existing rabies prevention and control programs in the country. It is important to reiterate that our reliance on WAHIS data source introduced certain limitations, such as potential gaps in local reporting and the exclusion of active surveillance data. However, this study brings to foresight the necessity of improving on the local Nigerian Animal Health database and disease reporting system. It has also laid the foundation for future research and public health initiatives on the urgent need for a more holistic data collection approach that integrates diverse sources for a comprehensive understanding of rabies dynamics in Nigeria. This will provide an accurate outlook of local disease burden, especially for rabies.

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