AOJ Public Health

Research Article

OpenAccess

Audit of Effectiveness of Rabies Post-Exposure Prophylaxis

Volume 1 Issue 1 - 2026

John Anjum
Assistant Professor, Department of Community Medicine, Pushpagiri Medical College, and Research Centre, Tiruvalla, Pathanamthitta, Kerala

Correspondence: Anjum John, Department of Community Medicine, Pushpagiri Institute of Medical Sciences and Research Center, Tiruvalla, Kerala, India.

Received: December 23, 2025 **Published:** March 07, 2026

Citation: John Anjum. Audit of Effectiveness of Rabies Post-Exposure Prophylaxis. AOJ Pub Health. 2026;1(1):01–09.

Abstract

Background: The state of Kerala in India reports rising dog bite rates and an increase in human rabies deaths.

Objective: To quantify the real-world effectiveness of PEP (post exposure prophylaxis) in preventing rabies deaths, using population-level data.

Methods: Dog-bite and rabies-mortality data from Kerala (2014–July 2025) were analysed, with detailed case-level information from 2021–2025. PEP effectiveness was defined as the difference between observed number of rabies deaths among PEP recipients and the expected rabies deaths without PEP.

Results: Between 2021 and 2025, approximately 1.29 million persons received PEP for dog bites in Kerala. Among these PEP recipients, an estimated 9,494 rabid stray-dog bites would have caused 1,567 deaths (had PEP not been given). PEP effectiveness analysis was restricted to bites and rabies deaths of stray dog origin. An estimated 14 PEP-failure deaths were from stray dog bites. This corresponds to 1,553 deaths prevented by PEP (1,567 expected deaths minus 14 observed deaths), consistent with a PEP effectiveness of 99.1% [(1,553/1,567)×100].

86% of PEP-failure cases involved high-risk bites to the head, face, neck or fingers. During this period, 88 rabies deaths occurred among those who did not receive PEP.

Conclusion: Even under conservative assumptions, Kerala's PEP programme remains highly effective. Most deaths occurred either in individuals who did not initiate PEP or in those with high-risk bites that left insufficient time for immunity to develop. Rather than indicating PEP failure, the steady rise in rabies cases reflects increasing dog-bite incidence, growth of the stray-dog population, and an expanding human–wildlife interface that increases contact with non-canine rabies reservoirs.

Keywords: Rabies, Rabies virus, Rabies Vaccines, dog bite, PEP, post-exposure prophylaxis

Introduction

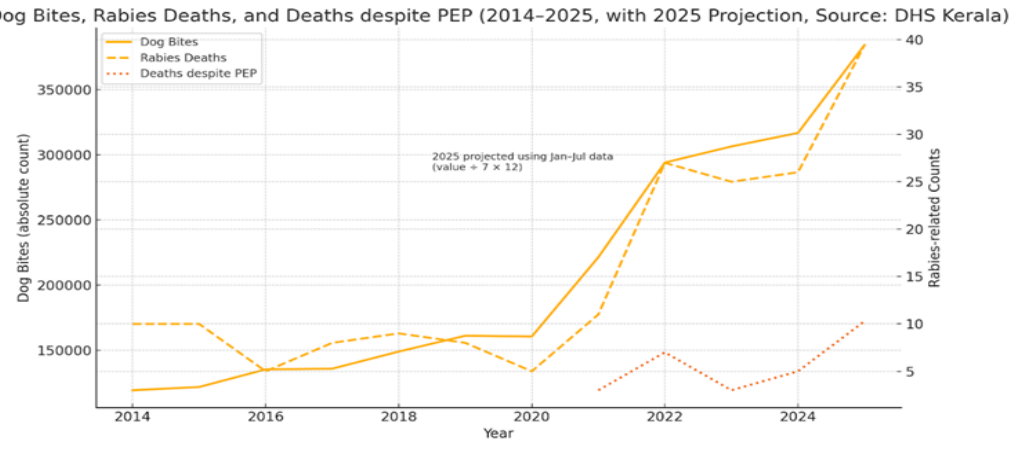
India accounts for the largest global burden of dog-bite injuries and remains endemic for rabies.[1] Each year, an estimated 9.1 million animal bites occur in the country, with an incidence of 6.6 per 1,000 population and about 5,726 human rabies deaths.[2] Rabies is uniformly fatal once symptoms appear, but entirely preventable with post-exposure prophylaxis—comprising wound washing, vaccination, and immune globulin infiltration for Category III exposures.[3]

Within this broader national pattern, the number of dog bites along with the number of rabies deaths has increased substantially over the past decade in the state of Kerala.[4] In 2014, there were 119,191 dog bites and 10 human rabies deaths; by 2024, these numbers had increased to 316,793 bites and 26 deaths (Table 1). A large proportion of rabies deaths in Kerala follow stray dog bites.[4,5] The number of stray dogs in Kerala has risen from 268,994 in 2015–16 to 700,000 in 2019–20, reaching approximately 900,000 in 2025.[6,7] Dog bites have risen in parallel (figure 1). Public concern in Kerala has increased in recent years because a few rabies deaths have occurred despite administering post-exposure prophylaxis (PEP).

Table 1. Annual number of reported dog bites and rabies deaths, 2014-2025 (DHS, Kerala)

Year	Number of dog bites	Number of rabies deaths
2014	119,191	10
2015	121,693	10
2016	135,217	5
2017	135,749	8
2018	148,899	9
2019	161,055	8
2020	160, 483	5
2021	221,379	11
2022	294,032	25
2023	306,427	27
2024	316,793	26
2025 (till July)	224,182	23

Figure 1: Dog Bites, Rabies Deaths, and Deaths PEP (2014-2025, With 2025 Projection, Source: DHS Kerala)



The intrinsic risk of developing rabies after a confirmed rabid-dog bite varies substantially—from approximately 5% for bites to the lower limbs to 45% for bites to the head or face in the absence of post-exposure prophylaxis.[8,9,10] Based on the distribution of bite locations and their varied risks, the overall probability of rabies following an untreated rabid dog bite has been estimated at 16.5%.[10]

The rationale for PEP is to neutralise the virus before it enters peripheral nerves and ascends to the central nervous system. Vaccine-induced antibody response is generated within a few days. Rabies Immunoglobulin (RIG), administered locally at the wound site for severe bites, provides an immediate jump-start to the immune response. Wound depth and severity, anatomical site, adequacy of immediate washing, promptness in administration of PEP, and adherence to schedule determine the likelihood of successful neutralisation.

Immune response following PEP has been studied widely in India. In a study from Bangalore, 100% of healthy volunteers achieved protective antibody titres by day 14 following intradermal rabies vaccination, although early responses at day 7 were limited.[11] This has practical implications for patients with severe bites to high-risk anatomical sites, where the incubation period is shorter and the immune system may need additional support through timely RIG infiltration.

Significant gaps in basic rabies prevention exist in India. Only 38.4% of bite victims perform proper wound washing after dog bites.[12] Cleaning the wound with soap helps inactivate the virus, while rinsing thoroughly with flowing water helps remove saliva containing viral particles from the bite site. Failure to do this results in higher initial viral load, while any delay in seeking PEP allows the virus more time to enter exposed nerve fibres. In India, wound care after dog bites is often inadequate: only 12.5–15.5% of rural bite victims wash wounds properly with soap and water,[13,14] and a multicentre survey found that 39.5% do not wash the wound at all.[15] A nationwide facility survey in India found anti-rabies vaccine was available in approximately 80% of public-sector facilities, whereas RIG—indicated for high-risk wounds—was available in only about 20%.[16]

This analysis quantifies PEP effectiveness in the state and examines the rare failures that occur.

Materials and Methods

Data were obtained from the Directorate of Health Services (DHS), Kerala.[4] These included annual dog bites (2014–July 2025), human rabies deaths (2012–July 2025) and detailed case profiles for rabies deaths between 2021 and 2025, including bite site and PEP status.

Data Analysis

1. Dog bites and PEP administration: Between 2021 and 2025, Kerala reported 1.36 million dog-bite cases. After excluding Category I (no skin breach) events, approximately 1.29 million individuals received PEP.[4] This included bites from both stray and pet dogs. The number of unreported bites during this period is unknown.
2. Estimated stray-dog exposures: As 32% of all dog bites in Kerala occur from stray dogs,[5] this translates to 412,800 of the 1.29 million PEP recipients.
3. Rabies prevalence in India's stray-dog population is unknown because reliable population-level testing requires brain tissue, and obtaining brain samples from healthy free-roaming dogs is ethically and operationally impossible. Existing Indian data come from dogs already suspected of rabies; unsurprisingly, 76% test positive in such selected samples.[17] Using these figures to represent community prevalence would grossly inflate estimates. In contrast, a 2009 study from China by Song M et al. analysed brain tissue from 2,887 apparently healthy, free-roaming village dogs—the closest analogue to Kerala's community strays—and found a 2.3% rabies prevalence.[18] Another study from China by Zhang et al. reported that 4.7% (165/3,492) of apparently healthy community dogs had saliva samples that were antigen-positive for rabies.[19] In a follow-up component of the same study, 81 apparently healthy dogs were euthanised for brain testing, and nested RT-PCR detected a 443-bp rabies viral N-gene fragment in 14.8% (12/81). Based on these findings, Zhang et al. emphasise that saliva- based PCR or antigen testing substantially underestimates prevalence because viral shedding in saliva is intermittent.[19] The low sensitivity of saliva testing has also been demonstrated in India in ante-mortem diagnostic studies of rabid dogs.[20] A further study from China reported a 3.26% rabies prevalence by sampling the brains of 3,032 apparently healthy ("normal") dogs.[21] Applying the lower 2.3% prevalence estimate to Kerala's 412,800 stray-dog bites yields 9,494 rabid-dog exposures.
4. Untreated case fatality risk: At an untreated fatality risk of 16.5%, these 9,494 rabid exposures from stray dogs would have resulted in 1,567 deaths.[10]

5. Rabies deaths during 2021–2025: Kerala recorded 112 confirmed human rabies deaths, among whom 88 individuals had not received PEP.
6. Anatomical pattern of PEP failures: Eighty-six percent of the 24 PEP failures involved high-risk anatomical sites such as on the head, face, neck or fingers—locations associated with short incubation periods because of dense nerve supply. These failures must be interpreted against a large denominator of 1.29 million dog bites during the same period.
7. Effectiveness calculation: PEP effectiveness is calculated retrospectively from real-world dog-bite outcomes. For this, we used data collected by the Kerala DHS regarding cases of dog bites that came to healthcare facilities, along with the reported number of rabies cases among people who received PEP, and among those who did not receive PEP.

The first step is to estimate how many rabies cases would have occurred if PEP had not been given. The second step is to determine how many cases actually occurred among those who received PEP. Effectiveness is then calculated using the formula:

(expected cases – observed cases) / expected cases × 100

Results

Observed cases after receiving PEP

There were 24 rabies deaths among individuals who received PEP. These resulted from bites by both stray and pet dogs. Because reliable data on rabies prevalence among pet dogs are not available, we restricted the effectiveness calculation to bites from stray dogs.

DHS data from 2021–2023 show that 58.3% of rabies deaths despite PEP were due to stray-dog bites (table 2). Applying this proportion to the five-year dataset, we estimate that 14 of the 24 PEP-failure deaths were the result of bites from stray rabid dogs.

Table 2. Type of bites among rabies deaths despite PEP, Kerala DHS, 2021-2023

No.	Year	Biting animal	Bite site(s)
1	2021	Jackal	–
2	2021	Stray dog	Left calf
3	2021	Stray dog	Scalp, right eye
4	2022	Stray dog	Lips, face
5	2022	Stray dog	Neck, both hands
6	2022	Dog	Hand (severe)
7	2022	Stray dog	Ears
8	2022	Stray dog	Face, forearm, hand
9	2022	Dog	Head, eyelids, trunk
10	2023	Wild cat	Hands, face
11	2023	Fox	Face
12	2023	Stray dog	Face, nose

Expected cases of rabies without PEP

To estimate how many rabid dog bites occurred among PEP recipients:
Stray-dog bite proportion = 1.29 million × 32% → 412,800 stray dog bites
Rabies prevalence among stray dogs = 412,800 × 2.3% → 9,494 rabid stray-dog exposures
Average fatality risk if untreated = 9,494 × 16.5% → expected 1,567 rabies deaths

PEP effectiveness

Observed deaths from stray rabid-dog exposures after PEP = 14
Expected deaths without PEP = 1,567
Deaths prevented by PEP = 1,553 (1,567 – 14)
PEP effectiveness = (1,567 – 14) / 1,567 × 100 = 99.1%

Ethical Considerations

This study is a retrospective analysis of aggregated, anonymized public health data and case-level information collected by the Directorate of Health Services (DHS), Government of Kerala, as part of routine surveillance. Because it did not involve direct contact with human subjects, animal experimentation, or any alteration of patient care, formal ethical review by an Institutional Ethics Committee was not required.

The calculation of PEP effectiveness is retrospective, as it is unethical to conduct a randomized controlled trial for rabies prevention. The risk of developing rabies after an untreated rabid-dog bite is substantial, and withholding standard post-exposure prophylaxis from any exposed individual in order to administer a placebo is not permissible.

Discussion

In our analysis, the extremely low death rate of 0.0019% observed among PEP recipients — 24 deaths out of 1.29 million who received PEP — stands in sharp contrast to the high baseline rabies risk of 5–45% following an untreated rabid-dog bite. The majority (58.3%) of these 24 deaths are estimated to have followed stray dog bites.[4] The remainder involved bites or scratches from pet dogs, foxes, jackals, and cats.[4,22]

Out of a total of 1.29 million reported dog-bite cases who received PEP over a five-year period in Kerala, approximately 412,800 bites (32%) were from stray dogs.[5] Among these, 9,494 bites are expected to have come from rabid stray dogs, based on a rabies prevalence of 2.3%. Without PEP, the expected number of rabies cases in this subgroup was 1,567, whereas the observed number following PEP administration was only 14. Even under conservative assumptions, therefore, PEP effectiveness was 99.1%, aligning with international evidence.[3] The estimate of 2.3% rabies prevalence among stray dogs was based on a large study from China,[18] as described earlier.

Given that India's incidence of human rabies (cases per 100,000 population) is roughly five times higher than China's,[23] it is unlikely that stray-dog rabies prevalence in India is lower than the 2.3% documented in China. Nevertheless, to test the robustness of our calculation, we repeated the analysis using a far more conservative assumption by artificially halving the rabies prevalence among stray dogs—from 2.3% to 1.15%. Even under this deliberately stricter assumption, PEP effectiveness remained high at 98.2%. This demonstrates that the conclusion is robust and does not depend on applying a higher prevalence estimate.

Comparing rabies incidence across India, the recent national annual estimate of human rabies deaths is approximately 5,700 cases (2). Based on Kerala's population share (2.76% of India's total population), the expected number of annual cases in Kerala would be approximately 5700 × 2.76% = 157. Over a five-year period, this national average would project to 786 expected rabies cases in Kerala. However, the observed number of cases in the state during this period was only 112, which is 86% lower than the national average projection. This suggests that PEP protocols are more effectively being implemented in the state, bolstered by community awareness about PEP.

In the current series reported from Kerala, 86% of post-exposure prophylaxis (PEP) failures were associated with high-risk wounds, where the incubation period was likely too short for an effective immune response to develop. This is consistent with worldwide literature on PEP failure.[23] As has been observed elsewhere, the majority of human rabies deaths in Kerala (88 of 112 cases, or 79%) occurred in individuals who never initiated PEP, highlighting a preventable gap in public health intervention.[13,14,15]

In a review of 122 PEP failures—human rabies cases worldwide that occurred despite PEP, 69% had high-risk wounds, and 57% received RIG.[24] In the few instances where testing was done, both vaccine and RIG potency were adequate. Analysis of bite-pairs—two individuals bitten by the same rabid animal but with different outcomes despite treatment—showed that inadequate wound cleansing, delays in receiving PEP, and high-risk bite locations were the factors associated with fatal outcomes. [24] Similar observations have been made from Kerala where several individuals bitten by the same rabid dog have survived with PEP, while a child who had high risk wounds developed rabies despite PEP.[25] These reports indicate that

apparent PEP failures are driven by a combination of risk factors rather than by inadequate vaccine efficacy. Among PEP failures in the review,[24] median time to symptom onset was only 20 days, far shorter than the typical median incubation period reported elsewhere of 66-71 days.[26,27] This supports the idea that in these breakthrough infections, the virus likely reached the nervous system rapidly, before an adequate immune response could develop.

A rabies case series from Bangladesh, in which 88% of patients had not received PEP, reported marked differences in incubation periods based on wound location: 30 days for head and neck bites, versus 89 days for bites to the leg. Among those who developed rabies despite receiving PEP, only 12% had completed the vaccine series, none had received RIG, and most had significant delays in seeking care.[28]

Wound care following dog bites remains a major hurdle in developing countries. In rural India, only 12.5–15.5% of bite victims washed wounds adequately with soap and water.[13,14] A larger survey across multiple Indian states found that 39.5% of bite victims did not wash the wound with soap and water.[15]

Despite substantial advances in public health parameters such as maternal mortality, infant mortality, longevity and healthcare access,[29] the recent rise of human rabies in Kerala is a matter of concern, particularly in the context of the global commitment to achieving zero human rabies deaths by 2030.[30]

Kerala is densely populated, with villages bordering extensive forest areas along the western ghats. Crossing of wild animals into human-inhabited regions in search of food—especially during summer when resources are scarce in the forest—creates opportunities for zoonotic spillover of circulating rabies viruses onto stray dogs that compete for the same food sources.

Studies from China indicate that 2.3-4.7% of apparently healthy free-roaming dogs have asymptomatic rabies.[18,19,21] Applying the lowest of these percentages to Kerala's stray dog population amounts to 20,700 (9,00,000 x 2.3%) apparently healthy stray dogs who carry the rabies virus. As these dogs roam freely, the virus can occasionally reach unvaccinated pet dogs including puppies as young as three months old, as well as cats and cattle.[31] Rabies is the flagbearer of the One Health concept, and mass dog vaccination, animal birth control, and timely post-exposure prophylaxis are designed as complementary strategies toward the zero-rabies goal.

Strengths

Strengths of the study include the use of several years of data compiled by the Directorate of Health Services, Kerala, covering the total number of dog bites, total rabies deaths, rabies deaths that occurred despite receiving PEP, and detailed descriptions of injuries among those who died despite PEP.

Limitations

As with any study that aims to determine the effectiveness of a public health intervention, this analysis too has limitations.

Data non availability: First, data on wound washing and immediate first aid were not available for the individual cases. This is a crucial determinant of risk of developing rabies following a dog bite.[7] Because this information was missing, we relied on KAP surveys from different parts of India to estimate compliance with recommended wound-care protocols.[13,15] Case-level data could have quantified how much risk was attributable to inadequate wound washing. Likewise, details of immunoglobulin administration and completion of PEP schedule are not available.

Although the total number of rabies cases among those who did not receive PEP (numerator) is known, the denominator of untreated dog bites in Kerala—the number of bite victims who did not present to medical facilities—remains unknown. It is likely that many of these bites involved pet dogs or were minor wounds or scratches that did not prompt a healthcare visit.

Finally, rabies prevalence in Kerala's free-roaming stray-dog population has not been measured directly as it is unlawful to euthanize healthy stray dogs in India. The 2.3% rabies prevalence used in this analysis is the lowest estimate from three studies from China.[18,19,21] Using a higher percentage would have increased the estimated PEP effectiveness even further.

Notwithstanding these limitations, the conclusions are robust because the number of PEP failures is extremely small relative to the large denominator.

Recommendations for future research

Although sensitivity is limited,[19,20] salivary RT-PCR testing can estimate asymptomatic circulation of rabies virus among apparently healthy stray dogs in India. Such prevalence data will be of value to policy-makers. As rabies is a zoonotic disease, studies comparing rabies prevalence in stray dogs living near forest margins with those in urban areas will provide useful insights, as the former have more frequent contact with wildlife reservoirs such as foxes and jackals. As generations change and

conflicting opinions circulate on social media, periodic KAP (Knowledge, Attitude and Practice) assessments will help evaluate whether dog-bite victims are likely to perform appropriate first aid and seek timely healthcare—both of which remain major determinants of rabies risk worldwide.

Policy recommendations

Ensuring universal availability and access to timely post-exposure prophylaxis (PEP), conducting robust community education on first aid and PEP, and strengthening wound-care practices with emphasis on complete Rabies Immune Globulin (RIG) infiltration for severe bites. Continued training - especially for newly recruited healthcare workers - is required to maintain adherence to PEP protocols. Ensuring patient compliance with the PEP schedule is crucial.

Human animal interface: Comprehensive animal control and prevention strategies are essential, consistent with the One Health concept. Key priorities include implementing sustained animal birth control (ABC) programs, achieving universal dog vaccination, improving waste management to reduce animal attractants, reducing opportunities for spillover from wild animals and adopting updated legal measures to responsibly manage stray-dog populations.

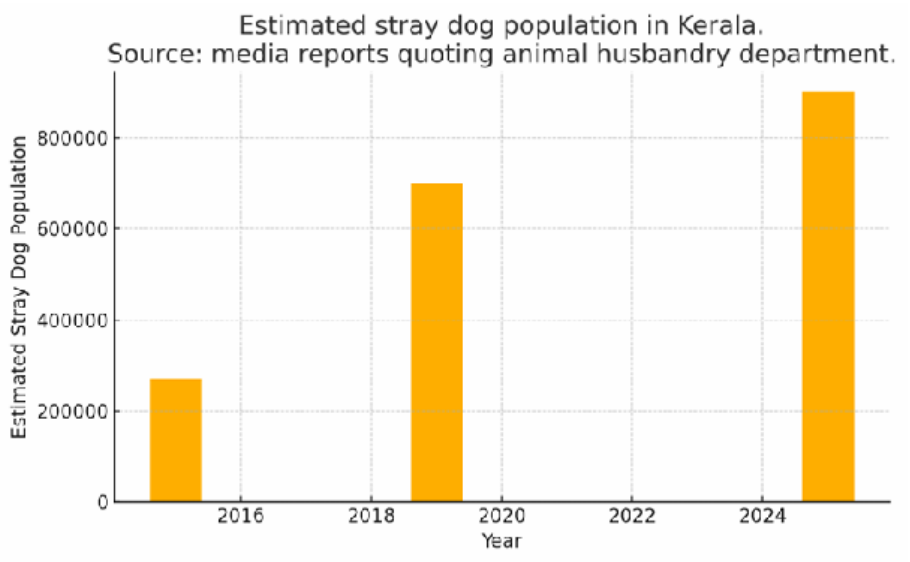
Conclusion

The post-exposure prophylaxis (PEP) program in Kerala is highly effective. Among the 1.2 million individuals who received it, this program prevented nearly all expected rabies cases following dog bites, with an effectiveness of 99.1% despite using conservative estimates.

The majority of rabies deaths (79%) occurred in individuals who never initiated PEP. A vast majority of the PEP failures (86%) were in patients with deep, anatomically high-risk bites that allowed the virus early access to the central nervous system. Stray dog bites accounted for an estimated 58.3% of deaths despite PEP. Rather than a failure of PEP, the rising number of rabies cases reflects the rising number of dog bites and increase in stray dog population (figure 2).

Figure 2 : Estimated Stray dog population in kerala.

Source: media reports quoting animal husbandry department



Acknowledgement

None

Ethics Committee Approval

This study is a retrospective analysis of aggregated, anonymized public health data and case-level information collected by the Directorate of Health Services (DHS), Government of Kerala, as part of routine surveillance. Because it did not involve direct contact with human subjects, animal experimentation, or any alteration of patient care, formal ethical review by an Institutional Ethics Committee was not required.

Conflict of Interest Statement

The authors declare no competing interests. They have received no financial support, grants, honoraria, consulting fees, or other payments from any organization that could be perceived to influence the submitted work. The authors have no personal, academic, political, or institutional conflicts related to the research, its interpretation, or publication. All authors had full access to the data, contributed to the manuscript, and take responsibility for its content.

Role of funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The corresponding author had full access to all the data and had final responsibility for the decision to submit for publication.

Artificial Intelligence Declaration Statement

ChatGPT (OpenAI; GPT-4–based version, accessed in 2025) was used for editing English language including improving clarity, grammar, and readability, and for assistance in creating figures and graphs based on author-provided data and instructions. The AI tool was not used for study design, data collection, data analysis, or interpretation of results. All intellectual content, analyses, visualizations, and conclusions are the sole responsibility of the authors, who take full accountability for the accuracy, originality, and integrity of the work.

References

1. Janekunte DB, Basava D, Ninganna OY, et al. State-wise geospatial analysis of dog bite burden in India from 2018 to 2023. *Porto Biomed J.* 2025;10(5):e305.
2. Thangaraj JWV, Krishna NS, Devika S, et al. Estimates of the burden of human rabies deaths and animal bites in India, 2022–23: a community-based cross-sectional survey and probability decision-tree modelling study. *Lancet Infect Dis*. 2025;25(1):126–34.
3. World Health Organization. WHO Expert Consultation on Rabies: Third Report. Geneva. *WHO*. 2018.
4. Directorate of Health Services (DHS). *Kerala*. 2025.
5. Times of India. 3.63 lakh dog bite cases reported in state in last one year. *govt tells Kerala High Court* . 2024
6. Onmanorama. *Kerala stray dog population may touch nine lakh*. 2025.
7. Outlook India. Worrying maths for dog-scared Kerala: in 3 years. *a pair of strays can multiply to*. 2016 .
8. Tenzin, Dhand NK, Gyeltshen T, et al. Dog bites in humans and estimating human rabies mortality in rabies-endemic areas of Bhutan. *PLoS Negl Trop Dis*. 2011;5(11):e1391.
9. Knobel DL, Cleaveland S, Coleman PG, et al. Re-evaluating the burden of rabies in Africa and Asia. *Bull World Health Organ*. 2005;83(5):360-8. PMID: 15976877. PMCID: PMC2626230.
10. Changalucha J, Lushasi K, Cleaveland S, et al. The need to improve access to rabies post-exposure vaccines: lessons from Tanzania. *Vaccine*. 2019;37(45):6544–50.
11. Sudarshan MK, Narayana DH, Madhusudana SN, et al. Evaluation of a one-week intradermal regimen for rabies post-exposure prophylaxis: results of a randomized, open-label, active-controlled trial in healthy adult volunteers in India. *Hum Vaccin Immunother*. 2012;8(8):1077–81.
12. Haradanhalli RS, Hulawadi AS, Banandur PS,et al. Health-seeking behavior and compliance to post-exposure prophylaxis among animal bite victims in India. *Indian J Public Health*. 2019;63(5):20–5.
13. Anandaraj R, Balu PS. Compliance to anti rabies vaccine and animal bite management practices in a rural area of Davangere, Karnataka, India. *Int J Community Med Public Health*. 2016;3(1):170–173.
14. Singh T, Mahajan S, Dahiya N. A cross-sectional study of awareness and practices regarding animal bites in a rural community, North India. *J Family Med Prim Care*. 2020;9(6):2751-7.
15. Sudarshan MK, Mahendra BJ, Madhusudana SN, et al. An epidemiological study of animal bites in India: results of a WHO sponsored national multi-centric rabies survey. *J Commun Dis*. 2006;38(1):32-9.
16. Krishna NS, Devika S, Selvaraj GM, et al. Availability of anti-rabies vaccine and rabies immunoglobulin in Indian health facilities: a nationwide cross-sectional health-facility survey. *PLoS One*. 2025;20(1):e0300559.
17. Killada AN, Rekha VB, Isloor S, et al. First report on dog bite epidemiology and rabies diagnosis in stray dogs: a One Health study from Puducherry. *Front Vet Sci*. 2025;12:1642231.
18. Song M, Tang Q, Wang DM, et al. Epidemiological investigations of human rabies in China. *BMC Infect Dis*. 2009;9:210.
19. Zhang JM, Zhang ZS, Deng YQ, et al. Incidence of human rabies and characterization of rabies virus nucleoprotein gene in dogs in Fujian Province, Southeast China, 2002–2012. *BMC Infect Dis*. 2017;17:599.
20. Singh CK, Ahmad A. Molecular approach for ante-mortem diagnosis of rabies in dogs. *Indian J Med Res*. 2018;147(5):513–6.

21. Tang HB, Pan Y, Wei XK, et al. Re-emergence of rabies in the Guangxi Province of Southern China. *PLoS Negl Trop Dis*. 2014;8(10):e3114.
22. Ramdas P. 23 died of rabies in Kerala in seven months. The New Indian Express. 2025.
23. World Health Organization. Epidemiology and burden of disease: Rabies [Internet]. Geneva: *WHO.* 2025
24. Whitehouse ER, Mandra A, Bonwitt J, et al. Human rabies despite post-exposure prophylaxis: a systematic review of fatal breakthrough infections after zoonotic exposures. *Lancet Infect Dis*. 2023;23(5):e167–74.
25. TNM Staff. Six-year-old Kerala girl dies of rabies, weeks after dog bite. *The News Minute*. 2025 29.
26. Liu JJ, Zhang N, Ding SJ, et al. Epidemiological characteristics of human rabies cases reported by sites in China from 2006 to 2022. *BMC Infect Dis*. 2024;(24):966.
27. Guo C, Li Y, Huai Y, et al. Exposure history, post-exposure prophylaxis use, and clinical characteristics of human rabies cases in China, 2006–2012. *Sci Rep*. 2018;(8):17188.
28. Ghosh S, Rana MS, Islam MK, et al. Trends and clinico-epidemiological features of human rabies cases in Bangladesh, 2006–2018. *Sci Rep*. 2020;(10):2410.
29. Registrar General of India. Sample Registration System (SRS) Statistical Report 2023. *New Delhi: Office of the Registrar General & Census Commissioner*. 2024.
30. Sudarshan MK, Madhusudana SN, Mahendra BJ, et al. Indian Multicentric Rabies Survey 2017. New Delhi. *World Health Organization–Association for Prevention and Control of Rabies in India*. 2018
31. Krithiga K, Purnima C, Vijayan N, Nair ND. Investigation on incidence of animal rabies in Central Kerala. *J Vet Anim Sci*. 2019;50(1):31–4.