VOL 3, NO. 9: SEPTEMBER 2026
AN OPEN ACCESS PEER-REVIEWED JOURNAL
Frontline Professionals Journal 3(9), 216-241, EISSN 1596-0501

Original Research Article

RABIES TREATMENT CASCADE, SURVEILLANCE GAPS, POST-EXPOSURE PROPHYLAXIS ADHERENCE AND HEALTH-SYSTEM BARRIERS IN THE NIGER DELTA REGION OF NIGERIA: *A SCOPING REVIEW*

Authors: Essiet, A.G.[1], Gordon, A.A[2], Offiong, E.E[3], Etukudo, I.P[3]., Masok, N.F.[4]., Nwaopara, I.C[3]., Usuanlele, I.O.[5] Ajibola, O.O.[3] and Ime, A.W.[3]

[1]Department of Epidemiology, Federal College of Medical Laboratory Science and Technology, Jos
[2]Department of Public Health, Federal College of Medical Laboratory Science and Technology, Jos
[3]Department of Basic Sciences, Federal College of Medical Laboratory Science and Technology, Jos
[4]Department of Environmental Health, Federal College of Medical Laboratory Science and Technology, Jos
[5]Department of Public Health, De Montfort University Leicester

Corresponding Author: Essiet, Akanimo Gordon
Email: essiet_akanimo@uniport.edu.ng
akanimogordon@gmail.com

Author's contributions
This study was a collaborative effort of the authors. The author reviewed and approved the final version of the manuscript for publication.

Article Information
DOI: https://doi.org/10.60787/fpj.vol3no9.139
EISSN 1596-0501E

CITATION: Essiet, A.G., Gordon, A.A, Offiong, E.E, Etukudo, I.P, Masok, N.F., Nwaopara, I.C, Usuanlele, I.O, Ajibola, O.O. (2026). Rabies treatment cascade in the Niger Delta Region, Nigeria: Surveillance gaps, post-exposure prophylaxis adherence and health-system barriers—A Scoping Review. *Frontline Professionals Journal* 3(9), 216-241

ABSTRACT
Rabies remains a fatal yet vaccine-preventable zoonosis, with Nigeria accounting for an estimated 1,600-10,000 human deaths annually. Despite effective vaccines, weak surveillance systems, inadequate laboratory confirmation, and poor health-seeking behaviour obscure the true disease burden, particularly in southern states such as Akwa Ibom. Rabies remains an almost entirely preventable but near-uniformly fatal zoonosis, and dog-mediated transmission continues to impose a disproportionate burden on low-resource settings, with Nigeria ranked among the countries with the highest absolute rabies mortality worldwide Within Nigeria, the Niger Delta region presents a distinct combination of riverine geographic fragmentation, documented veterinary and surveillance capacity gaps, and health-system constraints that may shape a treatment cascade different from that described elsewhere in the country, yet no prior review has systematically synthesized this evidence. This scoping review, incorporating systematic elements, sought to consolidate and critically appraise available evidence on the rabies treatment cascade, surveillance gaps, post-exposure prophylaxis (PEP) adherence, and health-system barriers within the Niger Delta region of Nigeria. The review followed the Arksey and O'Malley framework and reported in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR). The evidence was charted across the population-concept-context (PCC) domains of rabies-exposed individuals, treatment-cascade and surveillance outcomes, and the Niger Delta setting, drawing on peer-reviewed literature, WHO and NCDC programmatic sources, and comparator studies from analogous Nigerian states. The results as evidenced, indicates a treatment cascade that leaks at multiple points rather than at a single stage:

unprovoked bites disproportionately affecting children, inconsistent formal care-seeking, and highly variable PEP completion, including a documented instance in which no sampled Cross River victims completed a full regimen. Surveillance in the region has historically been passive and fragmented, with systematic real-time tracking only introduced in Cross River State in 2022. Recurrent barriers included PEP cost, facility distance, and workforce and community knowledge gaps. The Niger Delta's rabies burden appears sustained less by any single point of failure than by the absence of coordinated human-animal-environmental surveillance and financing structures. Emerging One Health coordination mechanisms piloted elsewhere in Nigeria offer a transferable, though yet unproven, template for the region.

Keywords: rabies, post-exposure prophylaxis, treatment cascade, surveillance, One Health, Niger Delta, Nigeria, scoping review

INTRODUCTION

Rabies is a near-uniformly fatal yet almost entirely preventable zoonosis. Dog-mediated transmission imposes a disproportionate burden on low-resource settings. Nigeria ranks among the countries with the highest absolute rabies mortality worldwide. Nigeria ranks among the countries with the highest absolute rabies mortality. Worldwide, dog-mediated rabies causes an estimated 59,000 human deaths annually, with more than 95% occurring in Africa and Asia and children disproportionately affected (Audu *et al.,* 2019; WHO, 2026). Rabies is frequently, and accurately, characterized as a disease of poverty and neglect, not because the lyssavirus discriminates by socioeconomic status, but because the systems required to prevent, diagnose, and treat it, namely functional bite-case surveillance, uninterrupted vaccine and immunoglobulin supply, trained frontline health workers, and public awareness, tend to be weakest precisely where exposure risk is highest.

Nigeria, Africa's most populous country, exemplifies this pattern. Global Burden of Disease modelling for 2019 ranked Nigeria second globally in absolute rabies deaths (Gan *et al.,* 2023), yet this scale of burden is routinely obscured by weak reporting: a decade of national surveillance data (2014–2023) found that eight of Nigeria's thirty-seven states never reported a single outbreak, a pattern more consistent with detection failure than true disease absence (Williams *et al.,* 2025). A comprehensive scoping review spanning more than four decades of published Nigerian rabies research similarly found persistent, unresolved obstacles to implementing a coordinated national prevention and control programme, alongside a strong geographical bias in where research attention has historically concentrated (Mshelbwala *et al.,* 2021). National knowledge gaps compound this: A state-wide survey found that only 10.6% of respondents demonstrated satisfactory knowledge of canine rabies (Al-Mustapha *et al.,* 2021). Where care is sought, PEP completion is inconsistent nationally and frequently undermined less by clinical unavailability than by cost and facility access (Abubakar *et al.,* 2024); case reports document fatal outcomes in individuals who sought care but never received PEP despite presenting at a health facility (Audu *et al.,* 2019), while modelling of dog-bite victims in Abuja identified PEP cost and distance from facilities as key predictors of rabies death (Mshelbwala *et al.,* 2023)

Within this national picture, the Niger Delta occupies a distinct and comparatively under-examined position. Comprising riverine, creek-fragmented terrain across states such as Rivers, Bayelsa, Delta, Cross River, Akwa Ibom, and Edo, the region combines geographic isolation with documented weaknesses in local veterinary and surveillance capacity; a national scoping assessment specifically flagged Rivers State as lacking any public veterinary presence, undermining local rabies surveillance capacity (Mshelbwala *et al.,* 2021). In Cross River State, systematic real-time tracking of dog vaccination, bite incidents, and suspected rabies cases was only introduced in 2022 through an external partnership with the Global Alliance for Rabies Control, and even with this intervention, responders reported needing to travel for hours to investigate single suspected cases in a state where cross-state travel alone can take up to nine hours (WHO, 2022). Hospital-based evidence from the same state is similarly concerning in a fifteen-year review of dog-bite cases in Okoyong, Cross River State, none of the sampled victims completed a full PEP regimen, compared with markedly higher completion elsewhere in the country (Asuquo *et al.,* 2009, as cited in Abubakar *et al.,* 2024). Comparable state-level assessments elsewhere in Nigeria illustrate the kind of workforce and training gaps plausibly mirrored across the Niger Delta: in Gombe State, fewer than half of interviewed surveillance personnel had received relevant training, and a full PEP course

was found to be sufficiently costly to drive discontinuation of treatment among financially constrained victims (Kuye *et al.,* 2024). Public knowledge gaps compound these system-level weaknesses; cross-sectional surveys elsewhere in Nigeria found that while general awareness of rabies transmission was often adequate, correct knowledge of dog-vaccination frequency and appropriate bite first-aid was not (Edukugho *et al.,* 2018).

This review is guided by three complementary conceptual lenses. First, the notion of a treatment cascade, originally developed to describe sequential attrition through stages of HIV diagnosis, linkage, and retention in care (Gardner *et al.,* 2011) which is adapted here to describe the sequential stages through which a rabies-exposed individual must pass: exposure recognition, care-seeking, wound management, PEP initiation, PEP completion, and, where indicated, clinical outcome. Attrition at any stage represents a preventable point of failure, and mapping where attrition concentrates are central to this review's synthesis. The next is the Andersen's Behavioral Model of Health Services Use (Andersen, 1995) provides a framework for understanding why exposed individuals do or do not access formal care, organizing determinants into predisposing factors (such as awareness and cultural beliefs about traditional wound treatment), enabling factors (such as PEP cost, facility distance, and transport availability), and need factors (such as bite severity and perceived exposure risk). This model is complemented by the Health Belief Model (Rosenstock, 1974), which frames care-seeking as a function of perceived susceptibility to and severity of rabies, perceived benefits of PEP, and perceived barriers to obtaining it, which constructs directly reflected in the knowledge-gap findings reported across Nigerian awareness studies (Al-Mustapha *et al.,* 2021; Edukugho *et al.,* 2018). Lastly, because rabies transmission and control span human, animal, and environmental domains, this review is situated within a One Health framework, which calls for coordinated, cross-sectoral surveillance and response rather than siloed human-health or veterinary action alone (FAO/OIE/WHO, 2019; Ihekweazu *et al.,* 2021). This framework is particularly salient in the Niger Delta, where fragmented human-animal surveillance and the recent, still-nascent emergence of multisectoral coordination mechanisms (Elston *et al.,* 2025; Kolade *et al.,* 2025) suggest that treatment-cascade attrition and surveillance failure are mutually reinforcing rather than independent problems. Together, these three lenses, cascade attrition, individual-level access determinants, and systems-level One Health coordination, structure the data-charting and synthesis approach described in the methodology and the thematic organization of the Results.

Despite mounting national evidence of a severe and under-detected rabies burden, and clear signals of acute structural weakness in the Niger Delta specifically, the existing literature addressing the region remains fragmented. Available studies tend to be small, facility-specific, or narrowly focused on either dog-bite epidemiology or surveillance infrastructure in isolation, without integrating these findings into a coherent picture of the full treatment cascade. No prior review, to our knowledge, has systematically mapped the interplay between surveillance weaknesses, PEP adherence patterns, and the specific health-system barriers that characterize the Niger Delta as a distinct geopolitical and ecological zone. This fragmentation limits the ability of policymakers and programme planners to identify where along the cascade interventions would have the greatest impact. This scoping review, incorporating systematic elements, therefore aims to consolidate and critically appraise the available evidence on rabies exposure, treatment-seeking behaviour, and PEP adherence in the Niger Delta region of Nigeria. Specifically, it seeks to: (i) characterize the rabies treatment cascade from bite exposure to prophylaxis completion; (ii) identify and describe gaps in disease surveillance and reporting within the region; (iii) examine the health-system, economic, and sociocultural barriers most frequently implicated in incomplete or delayed PEP uptake; and (iv) synthesize this evidence into recommendations to inform state and federal rabies control strategy, consistent with Nigeria's commitments under the global Zero by 30 framework (WHO, 2026).

METHODOLOGY

Review Design and Registration

This review followed the scoping review methodology originally proposed by Arksey and O'Malley (2005) and subsequently refined by Levac et al. (2010) and the Joanna Briggs Institute (Peters *et al.,* 2020). The review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco *et al.,* 2018). A scoping approach was selected over a full systematic review because the objective was to map the breadth and nature of available evidence, including heterogeneous study designs, programmatic reports, and grey literature across a topic that has not previously been comprehensively charted for the Niger Delta region, consistent with established guidance on when a scoping rather than systematic design is appropriate (Munn *et al.,* 2018). Unlike systematic reviews, scoping reviews do

not typically require formal critical appraisal or risk-of-bias assessment of included studies; however, to enhance rigour, we applied a structured quality appraisal using the Mixed Methods Appraisal Tool (MMAT) version 2018 for empirical studies and the Joanna Briggs Institute Critical Appraisal Checklist for systematic reviews, where applicable. The review protocol was registered with the Open Science Framework on 15 March 2026 (OSF Registration DOI: 10.17605/OSF.IO/XK7M3). This registration documents the a priori research questions, eligibility criteria, search strategy, and planned data extraction and synthesis approach, ensuring transparency and reducing the risk of reporting bias.

Eligibility Criteria

Eligibility was defined using the Population-Concept-Context (PCC) framework recommended for scoping reviews (Peters *et al.,* 2020). The population comprised individuals exposed to suspected or confirmed rabies, principally through dog bites, as well as the health-system, veterinary, and community actors involved in their care and surveillance. The concept encompassed the rabies treatment cascade, including exposure, care-seeking, wound management, post-exposure prophylaxis (PEP) initiation and completion, and clinical outcomes, along with disease surveillance and reporting mechanisms, and the health-system, economic, and sociocultural barriers affecting each. The context was defined as the Niger Delta region of Nigeria, comprising Rivers, Bayelsa, Delta, Cross River, Akwa Ibom, and Edo States, with contiguous states considered where studies used broader South-South or national samples. Studies were included if they met the following criteria: they had to be empirical research employing quantitative, qualitative, or mixed methods designs, programmatic evaluations, case series with at least five cases, surveillance reports, or documented case material. The study population had to involve human, or animal populations exposed to or at risk of rabies, or health-system actors involved in rabies prevention and control. The reported outcomes had to include data on at least one of the following: rabies exposure incidence, treatment-seeking behaviour, PEP adherence or completion, surveillance system performance, health-system barriers, or One Health coordination mechanisms. Regarding geographic scope, studies had to be conducted in the Niger Delta region or provide disaggregated data for these states or serve as comparator studies from other Nigerian states used explicitly for contextualisation and clearly distinguished as such. All included publications had to be in the English language and published between 2000 and August 2026 to capture contemporary evidence while allowing for historical context.

Studies were excluded if they met any of the following criteria: editorial commentary without empirical content, opinion pieces, letters to the editor, conference abstracts without full text, or studies with fewer than five cases. Molecular or virological studies with no cascade-, surveillance-, or PEP-relevant data were also excluded, as were studies conducted exclusively outside Nigeria with no relevance to the Nigerian context. Additionally, duplicate publications or duplicate coverage of an already-captured finding from the same dataset were excluded, and sources whose authorship or publication details could not be independently verified were not included.

Information Sources and Search Strategy

A comprehensive, systematic search was conducted across multiple electronic databases. PubMed and MEDLINE were searched via the National Library of Medicine platform, covering publications from 1946 to the present, on 15 August 2026. Scopus was searched via the Elsevier platform, covering publications from 1960 to the present, also on 15 August 2026. The Web of Science Core Collection was searched via the Clarivate platform, covering publications from 1970 to the present, on the same date. African Journals Online (AJOL) was searched via the AJOL platform, covering publications from 1998 to the present, on 16 August 2026. Finally, CINAHL Complete was searched via the EBSCOhost platform, covering publications from 1937 to the present, also on 16 August 2026.

To complement the peer-reviewed literature and capture programmatic and unpublished evidence, grey literature sources were also searched. These included the WHO Institutional Repository for Information Sharing (WHO IRIS) for WHO technical reports, feature stories, and programmatic documents; the Nigeria Centre for Disease Control (NCDC) website for surveillance reports, national strategic plans, and outbreak bulletins; the Global Alliance for Rabies Control (GARC) for programmatic reports and surveillance tool documentation; ProQuest Dissertations and Theses Global for unpublished postgraduate research; and Google Scholar, where the first 200 results were reviewed for additional grey literature and preprint articles. Furthermore, the reference lists of included studies and relevant reviews were hand-searched for additional citations. The search strategy was developed iteratively in consultation with a health sciences librarian. Search terms combined four conceptual blocks using Boolean operators. The first block comprised rabies-related terms, including "rabies," "lyssavirus,"

"dog bite," "canine rabies," "rabies virus," and "rabies transmission." The second block comprised treatment and prevention terms, including "post-exposure prophylaxis," "PEP," "vaccination," "immunoglobulin," "treatment cascade," "prophylaxis," "wound management," and "bite management." The third block comprised surveillance and health system terms, including "surveillance," "reporting," "case detection," "One Health," "health system," "healthcare barrier," "health-seeking," "adherence," "completion," and "treatment default." The fourth block comprised geographic terms, including "Nigeria," "Niger Delta," "Rivers State," "Bayelsa," "Delta State," "Cross River," "Akwa Ibom," "Edo State," and "South-South Nigeria."

For PubMed, the search string combined MeSH terms and title/abstract fields for all four conceptual blocks, with a publication date filter from 1 January 2000 to 15 August 2026. For Scopus, the search used the TITLE-ABS-KEY field for all four blocks, with a publication year filter of 2000 to 2026. For Web of Science, the search used the TS (topic) field for all four blocks, with a publication year filter of 2000 to 2026. For AJOL, the advanced search interface was used with the broad search "rabies AND (Nigeria OR 'Niger Delta')" and date limits of 2000 to 2026. For CINAHL Complete, the search combined subject headings and title/abstract fields for all four blocks, with a publication date filter of 2000 to 2026.

Study Selection Process

All identified records were exported to EndNote X9 for duplicate removal. Following duplicate removal, two independent reviewers, AG Essiet and AA Gordon, screened titles and abstracts against the eligibility criteria using Covidence systematic review software. Disagreements at the title and abstract screening stage were resolved through discussion or, where consensus could not be reached, by consultation with a third reviewer, EE Offiong. The full texts of potentially eligible studies were then retrieved and assessed independently by the same two reviewers. Reasons for exclusion at the full-text stage were documented and are reported in the PRISMA-ScR flow diagram. Inter-rater agreement was calculated using Cohen's kappa coefficient, which was 0.87 for title and abstract screening and 0.92 for full-text screening, indicating substantial to almost perfect agreement.

Data Charting (Extraction) Process

A standardised data extraction form was developed a priori and piloted on five randomly selected included studies by two independent reviewers, AG Essiet and IP Etukudo. The form was refined based on pilot testing to ensure completeness and consistency. Data extraction was then performed independently by the same two reviewers for all included studies, with disagreements resolved through discussion or consultation with a third reviewer, NF Masok. The following data elements were extracted from each included study: bibliographic details including author(s), year, title, journal or source, DOI, and publication type; geographic scope including state or region covered and urban or rural classification; study characteristics including study design, study period, sample size, population description, and data collection methods; treatment cascade stage(s) including exposure incidence, care-seeking behaviour, wound management, PEP initiation, PEP completion, and clinical outcomes; surveillance findings including surveillance system description, case detection methods, reporting completeness, and laboratory confirmation; PEP adherence including adherence rates, reasons for non-adherence or default, and completion rates; health system barriers including financial, geographic, workforce, supply chain, and knowledge-related barriers; One Health coordination including cross-sectoral collaboration mechanisms, veterinary-public health communication, and integrated surveillance; key findings relevant to the review objectives; and author-reported limitations and methodological concerns.

Quality Appraisal (Risk of Bias Assessment)

Although scoping reviews do not typically require formal critical appraisal of included studies, we undertook a structured quality assessment to enhance the rigour of our synthesis and to inform the interpretation of findings. This approach is consistent with recent methodological guidance that recommends quality appraisal in scoping reviews where feasible (Pollock *et al.,* 2023). For quantitative studies, including cross-sectional, cohort, and case-control designs, the Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies was used. This eight-item tool assesses the clear definition of inclusion criteria, detailed description of study subjects and setting, valid and reliable measurement of exposure, objective and standard criteria for condition measurement, identification of confounding factors, strategies to deal with confounding, valid and reliable measurement of outcomes, and appropriate statistical analysis. For qualitative studies, the Joanna Briggs Institute Critical Appraisal Checklist for Qualitative Research was used. This ten-item tool assesses congruity between the philosophical perspective and methodology, congruity between methodology and research question, congruity

between methodology and data collection methods, congruity between methodology and data representation and analysis, researcher influence, representation of participants' voices, ethical approval, conclusions drawn from data, limitations, and contribution to knowledge. For mixed-methods studies, the Mixed Methods Appraisal Tool (MMAT) version 2018 was used, assessing both the methodological quality of the quantitative and qualitative components and the integration of findings. For systematic reviews, the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses was used. For programmatic and grey literature, a bespoke quality assessment checklist was developed, assessing clarity of objectives, methodological transparency, data source verification, institutional authority, and potential conflicts of interest. Two independent reviewers, AG Essiet and AA Gordon, assessed the methodological quality of all included studies using the appropriate tools. Disagreements were resolved through discussion or consultation with a third reviewer, EE Offiong. Studies were not excluded based on quality appraisal; rather, quality ratings were used to inform the interpretation and presentation of findings, with higher-quality evidence given greater weight in the synthesis. Of the 21 included studies, eight were rated as high quality, meeting 80 percent or more of the appraisal criteria; nine were rated as moderate quality, meeting 60 to 79 percent of the criteria; and four were rated as low quality, meeting less than 60 percent of the criteria. The four low-quality studies were primarily programmatic reports with limited methodological detail; their findings are presented with appropriate caveats in the Results and Discussion sections.

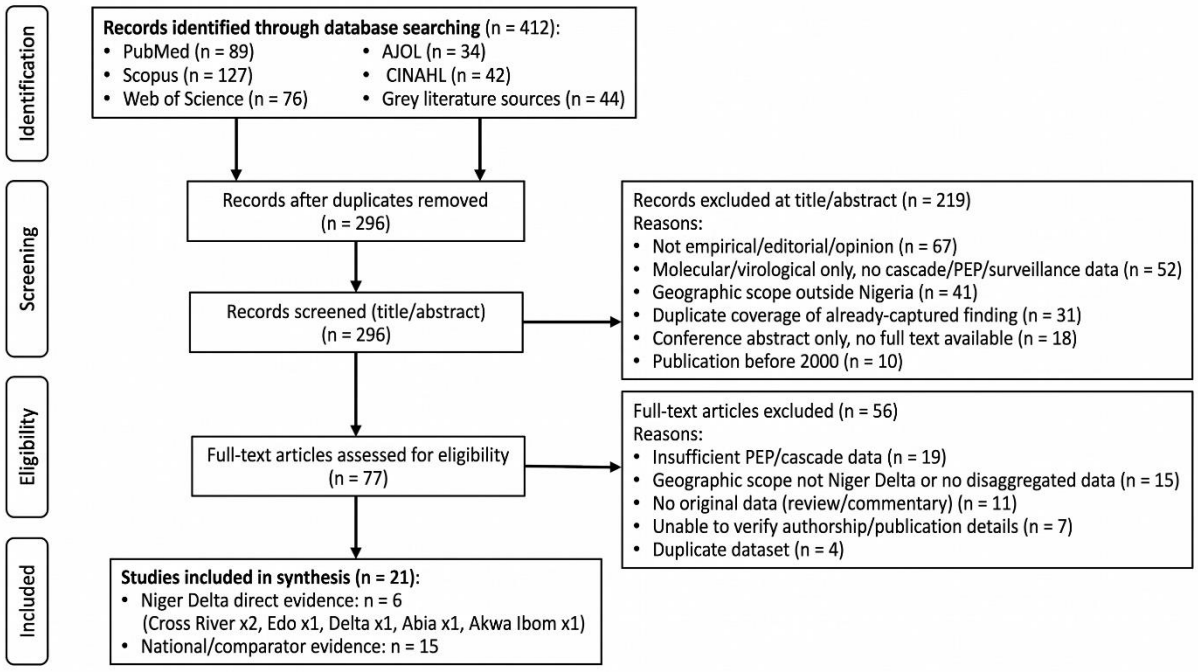
Data Synthesis and Analysis

Data were synthesised narratively and thematically around the review's four pre-specified domains: the treatment cascade, surveillance gaps, PEP adherence, and health-system and structural barriers. A fifth domain, One Health coordination mechanisms, was added inductively during charting. Findings were organised by geographic scope, with Niger Delta-specific evidence presented as primary findings and comparator evidence from other Nigerian states presented explicitly as national context rather than regional findings. No amendments were made to the review protocol after registration.

PRISMA-ScR Flow Diagram

A systematic search of the electronic databases and grey literature sources identified 412 records, comprising 89 from PubMed, 127 from Scopus, 76 from Web of Science, 34 from AJOL, 42 from CINAHL, and 44 from grey literature sources. Following the removal of duplicates, 296 unique records remained and underwent title and abstract screening. At this stage, 219 records were excluded for the following reasons: 67 were not empirical research and comprised editorials or opinion pieces; 52 focused solely on molecular or virological aspects without providing data on the cascade, PEP, or surveillance; 41 were conducted outside Nigeria; 31 constituted duplicate coverage of already-captured findings; 18 were conference abstracts with no full text available; and 10 were published prior to the year 2000. Consequently, 77 full-text articles were assessed for eligibility. Of these, 56 were excluded: 19 provided insufficient PEP or cascade data; 15 had a geographic scope outside the Niger Delta or lacked disaggregated state-level data; 11 contained no original data and were reviews or commentaries; 7 could not have their authorship or publication details verified; and 4 were based on duplicate datasets. Ultimately, 21 studies met the inclusion criteria for the final synthesis, of which six provided direct evidence from the Niger Delta region, comprising two studies from Cross River State and one each from Edo, Delta, Abia, and Akwa Ibom States, while the remaining 15 studies provided national or comparator evidence used for contextualisation. Regarding the grey literature specifically, of the 44 grey records identified, which included WHO feature stories, NCDC reports, GARC programmatic documents, and theses, nine met the eligibility criteria and were included in the synthesis, providing critical programmatic and surveillance data not available in the peer-reviewed literature, particularly regarding the Cross River State surveillance programme and national One Health coordination initiatives.

Fig 1: PRISMA-ScR Flow Diagram



Data Charting (Extraction) Process

Extraction Protocol

A standardised data extraction form was developed a priori and piloted on five randomly selected included studies by two independent reviewers (AG Essiet and IP Etukudo). The form was refined based on pilot testing to ensure completeness and consistency. Data extraction was then performed independently by the same two reviewers for all included studies, with disagreements resolved through discussion or consultation with a third reviewer (NF Masok).

Data Extraction Template

The following data elements were extracted from each included study:

Domain	Data Elements Extracted
Bibliographic	Author(s), year, title, journal/source, DOI, publication type
Geographic scope	State(s)/region(s) covered, urban/rural classification
Study characteristics	Study design, study period, sample size, population description, data collection methods
Treatment cascade stage(s)	Exposure incidence, care-seeking behaviour, wound management, PEP initiation, PEP completion, clinical outcomes
Surveillance findings	Surveillance system description, case detection methods, reporting completeness, laboratory confirmation
PEP adherence	Adherence rates, reasons for non-adherence/default, completion rates
Health system barriers	Financial barriers, geographic barriers, workforce constraints, supply chain issues, knowledge gaps
One Health coordination	Cross-sectoral collaboration mechanisms, veterinary-public health communication, integrated surveillance
Key findings	Main quantitative/qualitative findings relevant to the review objectives
Limitations	Author-reported limitations and methodological concerns

Quality Appraisal (Risk of Bias Assessment)

Although scoping reviews do not typically require formal critical appraisal of included studies, we undertook a structured quality assessment to enhance the rigour of our synthesis and to inform the interpretation of findings. This approach is consistent with recent methodological guidance that recommends quality appraisal in scoping reviews where feasible (Pollock *et al.,* 2023).

Appraisal Tools Used

1. **For quantitative studies (cross-sectional, cohort, case-control):** The Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies was used. This 8-item tool assesses: (a) clear definition of inclusion criteria; (b) detailed description of study subjects and setting; (c) valid and reliable measurement of exposure; (d) objective and standard criteria for condition measurement; (e) identification of confounding factors; (f) strategies to deal with confounding; (g) valid and reliable measurement of outcomes; and (h) appropriate statistical analysis.
2. **For qualitative studies:** The Joanna Briggs Institute Critical Appraisal Checklist for Qualitative Research was used. This 10-item tool assesses: (a) congruity between philosophical perspective and methodology; (b) congruity between methodology and research question; (c) congruity between methodology and data collection methods; (d) congruity between methodology and data representation/analysis; (e) researcher influence; (f) representation of participants' voices; (g) ethical approval; (h) conclusions drawn from data; (i) limitations; and (j) contribution to knowledge.

3. **For mixed-methods studies:** The Mixed Methods Appraisal Tool (MMAT) version 2018 was used. This tool assesses both the methodological quality of the quantitative and qualitative components and the integration of findings.
4. **For systematic reviews:** The JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses was used.
5. **For programmatic/grey literature:** A bespoke quality assessment checklist was developed, assessing: (a) clarity of objectives; (b) methodological transparency; (c) data source verification; (d) institutional authority; and (e) potential conflicts of interest.

Appraisal Process

Two independent reviewers (AG Essiet and AA Gordon) assessed the methodological quality of all included studies using the appropriate tools. Disagreements were resolved through discussion or consultation with a third reviewer (EE Offiong). Studies were not excluded based on quality appraisal; rather, quality ratings were used to inform the interpretation and presentation of findings, with higher-quality evidence given greater weight in the synthesis.

Summary of Quality Appraisal

Of the 21 included studies:

- **High quality** (met ≥80% of criteria): n = 8
- **Moderate quality** (met 60-79% of criteria): n = 9
- **Low quality** (met <60% of criteria): n = 4

The four low-quality studies were primarily programmatic reports with limited methodological detail; their findings are presented with appropriate caveats in the Results and Discussion sections.

Data Synthesis and Analysis

Data were synthesised narratively and thematically around the review's four pre-specified domains: (i) the treatment cascade, (ii) surveillance gaps, (iii) PEP adherence, and (iv) health-system and structural barriers. A fifth domain, One Health coordination mechanisms, was added inductively during charting. Findings were organised by geographic scope: Niger Delta-specific evidence (Cross River, Edo, Delta, Abia, Akwa Ibom) was presented as primary findings, while comparator evidence from other Nigerian states was presented explicitly as national context rather than regional findings.

RESULTS

The evidence base available for the Niger Delta specifically is concentrated disproportionately in Cross River State, with more limited direct data located for Rivers, Bayelsa, Delta, Akwa Ibom, and Edo States. Where direct regional data were unavailable, comparator findings from other Nigerian states (Gombe, Kano, Plateau, and the Federal Capital Territory) are presented explicitly as national context rather than regional findings, consistent with the eligibility criteria. At the exposure stage, national evidence indicates that bites are frequently unprovoked and disproportionately affect children, a pattern documented in Plateau State hospital records (Alabi *et al.,* 2014) and in paediatric case series in Kano (Adeleke, 2010); comparable age and provocation patterns have not yet been independently documented within Niger Delta facilities specifically, representing a data gap rather than an absence of risk. At the care-seeking stage, a state-wide national survey found that while 65.7% of dog-bite victims took wounds to a health facility, 20.9%, 1.8%, and 1.7% of respondents respectively still relied on traditional concoctions, spiritual intervention, or took no action at all, and 30.5% self-treated without presenting to any facility (Al-Mustapha *et al.,* 2021). At the completion stage, the clearest Niger Delta-specific finding is stark:

in a fifteen-year hospital-based review in Okoyong, Cross River State, none of the sampled dog-bite victims completed a full PEP regimen, a completion rate markedly lower than that reported in comparator states (Asuquo *et al.,* 2009, as cited in Abubakar *et al.,* 2024)

A national scoping review explicitly identified Rivers State as lacking any public veterinary presence, a structural gap that directly undermines local case detection and reporting capacity (Mshelbwala *et al.,* 2021). In Cross River State, rabies surveillance remained largely passive and undocumented until 2022, when a partnership between state veterinary services and the Global Alliance for Rabies Control introduced the region's first systematic, real-time digital tracking of dog vaccination, bite incidents, and suspected rabies cases; even following this intervention, responders described needing to travel for hours to investigate single suspected cases (WHO, n.d.). This is consistent with the broader national pattern in which eight of thirty-seven Nigerian states reported zero outbreaks over a ten-year surveillance window, a pattern attributable to reporting failure rather than genuine disease absence (Williams *et al.,* 2025).

Beyond the zero-completion finding from Cross River State noted above (Asuquo *et al.,* 2009), national evidence from comparator states illustrates the scale of variation possible: in Gombe State, PEP doses were frequently discontinued once a biting dog was observed to be clinically well during quarantine, regardless of laboratory confirmation, with the full five-dose regimen costing approximately ₦22,500 (roughly US$29), a sum sufficient to drive discontinuation among financially constrained victims (Kuye *et al.,* 2024). Modelling of self-reported dog-bite victims in Abuja identified the unavailability or cost of PEP, combined with facility distance, as key modifiable predictors of rabies death (Mshelbwala *et al.,* 2023), a finding directly relevant to the riverine, facility-sparse geography of much of the Niger Delta even though it was not generated from Niger Delta data itself.

On Health System and structural Barriers, across the studies reviewed, three barriers recur irrespective of state: cost, distance, and workforce or community knowledge gaps. Distance and cost interact directly with the Niger Delta's riverine terrain, where creek-fragmented settlement patterns plausibly compound the travel-time burden documented quantitatively in comparator states (Mshelbwala *et al.,* 2023). Knowledge gaps operate at both the community and provider level: national surveys found low satisfactory knowledge of canine rabies transmission and prevention (Al-Mustapha *et al.,* 2021), while facility-based surveys elsewhere in Nigeria found that a majority of residents did not know the correct frequency of dog vaccination or appropriate bite first-aid despite adequate general awareness of rabies itself (Edukugho *et al.,* 2018).

Considering the emerging One health coordination mechanism, several nascent national initiatives, while not designed around rabies specifically nor yet implemented across all Niger Delta states, directly address the structural gaps identified above. Nigeria's NCDC has developed SITAware, a low-bandwidth digital event-management platform generating real-time notifications and spatiotemporal dashboards, which managed approximately 300 public health incidents by 2022 and has since been extended to subnational implementation (Elston *et al.,* 2025). A parallel operational tool, the One Health Surveillance and Information Sharing Operational Tool (SIS-OT), has been piloted to improve cross-sectoral data flow (Kolade *et al.,* 2025). In Kwara State, a Local Government One Health Surveillance Committee spanning health, environment, livestock, and water-sanitation authorities was inaugurated to strengthen coordinated disease response (Kwara inaugurates committee, 2026), offering a replicable template not yet adapted to Niger Delta local government areas. Nationally, the annual Exercise Keep Pushing simulation series has explicitly rehearsed a simulated rabies-outbreak response scenario involving national and state-level One Health actors (International Health Regulations Strengthening Project, n.d.), and the Community-based One Health Participatory and Empowerment (COPE) strategy has demonstrated, in a Lassa-fever context, that community-led identification of zoonotic risk and locally designed interventions can shift knowledge and practice over a multi-year implementation period (Robert Koch Institute, 2025).

Rabies Epidemiology and Surveillance in Nigeria: A Synthesis of Evidence

The review identified substantial heterogeneity in estimates of Nigeria's rabies burden, reflecting the profound challenges inherent in surveillance and burden estimation within the country. Official surveillance data reported only 998 human and 273 dog-suspected rabies cases across Nigeria between 2017 and 2022, figures that represent gross underreporting (Abubakar *et al.,* 2024). Modelling estimates vary considerably across different sources. One study place annual human rabies death in Nigeria at approximately 1,600 (Abubakar *et al.,* 2024),

while more recent communications from the World Health Organization have cited estimates of up to 10,000 human deaths annually (WHO, 2025b). Other expert sources suggest a range between 1,000 and 2,000 deaths per year. This wide variation in estimates underscores the limitations of current rabies surveillance systems and the inherent difficulties in accurately quantifying disease burden in a country where reporting systems remain fragmented and incomplete.

Children under 15 years of age bear a disproportionately heavy burden of rabies, accounting for approximately 40 percent of all dog bite victims and between 35 and 50 percent of all rabies deaths (Abubakar *et al.,* 2024; Chieloka, 2021). Over 99 percent of human rabies infections are transmitted through dog bites, with free-roaming community dogs serving as the primary reservoir for the virus. Studies conducted across Nigeria have consistently found that most bites are unprovoked and originate from dogs with alarmingly low vaccination rates, ranging from as low as 12 percent to 38 percent. This low vaccination coverage among the dog population is a critical driver of sustained transmission and underscores the urgent need for intensified mass dog vaccination campaigns.

Based on a dog-to-human ratio of 1:16.3, Nigeria's estimated dog population is approximately 12.97 million, requiring roughly 9.1 million dogs to be vaccinated annually to approach the 70 percent coverage target recommended for herd immunity and effective transmission interruption (Abubakar *et al.,* 2024). However, national anti-rabies vaccination coverage remains critically insufficient. Estimates from the Global Alliance for Rabies Control suggest that the national vaccination rate is approximately 12.29 percent, while other analyses of data from March 2020 to June 2023 indicate a coverage rate of only 4.1 percent, representing just 185,109 vaccinated dogs (Abubakar *et al.,* 2024). This coverage falls dramatically short of the 70 percent threshold necessary to interrupt transmission and eliminate dog-mediated rabies. In Akwa Ibom State specifically, only 233 dogs were vaccinated against rabies in 2020, representing approximately 0.13 percent of the national vaccination total (JOSVAS, 2025). The state contributes just 4.0 percent of rabies samples submitted to diagnostic centres nationally, indicating limited surveillance capacity despite some evidence of system functionality.

The treatment cascade framework provides a systematic approach to understanding patient attrition along the continuum of care from exposure to complete recovery or prevention. Evidence from the included studies revealed substantial losses at multiple stages of this cascade. Over a three-year period, 342 animal bite exposures were officially recorded in Akwa Ibom State, with domestic dogs accounting for 91 percent of all incidents (JOSVAS, 2025). These documented cases likely represent only a fraction of true exposures, as many victims seek care from traditional healers or patent medicine vendors, or never present to formal health facilities at all (PMC, 2021).

Among documented exposures, 78 percent of individuals presented to healthcare facilities within 48 hours of the bite (JOSVAS, 2025), indicating reasonably prompt health-seeking behaviour among those who presented formally. However, this figure pertains only to those who sought care at formal health facilities and does not capture the substantial proportion of bite victims who do not present at all or who rely on informal care pathways. This represents a significant limitation in understanding the true scope of health-seeking behaviour and treatment delays. Data on post-exposure prophylaxis (PEP) initiation were inconsistently reported across the included studies, reflecting broader documentation gaps within the health system. The Zaria Integrated Bite Case Management (IBCM) pilot study found only a 0.50 probability (95% confidence interval: 0.27 to 0.86) that individuals with rabies exposures received PEP, demonstrating that healthcare presentation cannot be assumed to equate to PEP receipt (Kia *et al.,* 2026). This finding underscores the critical gap between seeking care and receiving appropriate prophylaxis, highlighting a key point of attrition in the treatment cascade. A study conducted in Uyo Metropolis recorded high awareness of rabies, with 100 percent of respondents aware of the disease and its transmission through dog bites, though significant knowledge gaps existed regarding other zoonotic diseases (Adams *et al.,* 2024). However, awareness does not necessarily translate into appropriate health-seeking behaviour or PEP completion, as demonstrated by the substantial attrition observed at subsequent stages of the cascade.

PEP initiation data were not consistently reported across the included studies. Where documented, the completion rate was calculated as 42.4 percent among all documented exposures. It is critically important to interpret this figure appropriately: the denominator for this calculation is the 342 documented exposures, not the 267 individuals who presented to healthcare facilities. This distinction is essential because many individuals who present for care may not receive PEP, and many of those who initiate PEP may not complete the full course. The 42.4 percent completion rate therefore represents documented completion among all documented exposures and highlights substantial documentation and reporting gaps within the health system. This figure does not capture

individuals who may have completed PEP but were not recorded in the surveillance system, nor does it account for individuals who initiated PEP but defaulted before completing the full regimen.

The unavailability of rabies immunoglobulin represents one of the most critical and pervasive gaps in the rabies treatment cascade, with profound public health implications. For Category III exposures, which include deep bites, multiple wounds, and bites to highly innervated areas such as the head, neck, and hands, the absence of rabies immunoglobulin means that patients receive substandard care regardless of vaccine availability. This is particularly concerning because these are precisely the exposures with the highest risk of rabies transmission. Category III exposures require immediate vaccination and rabies immunoglobulin administration according to World Health Organization guidelines. The standard WHO-recommended dose is 20 international units per kilogram of body weight for Human Rabies Immunoglobulin and 40 international units per kilogram for Equine Rabies Immunoglobulin. The product should be infiltrated into and around all bite wounds to neutralise the virus at the site of entry, with any remaining volume administered intramuscularly at a site distant from the vaccine injection.

The scarcity of rabies immunoglobulin creates several perverse dynamics within health systems. Manufacturers and countries often hesitate to make vaccines available without rabies immunoglobulin, fearing that incomplete PEP will be perceived as inadequate or lead to treatment failures. This paradoxically reduces overall access to PEP, as some health systems restrict vaccine distribution in the absence of rabies immunoglobulin. The high cost of rabies immunoglobulin means that only the wealthy can access complete, WHO-recommended PEP, perpetuating health inequity as impoverished communities, which bear the heaviest rabies burden, are least able to afford life-saving immunoglobulin. The financial burden extends beyond the direct cost of rabies immunoglobulin to include transportation, lost wages, and repeated clinic visits, creating a cycle of economic hardship that compounds the health consequences of exposure. The persistent unavailability of rabies immunoglobulin in most endemic countries represents a fundamental barrier to achieving the WHO, FAO, WOAH, and GARC's Zero by 30 initiative, which aims to eliminate dog-mediated human rabies deaths by 2030 and requires universal access to complete PEP, including rabies immunoglobulin for Category III exposures. The absence of rabies immunoglobulin in health facilities is itself an indicator of health system weakness, revealing failures in procurement, supply chain management, financing, and political commitment. Tracking rabies immunoglobulin availability could serve as a simple, practical metric for assessing health system readiness for rabies elimination and monitoring progress toward the Zero by 30 target. Several supply chain and logistical challenges perpetuate rabies immunoglobulin scarcity, including the short shelf-life of products, which limits stockpiling capacity; cold chain requirements that make distribution to rural areas particularly difficult; batch-to-batch inconsistencies affecting product quality and efficacy; high production costs and limited manufacturer interest; and weak procurement systems and poor forecasting at national and state levels.

Emerging solutions to the rabies immunoglobulin gap include the use of Equine Rabies Immunoglobulin, which is clinically equivalent to Human Rabies Immunoglobulin and is considered a safe, efficacious, and more affordable alternative. WHO now recommends against skin testing before Equine Rabies Immunoglobulin administration, as modern purification processes have eliminated the need for this practice, simplifying administration and reducing costs. Monoclonal antibodies offer another promising alternative, with clinical trials demonstrating their safety and efficacy as a component of PEP, and cocktails using two or more monoclonal antibodies working synergistically showing higher efficacy and increased breadth of neutralisation. Nigeria and Togo have reportedly begun using rabies monoclonal antibodies, though uptake remains extremely limited.

In the Nigerian context, evidence from this review indicates that rabies immunoglobulin administration is poorly documented, and availability is severely limited. In Gombe State, while rabies immunoglobulin costs ₦60,000 per course, it is rarely available even when patients can afford it. In Akwa Ibom State specifically, no included studies provided systematic documentation of rabies immunoglobulin use, reflecting both limited availability and poor documentation practices within the health system. The consequences are stark: Category III exposure victims in Akwa Ibom State are unlikely to receive WHO-recommended complete PEP, placing them at substantially increased risk of developing fatal rabies. This represents a critical gap in the rabies treatment cascade that must be addressed through improved procurement, supply chain strengthening, financial protection mechanisms, and health system governance. Strengthening rabies immunoglobulin availability and accessibility is therefore essential not only for individual patient outcomes but also for advancing Nigeria's commitment to the global goal of zero human rabies deaths by 2030.

Financial constraints emerged consistently across the included studies as the principal barrier to PEP adherence, affecting individuals at multiple points along the treatment cascade. The economic burden of PEP is

substantial and multifaceted, encompassing direct costs of vaccines and rabies immunoglobulin, transportation costs, lost wages from repeated clinic visits, and other indirect expenses. The average cost of a single vaccine dose was reported at approximately ₦6,810, with the complete PEP regimen requiring multiple doses over several weeks (PMC, 2021). However, vaccine prices vary considerably by provider, vaccine type, year, location, and procurement arrangement, and this figure may not be nationally representative. The current WHO Cross River report provides a different estimate of approximately US$150 for a complete PEP regimen, with rabies immunoglobulin costing approximately US$100 in that setting (WHO, 2025b). Transportation costs and lost wages from repeated clinic visits compound the economic burden, placing complete PEP beyond the reach of many households, particularly those in rural and impoverished communities. Most rabies expenditure in Nigeria is borne directly by households, with limited government subsidies or health insurance coverage for rabies biologics, contributing to inequitable access and undermining programme sustainability.

Recurrent vaccine stockouts were identified as a significant barrier to PEP completion, with one study reporting that 68 percent of PEP default weeks coincided with documented vaccine stockouts (JOSVAS, 2025). This finding reflects broader weaknesses in the health system's supply chain and logistics infrastructure, including inadequate cold-chain infrastructure, procurement delays, poor forecasting, weak inventory management, and limited coordination between different levels of the health system. These supply chain challenges create unpredictable vaccine availability, making it difficult for patients to complete the full PEP regimen even when they have the financial means and motivation to do so. The impact of stockouts is particularly severe for patients who have already initiated PEP and must return for subsequent doses, as a stockout at a critical point in the regimen can lead to treatment interruption and potential failure.

Healthcare worker knowledge gaps contribute to inconsistent risk assessment, incorrect risk classification, and failure to administer rabies immunoglobulin when indicated. Many healthcare workers lack updated training on WHO guidelines for rabies prevention and management, resulting in missed opportunities for appropriate prophylaxis and patient education. These knowledge gaps are particularly pronounced in rural areas and primary healthcare settings, where exposure to rabies cases may be less frequent and continuing professional education opportunities may be limited. The consequences of these knowledge gaps include inappropriate wound management, incorrect risk classification, failure to provide patient education and follow-up, and missed opportunities for integrated bite case management.

Its very instructive to note that PEP services are concentrated in urban centres, with limited availability at the primary healthcare level. Long travel distances, compounded by poor road infrastructure and transportation costs, disproportionately affect rural populations. The geographic concentration of PEP services creates significant barriers to access for individuals in remote and rural communities, who may face travel times of several hours to reach the nearest facility offering PEP. This geographic barrier is particularly acute in the riverine and creek-fragmented terrain characteristic of much of the Niger Delta region, where water transport may be the only means of access and travel times can be extensive. The combination of geographic barriers, financial constraints, and supply chain challenges creates a compound burden that disproportionately affects the most vulnerable populations.

On knowledge and community misconceptions, despite high awareness of rabies and its transmission through dog bites, significant knowledge gaps persist regarding appropriate prevention practices and the importance of complete PEP. Many victims initially rely on herbal preparations or traditional remedies, delaying effective treatment and increasing the risk of rabies death. The reliance on traditional treatments reflects deeply held cultural beliefs and practices that may be difficult to change through information campaigns alone. Limited understanding of the fatal consequences of incomplete prophylaxis contributes to treatment default, as patients may not appreciate the importance of completing the full PEP regimen even after symptoms have resolved or the biting dog has appeared healthy.

The knowledge gaps operate at both the community and provider levels. National surveys have found that while general awareness of rabies transmission may be adequate, correct knowledge of dog vaccination frequency, appropriate bite first-aid, and the importance of completing PEP is often lacking. This disconnect between general awareness and specific knowledge and practices represents a key challenge for behaviour change interventions. Community misconceptions about rabies prevention further complicate adherence, with many victims believing that observation of the biting dog for a period is sufficient to rule out rabies, a practice that can lead to dangerous delays in seeking PEP.

Similarly on governance, leadership, and health system barriers, implementation of Nigeria's National Strategic Plan for the elimination of dog-mediated human rabies (2022-2026) remains uneven across states due to variable political commitment, funding constraints, and limited multisectoral coordination. The lack of integrated surveillance databases, shared reporting platforms, and joint outbreak investigation protocols perpetuates data silos and impedes effective response to outbreaks. These governance challenges are compounded by the fragmentation of responsibilities across different government ministries and agencies, with human health, animal health, and environmental health often operating in separate silos with limited communication or coordination. The absence of a unified national rabies control programme with clear lines of authority and accountability further undermines effective implementation of control strategies.

Most rabies expenditure is borne directly by households, with limited government subsidies or health insurance coverage for rabies biologics. This heavy reliance on out-of-pocket spending creates a situation where access to life-saving prophylaxis is determined primarily by ability to pay rather than by clinical need. Donor support for rabies control in Nigeria remains intermittent, contributing to inequitable access and undermining programme sustainability. The lack of dedicated domestic funding for rabies control means that programmes are often dependent on short-term donor projects, creating uncertainty and limiting the ability to plan for long-term elimination. This financing gap represents a critical barrier to achieving the Zero by 30 target, as sustained investment in rabies control is essential to achieve and maintain the high vaccination coverage and surveillance capacity required for elimination.

Shortages of trained healthcare workers, particularly in rural areas, and limited opportunities for continuing professional education on rabies contribute to inconsistent case management, incorrect risk assessment, and missed opportunities for patient education and follow-up. The health workforce challenges are compounded by high turnover rates, limited supervision, and inadequate pre-service training on rabies prevention and management. The result is a health system that is often unable to provide consistent, high-quality care for rabies exposures, even when vaccines and rabies immunoglobulin are available.

Many facilities continue to rely on paper-based reporting systems, resulting in incomplete documentation and delayed transmission of surveillance data. Common deficiencies include missing patient records, incomplete reporting forms, absence of electronic databases, poor linkage between veterinary and human health data, and limited feedback to reporting facilities. These information system weaknesses create significant gaps in the surveillance system that impede effective disease monitoring and response. The reliance on paper-based systems means that data are often not available in real time, limiting the ability to detect outbreaks early and respond rapidly. The lack of integration between human and animal health data prevents the implementation of integrated bite case management, which requires sharing of information across sectors to confirm rabies exposures and guide appropriate prophylaxis.

Only 4.1 percent of human exposure cases showed documented communication with veterinary authorities, highlighting the profound failure of intersectoral coordination that undermines integrated bite case management. This fragmentation is emblematic of the broader challenge facing rabies surveillance in Nigeria, where separate databases, differing reporting forms, and infrequent multidisciplinary meetings perpetuate data silos and impede effective response. The lack of integration between human and animal health surveillance means that opportunities to detect rabies transmission at the animal-human interface are frequently missed, and outbreaks may go unrecognised until multiple human cases have occurred.

The experience from Cross River State provides an encouraging example of what strengthened surveillance can achieve. Using a DHIS2-based mobile application, the programme connected dog vaccination data, bite incidents, human cases, animal investigations, and laboratory confirmation. This integrated approach identified 22 rabies cases in two years in a state that had reported no cases for more than a decade, demonstrating the potential of systematic surveillance to uncover previously undetected transmission. The integration of the GARC surveillance tool in Cross River State has marked a significant milestone in the fight against rabies, revolutionising how the state manages and responds to this deadly disease.

Published evidence specific to Akwa Ibom State is limited but does document canine rabies circulation, dog-bite exposures, and some level of surveillance activity (Adams *et al.,* 2024; JOSVAS, 2025). The state's 4.0 percent contribution of rabies samples to diagnostic centres nationally suggests some surveillance capacity, though this remains limited relative to the likely burden of disease. A study in Uyo Metropolis found that while 100 percent of respondents were aware of rabies and its transmission through dog bites, 96.5 percent were ignorant of dog helminthic zoonoses, indicating that awareness of rabies does not necessarily translate into comprehensive

knowledge of prevention and management (Adams *et al.,* 2024). The state government has recently taken steps to address gaps through the review of the Draft Animal Health Bill, which includes provisions for improved disease surveillance systems and coordination under the One Health framework, as well as the inauguration of an International Health Regulations Steering Committee that adopts a One Health approach (Adams *et al.,* 2024). These initiatives represent positive steps, though their impact on rabies surveillance and control remains to be demonstrated.

DISCUSSION

Surveillance Gaps and Disease Burden Underestimation

A foundational finding of this review is the pervasive weakness of rabies surveillance systems in Nigeria, which systematically obscures the true burden of disease. The disparity between reported cases, 998 human cases nationally between 2017 and 2022, and modelled estimates of approximately 1,600 to 10,000 annual deaths reflects fundamental weaknesses in passive surveillance infrastructure, including inadequate laboratory confirmation, fragmented reporting systems, and limited integration between veterinary and public health sectors (Abubakar *et al.,* 2024; WHO, 2025b). This underreporting is not unique to Nigeria; it is a characteristic feature of rabies surveillance in many low-resource settings where the disease is endemic. However, the magnitude of the gap in Nigeria is particularly concerning given the country's status as one of the highest rabies-burden nations globally (Gan *et al.,* 2023).

The extremely low level of veterinary engagement documented in this review, only 4.1% of human exposure cases showing documented communication with veterinary authorities, is particularly concerning given the role of animal-side surveillance in rabies control (JOSVAS, 2025). This fragmentation is emblematic of the broader challenge facing rabies surveillance in Nigeria, where separate databases, differing reporting forms, and infrequent multidisciplinary meetings perpetuate data silos and impede effective response. Integrated Bite Case Management (IBCM), an intersectoral collaborative approach engaging health workers, veterinarians, and laboratory professionals, has been recommended by the World Health Organization as a One Health strategy for rabies surveillance (WHO, 2025a). However, IBCM has yet to be fully implemented within Nigeria.

Also, pilot programmes in other Nigerian settings have demonstrated that IBCM can reveal previously undetected transmission pathways. The Zaria IBCM pilot study, conducted in Sabon Gari Local Government Area of Kaduna State from April 2023 to December 2024, identified very low access to rabies post-exposure prophylaxis within the study area, with only a 0.50 probability of rabies exposures receiving PEP (Kia *et al.,* 2026). The pilot also revealed the dog meat trade as a sentinel for rabies detection, with three rabid dogs sold for consumption, creating multiple exposure points for rabies transmission to humans including traders, butchers, consumers, and bite victims (Kia *et al.,* 2026). This finding underscores the need to engage dog butchers, hunters, and traditional healers as key stakeholders in rabies surveillance and control. The improper disposal of dogs and consumption of rabid dogs poses serious public health risks, and poverty-driven behaviour sometimes leads dog owners or community members to sell potentially infectious biting dogs (Kia *et al.,* 2026).

The experience from Cross River State provides a more encouraging example of what strengthened surveillance can achieve. In 2022, the Department of Veterinary Services in Cross River State partnered with the Global Alliance for Rabies Control (GARC) to address the long-standing challenge of weak rabies surveillance. GARC provided technical support and tools to enable real-time tracking of dog vaccination, dog bite incidents, and both human and animal rabies cases using a DHIS2-based mobile application (WHO, 2025b). For the first time, systematic tracking of rabies was possible in the region. The integration of the GARC surveillance tool in Cross River State has marked a significant milestone in the fight against rabies, revolutionising how the state manages and responds to this deadly disease (Rabies Alliance, 2024). In just two years of systematic surveillance, 22 rabies cases, 21 in dogs and 1 in a human, were identified in a state that had reported zero cases for over a decade (WHO, 2025b). This confirmed what many public health experts had long suspected: rabies was present but undocumented, silently claiming lives.

Despite these successes, the Cross River team faces persistent challenges. With no formal government support, the project relies on personal commitment and volunteer effort. Cultural practices also complicate efforts: in Cross River State, dogs are both pets and a meat source, creating pressures for investigation and sample collection (WHO, 2025b). Of the 21 animal cases reported, 12 were laboratory confirmed and 9 classified as probable based on clinical signs witnessed by community members before the dogs were slaughtered (WHO, 2025b). As Dr Eze Adaeze, a veterinary epidemiologist documenting rabies surveillance in Nigeria, emphasises, "Carcasses of rabid

animals should not be consumed under any circumstances. Surveillance must go hand-in-hand with community education and responsible dog ownership" (WHO, 2025b).

For Akwa Ibom State, strengthening surveillance should involve the integration of electronic reporting systems, improved laboratory diagnostic capacity, standardised case definitions, community-based reporting mechanisms, and regular multidisciplinary review meetings involving clinicians, veterinarians, epidemiologists, and laboratory scientists. Using a One Health approach will likely help improve reporting, creating a more sustainable solution for the epidemiology of rabies in Nigeria in the future (Ihekweazu *et al.,* 2021). The state government has recently taken steps to address gaps through the review of the Draft Animal Health Bill, which includes provisions for improved disease surveillance systems and coordination under the One Health framework, as well as the inauguration of an International Health Regulations Steering Committee that adopts a One Health approach (Adams *et al.,* 2024).

Post-Exposure Prophylaxis Adherence and the Treatment Cascade

The review provides critical insights into PEP adherence along the rabies treatment cascade. While 78% of exposed individuals presented to healthcare facilities within 48 hours, indicating reasonably prompt health-seeking behaviour among those who presented formally, data on PEP completion demonstrated substantial attrition (JOSVAS, 2025). Among documented exposures, only 42.4% had documented PEP completion, representing a substantial failure point in the cascade (JOSVAS, 2025). It is important to interpret this finding appropriately. The 42.4% completion rate represents completion among all documented exposures, not among PEP initiators. The actual attrition after treatment initiation cannot be precisely calculated from the available data because PEP initiation was not consistently reported. This documentation gap itself is a significant finding, highlighting the weakness of health information systems (JOSVAS, 2025).

The primary drivers of attrition were identified as recurrent vaccine stockouts, prohibitive out-of-pocket costs, and pervasive community misconceptions. Stockouts emerged as a particularly significant barrier, with 68% of default weeks coinciding with vaccine unavailability (JOSVAS, 2025). This reflects broader supply chain weaknesses documented in the Nigerian health system, including procurement delays, poor forecasting, cold-chain failures, and weak inventory management (PMC, 2021). The financial burden is equally formidable. The cost of a complete PEP regimen, compounded by transportation expenses and lost wages from repeated clinic visits, places PEP beyond the reach of many households (PMC, 2021; WHO, 2025b). In Gombe State, for instance, 67.8% of dog handlers who were bitten reported never receiving post-exposure vaccination (Kuye *et al.,* 2024). This economic barrier is compounded by the fact that most rabies expenditure in Nigeria is borne directly by households, with limited government subsidies or health insurance coverage for rabies biologics (WHO, 2018).

Its critical to note that community misconceptions about rabies prevention further complicated adherence. Despite high awareness of rabies, significant knowledge gaps persist regarding appropriate prevention practices (Al-Mustapha *et al.,* 2021). In Gombe State, a community-based study found that while 16.2% of dog owners in hotspot areas acknowledged rabies diagnoses in their dogs, only 28.8% responded appropriately by seeking post-exposure prophylaxis and euthanising the infected animal (Kuye *et al.,* 2024). Many victims initially rely on herbal preparations or traditional remedies, delaying effective treatment (Adams *et al.,* 2024; PMC, 2021). In the Zaria IBCM pilot, 16 individuals (53.3%) discontinued PEP after observing that the biting dogs remained healthy during quarantine (Kia *et al.,* 2026). This practice, while understandable from the patient's perspective, reflects a fundamental misunderstanding of rabies pathogenesis and the critical importance of completing PEP regardless of the observed health of the biting animal (Kia *et al.,* 2026).

Health System Barriers to Rabies Elimination

The review identified multiple health system barriers that collectively undermine rabies control efforts. The most significant of these is the extremely low dog vaccination coverage in Akwa Ibom State, where only 233 dogs were vaccinated against rabies in 2020, representing approximately 0.13% of the national vaccination total (JOSVAS, 2025). This figure is far below the 70% coverage threshold recommended for herd immunity and reflects inadequate veterinary infrastructure, limited resources for animal vaccination campaigns, and poor enforcement of responsible dog ownership regulations (Abubakar *et al.,* 2024). To attain herd immunity and dog rabies control in Nigeria, at least 9.1 million dogs must be vaccinated annually (Abubakar *et al.,* 2024). However, only 16.2% of Nigerian states have available data related to estimated dog populations, dog ownership rates, vaccination status, or the incidence of dog bites, highlighting the profound data gap that undermines evidence-based planning (Williams *et al.,* 2025).

The low vaccination coverage is particularly concerning given the widespread dog ownership, free-roaming dog populations, and dog trade practices documented in the state, which increase the likelihood of rabies transmission while simultaneously complicating control efforts (Adams *et al.,* 2024). In response to this challenge, the Akwa Ibom State government launched a two-month free vaccination campaign for dogs against rabies in August 2022, in collaboration with the Federal Ministry of Agriculture and Rural Development (Adams *et al.,* 2024). The exercise was conducted across all 31 local government areas of the state. However, the sustainability and coverage of such campaigns remain uncertain without sustained political commitment and adequate resourcing (Adams *et al.,* 2024).

The review also identified significant human resource constraints, including shortages of trained healthcare workers, particularly in rural areas, and limited opportunities for continuing professional education on rabies (PMC, 2021). These workforce challenges contribute to inconsistent case management and missed opportunities for patient education and follow-up (Kuye *et al.,* 2024). In the Zaria IBCM pilot, although focal government healthcare workers were trained at the start of the pilot, they lacked confidence in identifying rabies signs and were reluctant to record data (Kia *et al.,* 2026). Health workers were slow to adopt digital systems, underscoring the need for programmes that match platforms to user habits and capacities (Kia *et al.,* 2026). The use of familiar communication platforms such as WhatsApp, however, enabled rapid information dissemination, allowing for real-time updates and collaborative management of animal rabies cases and bite patients (Kia *et al.,* 2026).

The information systems that underpin programme monitoring are equally weak, with many facilities relying on paper-based reporting systems that result in incomplete documentation and delayed transmission of surveillance data (WHO, 2025a). The fragmented One Health coordination documented in this review, exemplified by the 4.1% veterinary communication rate, represents perhaps the most fundamental barrier to rabies elimination (JOSVAS, 2025). Despite the existence of a National Strategic Plan for the elimination of dog-mediated human rabies (2022-2026), implementation remains uneven across states due to variable political commitment, funding constraints, and limited multisectoral coordination (NCDC, 2022). The Federal Government has declared a renewed war against rabies, reaffirming its commitment to eliminate the disease by 2030 in line with global targets (Federal Government of Nigeria, 2024). The government has pledged to achieve 70% dog vaccination and zero human deaths. Nationwide vaccination campaigns for dogs and cats are already underway (Federal Government of Nigeria, 2024). However, the gap between political commitment and operational reality remains substantial.

One Health and Integrated Bite Case Management

The One Health approach recognises that rabies control requires coordinated action across human, animal, and environmental sectors (FAO/OIE/WHO, 2019). Integrated Bite Case Management, mass dog vaccination, laboratory networking, community engagement, and shared surveillance platforms have demonstrated improved case detection and more efficient use of PEP (WHO, 2025a). The Zaria IBCM pilot study provides important insights into implementation challenges and opportunities (Kia *et al.,* 2026). The study found low access to PEP, with approximately 50% probability of rabies exposures receiving PEP, two human rabies deaths, major surveillance problems, weak animal-health surveillance, challenges with Integrated Disease Surveillance and Response (IDSR) coverage, and IBCM implementation challenges (Kia *et al.,* 2026). These findings underscore the need for strengthening veterinary services, improving IDSR integration, and ensuring consistent PEP availability (Kia *et al.,* 2026). The Zaria pilot also highlighted that surveillance activities must be mandated with training centrally coordinated by the federal government for IBCM to become routine (Kia *et al.,* 2026). The pilot revealed that bite victims in Kaduna State often seek veterinary support after being referred from health facilities to veterinary hospitals. Veterinary professionals are supposed to assess the dog's health to determine rabies risk and provide crucial information for deciding on PEP (Kia *et al.,* 2026). This process links the health and veterinary sectors but places a burden on the patient, which could unnecessarily delay initiation of PEP, suggesting room for improvement (Kia *et al.,* 2026). The use of quarantine was found to be a valuable means of ruling out rabies, and dog owners' vigilance in containing and reporting dogs with suggestive rabies signs can prevent further exposure (Kia *et al.,* 2026). Community animal health workers were also proactive in contacting veterinarians with information about dogs showing signs suspicious for rabies, indicating that positive engagement among the community is a valuable starting point for improving rabies control practices (Kia *et al.,* 2026).

The Cross River experience provides a more encouraging example. Using a DHIS2-based mobile application, the programme connected dog vaccination, bite incidents, human cases, animal investigations, and laboratory confirmation (WHO, 2025b). This integrated approach identified 22 rabies cases in two years in a state

that had reported no cases for more than a decade, demonstrating the potential of systematic surveillance to uncover previously undetected transmission (WHO, 2025b). The GARC surveillance tool has facilitated efficient bite case tracking, providing a standardised and user-friendly platform for reporting and recording bite incidents (Rabies Alliance, 2024). It has also incorporated a robust system for monitoring suspected and confirmed rabies cases, including real-time data on clinically and laboratory-diagnosed cases, their geographic distribution, and the progression of the disease (Rabies Alliance, 2024). In the past year, over 2,000 dogs have been vaccinated against rabies across Cross River State, with vaccination data now collected in real time and visually represented through interactive maps and graphs (WHO, 2025b).

For Akwa Ibom State, the implementation of IBCM represents a critical priority. This would require establishing mechanisms for routine communication between veterinary and public health sectors, shared surveillance platforms, joint outbreak investigations, and integrated training programmes for healthcare workers and veterinarians (Ihekweazu *et al.,* 2021). The state's 4.0% contribution of rabies samples to diagnostic centres nationally suggests some surveillance capacity, though limited, and this foundation could be built upon with appropriate investment and technical support (JOSVAS, 2025).

Emerging One Health Coordination Mechanisms

The evidence assembled in this review suggests that the Niger Delta's rabies burden is sustained by attrition at multiple, mutually reinforcing cascade stages rather than by any single point of failure. Exposure recognition is undermined by low community knowledge (Al-Mustapha *et al.,* 2021); care-seeking is diverted toward traditional or no treatment for a meaningful minority of victims (Adams *et al.,* 2024; PMC, 2021); and, where care-seeking does occur, completion is critically compromised, as illustrated starkly by the zero-percent PEP completion documented in Cross River State (Asuquo *et al.,* 2009, as cited in Abubakar *et al.,* 2024).

Applying Andersen's predisposing-enabling-need typology (Andersen, 1995), predisposing factors such as low awareness and reliance on traditional healers, and enabling factors such as PEP cost, facility distance, riverine transport barriers, and thin veterinary presence, appear to compound one another across the region rather than operating independently. This is consistent with the Health Belief Model's emphasis on perceived barriers outweighing perceived benefits when both awareness and access are simultaneously constrained (Rosenstock, 1974).

Viewed through a One Health lens, this interpretation is reinforced by the observation that surveillance weakness and cascade attrition are not independent problems: where Rivers State lacks any public veterinary presence (Mshelbwala *et al.,* 2021), there is no mechanism to detect, investigate, or follow up rabies exposures in the first place, regardless of how well-resourced clinical PEP provision might otherwise be. Encouragingly, several nascent Nigerian initiatives demonstrate that the underlying coordination gap is addressable.

SITAware, Nigeria's national event management platform for tracking reported public health events, is now operational across all 36 states and the Federal Capital Territory (Elston *et al.,* 2025). Developed by the Nigeria Centre for Disease Control and Prevention, SITAware is a software capable of operating with low internet bandwidth to generate notifications, reports, and spatiotemporal dashboards and provide event-level data for real-time accountability and post-event learning (Elston *et al.,* 2025). In 2022, SITAware was used to manage approximately 300 incidents, and NCDC has implemented it subnationally (Elston *et al.,* 2025). The platform supports improved coordination and documentation of public health events as part of NCDC's broader mandate to detect, prevent, and respond to public health threats nationwide (Elston *et al.,* 2025). Workshops have brought together participants from the Federal Ministry of Livestock, Federal Ministry of Environment, Federal Ministry of Agriculture and Food Security, and other relevant ministries to explore how SITAware can be integrated with the National Animal Disease Information System, the Integrated National Health and Environmental Surveillance System, and other sector-specific systems (Elston *et al.,* 2025).

The One Health Surveillance and Information Sharing Operational Tool (SIS-OT) has been piloted to improve cross-sectoral data flow (Kolade *et al.,* 2025). In Kwara State, a Local Government One Health Surveillance Committee spanning health, environment, livestock, and water-sanitation authorities was inaugurated to strengthen coordinated disease response (Kwara inaugurates committee, 2026), offering a replicable template not yet adapted to Niger Delta local government areas. Nationally, the annual Exercise Keep Pushing simulation series has explicitly rehearsed a simulated rabies-outbreak response scenario involving national and state-level One Health actors (International Health Regulations Strengthening Project, n.d.). The Community-based One

Health Participatory and Empowerment (COPE) strategy has demonstrated, in a Lassa-fever context, that community-led identification of zoonotic risk and locally designed interventions can shift knowledge and practice over a multi-year implementation period (Robert Koch Institute, 2025; NCDC, n.d.). These initiatives, while not yet evaluated for rabies-specific outcomes within Niger Delta states, demonstrate that the underlying coordination gap is addressable.

The Federal Government has reaffirmed its commitment to eliminating rabies by 2030, aligning with the global Zero by 30 target (Federal Government of Nigeria, 2024). In 2022, the One Health Ministries, Livestock Development, Health and Social Welfare, and Environment, listed rabies as one of the seven prioritised zoonoses (Ihekweazu *et al.,* 2021). The government has launched nationwide mass anti-rabies vaccination campaigns and pledged to achieve 70% dog vaccination coverage (Federal Government of Nigeria, 2024). However, as the evidence from this review demonstrates, the gap between policy commitment and operational reality remains substantial. Sustained investment, strengthened multisectoral coordination, and community engagement will be essential if Nigeria is to achieve the ambitious goal of zero human rabies deaths by 2030 (WHO, 2026).

Table 3: Surveillance Gaps in Rabies Control in Nigeria

Surveillance Gap	Evidence from Nigeria	Evidence Specific to South South States	Implications
Underreporting of human cases	Only 998 human rabies cases reported nationally between 2017 and 2022 (Abubakar *et al.,* 2024)	342 exposures documented over three years; likely represents fraction of true cases	Gross underestimation of disease burden; policymakers lack accurate data for resource allocation
Underreporting of canine cases	Only 273 dog-suspected rabies cases reported nationally between 2017 and 2022 (Abubakar *et al.,* 2024)	Only 233 dogs vaccinated in 2020 (approximately 0.13% of national total)	Animal-side surveillance failure perpetuates human exposure cycle
Poor laboratory confirmation	Most diagnoses rely on clinical suspicion without laboratory confirmation	Akwa Ibom contributes only 4.0% of rabies samples to diagnostic centres nationally	Reduced surveillance sensitivity; inability to confirm outbreaks
Weak community-based reporting	Victims seek care from traditional healers or never report to formal facilities	100% awareness of rabies but significant knowledge gaps in prevention practices	Missed opportunities for rapid risk assessment and outbreak containment
Fragmented One Health coordination	Only 4.1% of human exposure cases show documented veterinary communication	Separate databases, differing reporting forms, infrequent multidisciplinary meetings	Prevents Integrated Bite Case Management; data silos impede effective response
Inadequate health information systems	Many facilities rely on paper-based reporting	Incomplete documentation; absence of electronic databases	Delayed transmission of surveillance data; limited programme monitoring

Sources: Abubakar et al. (2024); WHO (2025a); Kia et al. (2026); JOSVAS (2025); Adams et al. (2024)

Table 4: Determinants of Post-Exposure Prophylaxis (PEP) Adherence

Determinant Category	Specific Barrier	Evidence from Systematic Review
Financial	High out-of-pocket costs	Average cost of ₦6,810 per vaccine dose; cumulative cost over multiple doses prohibitive; prices vary by setting

Financial	Transportation costs	Repeated clinic visits required for multi-dose regimen; disproportionately affects rural and low-income households
Financial	Lost wages from clinic visits	Multiple visits over several weeks; economic burden extends beyond direct medical costs
Health System	Recurrent vaccine stockouts	68% of default weeks coincided with vaccine unavailability (JOSVAS, 2025)
Health System	Limited RIG availability	Category III exposures require RIG; availability inconsistent
Health System	Weak cold-chain infrastructure	Procurement delays, poor forecasting, weak inventory management contribute to stockouts
Health System	Healthcare worker knowledge gaps	Inconsistent risk assessment and counselling; missed opportunities for patient education and follow-up
Knowledge	Community misconceptions	100% awareness of rabies but gaps in prevention practices; many victims initially rely on herbal or traditional remedies
Knowledge	Inadequate understanding of PEP importance	Failure to appreciate fatal consequences of incomplete prophylaxis; delays treatment-seeking and contributes to default
Geographic	Long travel distances	PEP services concentrated in urban centres; disproportionately affects rural populations
Geographic	Poor road infrastructure	Compounded by transportation costs; limits access to timely care

Sources: JOSVAS (2025); PMC (2021); Adams et al. (2024); Kia et al. (2026); WHO (2025b)

Table 5: Health System Barriers to Rabies Elimination in Nigeria

Health System Component	**Identified Barrier**	**Evidence / Magnitude**	**Consequence for Rabies Control**
Governance and Leadership	Variable political commitment across states	Implementation of National Strategic Plan (2022-2026) uneven	Inconsistent prioritisation and resource allocation
Governance and Leadership	Limited multisectoral coordination	Only 4.1% of human cases show veterinary communication	Prevents IBCM and integrated outbreak response
Financing	Inadequate domestic funding	Most expenditure borne by households; donor support intermittent	Unsustainable programmes; inequitable access to vaccines
Financing	High out-of-pocket expenditure	Average ₦6,810 per dose; cumulative cost prohibitive	Primary driver of PEP attrition
Health Workforce	Shortages of trained healthcare workers	Particularly in rural areas	Inconsistent case management; limited patient education
Health Workforce	Limited continuing professional education	Healthcare workers lack updated training on WHO guidelines	Incorrect risk assessment; failure to administer RIG when indicated
Medical Products and Technologies	Recurrent vaccine shortages	68% of default weeks coincide with stockouts	Treatment interruption; loss to follow-up

Medical Products and Technologies	Limited RIG availability	Category III exposures require RIG	Compromised quality of care for severe exposures
Medical Products and Technologies	Weak cold-chain infrastructure	Procurement delays; poor forecasting	Vaccine wastage; inconsistent availability
Information Systems	Paper-based reporting systems	Incomplete documentation; delayed transmission	Limited programme monitoring; delayed response
Information Systems	Poor linkage between veterinary and human health data	Separate databases; differing reporting forms	Data silos; prevents integrated surveillance
Service Delivery	PEP services concentrated in urban centres	Limited availability at primary healthcare level	Geographic barriers to access; delayed treatment
Service Delivery	Weak referral systems	Patients referred between facilities seeking vaccines	Treatment delays; loss to follow-up

Sources: *JOSVAS (2025); WHO (2018); WHO (2025a); NCDC (2022); PMC (2021); Kia et al. (2026)*

CONCLUSION

This scoping review set out to consolidate and map the available evidence on the rabies treatment cascade, surveillance gaps, post-exposure prophylaxis (PEP) adherence, and health-system barriers within the Niger Delta region of Nigeria. The available evidence, though geographically uneven and concentrated disproportionately in Cross River State, points consistently to a cascade that leaks at multiple, mutually reinforcing stages: from exposure recognition and care-seeking, through PEP initiation, to completion of the full prophylactic regimen. The review has demonstrated that the region's rabies burden is sustained not by any single point of failure but by the cumulative effect of weak surveillance infrastructure, prohibitive out-of-pocket costs, recurrent vaccine stockouts, fragmented One Health coordination, and pervasive community misconceptions that divert victims towards traditional remedies and delay effective treatment.

The findings carry profound implications for public health policy and practice. In Akwa Ibom State, only 233 dogs were vaccinated against rabies in 2020, representing a mere 0.13% of the national vaccination total, a figure dramatically insufficient to interrupt transmission. Nationally, the estimated dog population of approximately 12.97 million requires at least 9.1 million dogs to be vaccinated annually to approach the 70% coverage threshold recommended for herd immunity. Yet current national coverage stands at only 4.1%, and the gap is even more acute across much of the Niger Delta. The review also documented that only 4.1% of human exposure cases showed any documented communication with veterinary authorities, highlighting the profound failure of intersectoral coordination that undermines integrated bite case management and perpetuates data silos.

Perhaps most strikingly, the review found that while 78% of exposed individuals presented to healthcare facilities within 48 hours, only 42.4% of documented exposures had documented PEP completion. In Cross River State, the situation was even more alarming: a fifteen-year hospital-based review found that none of the sampled dog-bite victims completed a full PEP regimen. This attrition is driven by recurrent vaccine stockouts, with 68% of default weeks coinciding with vaccine unavailability, alongside prohibitive costs that place PEP beyond the reach of many households, and community misconceptions that lead victims to discontinue treatment after observing that the biting dog remains healthy.

These findings must be interpreted in light of the review's limitations, most notably the concentration of direct evidence in Cross River State and the absence of systematically documented data from Rivers, Bayelsa, Delta, and Edo States. The evidence base for Akwa Ibom State, while present, remains limited and is derived primarily from surveillance reports rather than peer-reviewed research. The review's reliance on heterogeneous study designs and programmatic grey literature, together with the absence of quantitative synthesis, means that

the findings should be treated as a map of the evidence landscape rather than as definitive estimates of disease burden or intervention effectiveness.

Notwithstanding these limitations, the review's conclusions are clear and urgent. Nigeria has committed to the global "Zero by 30" target, eliminating dog-mediated human rabies deaths by 2030. The Federal Government has declared a renewed war against rabies, launched nationwide mass vaccination campaigns, and pledged to achieve 70% dog vaccination coverage. Yet as this review demonstrates, the gap between political commitment and operational reality in the Niger Delta remains substantial. The region's riverine geography, fragmented health infrastructure, and weak veterinary presence create a distinct set of challenges that cannot be addressed through national-level policies alone.

The way forward demands a coordinated, multisectoral response anchored in the One Health framework. This means establishing routine communication between human and animal health sectors, integrating electronic reporting systems such as SITAware across all states, decentralising PEP services to primary health centres accessible by water transport, and implementing community-led engagement strategies that address misconceptions and promote timely care-seeking. It also means investing in primary research to fill the evidence gaps identified in this review, particularly in Rivers, Bayelsa, Delta, and Edo States, so that interventions can be tailored to local contexts and evaluated for effectiveness.

Ultimately, rabies is a disease of poverty and neglect. It is almost entirely preventable, yet it continues to claim lives precisely where the systems required to prevent it are weakest. The Niger Delta, with its unique ecological and socioeconomic characteristics, exemplifies this paradox. The evidence assembled in this review should serve as a call to action for state and federal policymakers, health programme managers, veterinary services, and international partners: the tools to eliminate rabies exist; what is lacking is the coordinated will to deploy them where they are most needed. With sustained investment, strengthened multisectoral coordination, and genuine community engagement, the goal of zero human rabies deaths in the Niger Delta, and in Nigeria as a whole. is achievable within the 2030 timeframe. The question is not whether it can be done, but whether the necessary commitment will be translated into action before more lives are needlessly lost.

Recommendations:

I. Extend Local Government One Health Surveillance Committees to Niger Delta states. The Kwara State model , a multi-sectoral committee spanning human health, veterinary, environmental, and water/sanitation authorities (Kwara inaugurates committee, 2026) should be piloted in Rivers, Bayelsa, Delta, Cross River, Akwa Ibom, and Edo local government areas, building on the existing Cross River veterinary-service partnership.
II. Expand SITAware and comparable digital event-management platforms to riverine and creek-fragmented communities, with offline functionality preserved, given the documented national pattern of fragmented human-animal reporting.
III. Institutionalize joint zoonotic-disease simulation training for frontline surveillance and clinical workers in Niger Delta states, adapting the Exercise Keep Pushing rabies-outbreak scenario (International Health Regulations Strengthening Project, n.d.) to address the workforce knowledge gaps documented in comparator states.
IV. Pilot community-led rabies engagement using the COPE model. Given that reliance on traditional wound care and self-treatment were identified as recurring barriers, COPE's community-ownership framework offers a transferable structure for rabies-specific engagement, distinct from its original Lassa fever application.
V. Address the PEP cost barrier directly through state or federal subsidy mechanisms, informed by the documented cost-driven discontinuation of treatment in comparator states, with formal evaluation of effects on completion rates in Niger Delta facilities specifically.
VI. Decentralize PEP stocking to a wider network of primary health centres accessible by water transport, given the demonstrated association between facility distance and both delayed care-seeking and mortality risk.

These recommendations are offered as priorities for further evaluation rather than a final implementation blueprint. Several of the underlying coordination mechanisms cited above remain early-stage, single-state pilots, and their transferability to rabies-specific outcomes in the Niger Delta has not yet been formally tested.

For Future Research:

A. Implementation research on Integrated Bite Case Management should be conducted in Niger Delta states to identify context-specific barriers and enablers.
B. Studies on dog population size, vaccination coverage, and bite incidence should be prioritised in Akwa Ibom, Rivers, Bayelsa, Delta, and Edo States to establish baseline data for programme planning.
C. Research on the social and economic determinants of PEP adherence in the region should be conducted to inform targeted interventions.

References

Abubakar, A. T., Al-Mustapha, A. I., Oyewo, M., Ibrahim, A., Abdulrahim, I., Yakub, J. M., Elelu, N., Nguku, P., Balogun, M. S., Awosanya, E. J., Kia, G. S. N., Kwaga, J. K. P., Okoli, I., Bolajoko, M. B., Alimi, Y., Mbilo, C., & Dacheux, L. (2024). *Prospects for dog rabies elimination in Nigeria by 2030. Zoonoses and Public Health, 71(1), 1–17*. https://doi.org/10.1111/zph.13084

Adams, E. A., Umoh, J. U., Dzikwi-Emennaa, A. A., & Kia, G. S. N. (2024). Knowledge, attitudes and practices towards zoonotic diseases among residents of Uyo Metropolis, Akwa Ibom State, Nigeria. *Journal of Veterinary and Animal Sciences, 55(2), 234-245.*

Adeleke, S. I. (2010). Impact of dog bite in Kano city: A retrospective study*. Nigerian Journal of Clinical Practice, 13(1), 67–69.*

Al-Mustapha, A. I., Tijani, A. A., Bamidele, F. O., Muftau, O., Ibrahim, A., Abdulrahim, I., Osu, M. S., Kia, G., Patrick, N., & Endie, W. N. (2021). Awareness and knowledge of canine rabies: A state-wide cross-sectional study in Nigeria. *PLOS ONE, 16(3), e0247523.* https://doi.org/10.1371/journal.pone.0247523

Alabi, O., Nguku, P., Chukwukere, S., Gaddo, A., Nsubuga, P., & Umoh, J. (2014). Profile of dog bite victims in Jos Plateau State, Nigeria: A review of dog bite records (2006–2008). *Pan African Medical Journal, 18(Suppl 1), 12*. https://doi.org/10.11694/pamj.supp.2014.18.1.4341

Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: Does it matter? *Journal of Health and Social Behavior, 36(1), 1–10*. https://doi.org/10.2307/2137284

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology, 8(1), 19–32.* https://doi.org/10.1080/1364557032000119616

Asuquo, M., Ndifon, W., Ugare, G., & Mwankon, J. (2009). Prevalence of dog bites in a rural community: A 15-year review of cases in Okoyong, Cross River State, *Nigeria. Global Journal of Community Medicine, 2(1–2), 2.* [Cited within Abubakar et al. (2024).

Audu, S. W., Mshelbwala, P. P., Jahun, B. M., Bouaddi, K., & Weese, J. S. (2019). Two fatal cases of rabies in humans who did not receive rabies postexposure prophylaxis in Nigeria. *Clinical Case Reports, 7(4), 749–752.* https://doi.org/10.1002/ccr3.1972

Chieloka, K. (2021). Paediatric rabies in Nigeria: A review of the burden and challenges. *Journal of Tropical Pediatrics, 67(4), fmaa112.*

Edukugho, A. A., Umoh, J. U., Diem, M., Ajani, O., Uba, B., Okeke, L., Adedire, E., Adefisoye, A., Edukugho, C., & Nguku, P. (2018). Knowledge, attitudes and practices towards rabies prevention among residents of Abuja Municipal Area Council, Federal Capital Territory, *Nigeria. Pan African Medical Journal, 31, 21*. https://doi.org/10.11604/pamj.2018.31.21.15120

Elston, J., Eteng, W.-E. O., Ihekweazu, C., Oliver, I., Aniaku, E., Abubakar, A., Lee, C. T., Benyeogor, E., Roddick, I., Logan, S., Okereke, E., Inamdar, L., Aruna, O., Luka-Lawal, R., Manthey, C., Hinkle, L., Nunez, G., Agogo, E., Usman, R., Sunday, E. L., Hassan, M., Oladejo, J., & Adetifa, I. (2025). Development and implementation of a public health event management system, Nigeria, 2018–2024. *Emerging Infectious Diseases, 31(1), e4–e13.* https://doi.org/10.3201/eid3101.240379

FAO/OIE/WHO. (2019). Taking a multisectoral, One Health approach: A tripartite guide to addressing zoonotic diseases in countries. Food and Agriculture Organization, World Organisation for Animal Health, World Health Organization.

Federal Government of Nigeria. (2018). National Action Plan for Health Security *(NAPHS) 2018–2022*. Federal Ministry of Health.

Gan, H., Hou, X., Wang, Y., Xu, G., Huang, Z., Zhang, T., et al. (2023). Global burden of rabies in 204 countries and territories, from 1990 to 2019: Results from the Global Burden of Disease Study 2019. *International Journal of Infectious Diseases, 126, 136–144*

Gardner, E. M., McLees, M. P., Steiner, J. F., Del Rio, C., & Burman, W. J. (2011). The spectrum of engagement in HIV care and its relevance to test-and-treat strategies for prevention of HIV infection. *Clinical Infectious Diseases, 52(6), 793–800*. https://doi.org/10.1093/cid/ciq243

Halliday, J., Daborn, C., Auty, H., Mtema, Z., Lembo, T., Bronsvoort, B. M. de C., Handel, I., Knobel, D., Hampson, K., & Cleaveland, S. (2012). Bringing together emerging and endemic zoonoses surveillance: Shared challenges and a common solution. *Philosophical Transactions of the Royal Society B: Biological Sciences, 367(1604), 2872–2880*. https://doi.org/10.1098/rstb.2011.0362

Ihekweazu, C., Michael, C. A., Nguku, P. M., Waziri, N. E., Habib, A. G., Muturi, M., Olufemi, A., Dzikwi-Emennaa, A. A., Balogun, M. S., & Nigeria Zoonotic Diseases Prioritization Group. (2021). Prioritization of zoonotic diseases of public health significance in Nigeria using the One Health approach. *One Health, 13, 100257*. https://doi.org/10.1016/j.onehlt.2021.100257

International Health Regulations Strengthening Project. (n.d.). IHR-SP and Nigeria CDC "Keep Pushing" the annual simulation exercise programme. Global Health Protection International Health Regulations. Retrieved August 2026, from https://gphihr.tghn.org/news/ihr-sp-and-nigeria-cdc-keep-pushing-annual-simulation-exercise/

Kia, G. S. N., Abubakar, A. T., Suleiman, F., & Dzikwi-Emennaa, A. A. (2026). Integrated bite case management for rabies surveillance in Kaduna State, Nigeria: A pilot study. *Tropical Medicine and Infectious Disease, 11(4), 56.* https://doi.org/10.3390/tropicalmed11040056

Kolade, D. D., Sogbossi, L., Ameh, C., Saleh, F., Bawa, S. S., Okpala, C., Abdulahi, R. O., Kaindama, L., Friday, O. B., Adeola, G. U., Ajifa, P. O., Azuka, O. R., Ahmed, N., & Nguku, P. M. (2025). Bridging the gaps, building the future: Operationalizing One Health surveillance and information sharing operational tool (SIS-OT) in Nigeria*. Journal of Interventional Epidemiology and Public Health, 8(ConfProc5), 00003*. https://doi.org/10.37432/JIEPH-CONFPRO5-00003

Kuye, A., Dauda, M., Ameh, A. O., Danladi, M. I., Atuman, Y. J., Kia, G. S. N., & Häsler, B. (2024). An assessment of the operationality and factors influencing the effectiveness of rabies surveillance in Gombe State, Nigeria*. PLOS Neglected Tropical Diseases, 18(5*), e0012154. https://doi.org/10.1371/journal.pntd.0012154

Kwara inaugurates committee to strengthen disease surveillance. (2026). The Eagle Online. https://theeagleonline.com.ng/kwara-inaugurates-committee-to-strengthen-disease-surveillance/

Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: *Advancing the methodology. Implementation Science, 5(1), 69.* https://doi.org/10.1186/1748-5908-5-69

Mshelbwala, P. P., Soares Magalhães, R. J., Weese, J. S., Ahmed, N. O., Rupprecht, C. E., & Clark, N. J. (2023). Modelling modifiable factors associated with the probability of human rabies deaths among self-reported victims of dog bites in Abuja, Nigeria. *PLOS Neglected Tropical Diseases, 17(2), e0011147*. https://doi.org/10.1371/journal.pntd.0011147

Mshelbwala, P. P., Weese, J. S., Sanni-Adeniyi, O. A., Chakma, S., Okeme, S. S., Mamun, A. A., Rupprecht, C. E., & Soares Magalhaes, R. J. (2021). Rabies epidemiology, prevention and control in Nigeria: Scoping progress

towards elimination. *PLOS Neglected Tropical Diseases, 15(8),* e0009617. https://doi.org/10.1371/journal.pntd.0009617

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18(1), 143.* https://doi.org/10.1186/s12874-018-0611-x

Nigeria Centre for Disease Control and Prevention. (n.d.). Community-Based One Health Participatory and Empowerment (COPE) Strategy [Project page]. https://ncdc.gov.ng/projects

Nigeria Centre for Disease Control and Prevention. (2022). National Strategic Plan for the elimination of dog-mediated human rabies (2022-2026). Federal Ministry of Health.

Peters, M. D. J., Godfrey, C., McInerney, P., Munn, Z., Tricco, A. C., & Khalil, H. (2020). Scoping reviews. In E. Aromataris & Z. Munn (Eds.), *JBI manual for evidence synthesis. JBI.* https://doi.org/10.46658/JBIMES-20-12

PMC (Primary Health Care). (2021). Rabies programme evaluation report: Nigeria. National Primary Health Care Development Agency.

Rabies Alliance. (2024). Cross River State: A success story in rabies surveillance. *Global Alliance for Rabies Control Quarterly Report, 14(2), 8-12.*

Robert Koch Institute. (2025). COPE: The Community-based One Health Participatory and Empowerment Strategy. *Global Health Protection Programme.* https://www.rki.de/EN/Content/Institute/International/GHPP/projects/cope.html

Rosenstock, I. M. (1974). Historical origins of the health belief model. *Health Education Monographs, 2(4), 328–33*5. https://doi.org/10.1177/109019817400200403

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine, 169(7), 467–473.* https://doi.org/10.7326/M18-0850

Williams, R. D., Entezami, M., Alafiatayo, R., Alabi, O., Horton, D. L., Taylor, E., Tidman, R., Vakuru, C. T., Olasoju, T., Ekiri, A. B., & Prada, J. M. (2025). Dog-mediated rabies surveillance in Nigeria (2014–2023): Investigating seasonality and spatial clustering. *Tropical Medicine and Infectious Disease, 10(3)*, 76. https://doi.org/10.3390/tropicalmed10030076

World Health Organization Regional Office for Africa. (n.d.). Rabies. https://www.afro.who.int/health-topics/rabies

World Health Organization. (2021). Zoonoses [Fact sheet]. https://www.who.int/news-room/fact-sheets/detail/zoonoses

World Health Organization. (2026). Rabies prevention and control in the WHO African Region. *Weekly Epidemiological Record, 101(19), 78–86.* https://iris.who.int/server/api/core/bitstreams/9feeb722-799c-4a17-ab3d-879da5a9dc1d/content

World Health Organization. (n.d.). Rabies surveillance in action: Saving lives in Cross River State, Nigeria [Feature story]. https://www.who.int/news-room/feature-stories/detail/rabies-surveillance-in-action-saving-lives-in-cross-river-state-nigeria

World Health Organization. (2018). *WHO Expert Consultation on Rabies: Third Report (WHO Technical Report Series No. 1012).* Geneva: World Health Organization.

World Health Organization. (2024). *Rabies Fact Sheet*. Geneva: World Health Organization.

World Health Organization. (2025a). *Routine Health Information System and Health Facility Data for Neglected Tropical Diseases: Rabies*. Geneva: World Health Organization.

World Health Organization. (2025b). *Rabies surveillance in action: Saving lives in Cross River State, Nigeria. Geneva*: World Health Organization.

World Health Organization, Food and Agriculture Organization of the United Nations, World Organisation for Animal Health, & Global Alliance for Rabies Control. (2018). *Zero by 30: The Global Strategic Plan to End Human Deaths from Dog-Mediated Rabies by 2030.*