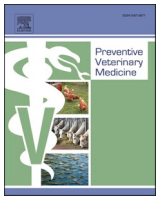
Preventive Veterinary Medicine 249 (2026) 106803

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed



Modelling factors associated with the probability of seeking traditional care after dog bites in Sierra Leone

Philip P. Mshelbwala [a,*], Roland Suluku [b], Anayochukwu E. Anyasodor [c], Oyinkansola Fadiji [d], Andrew M. Adamu [e], Solomon W. Audu [f], Claude T. Sabeta [g], Charles E. Rupprecht [h], Kinley Wangdi [i,j]

[a] NSW Department of Primary Industries, Orange, NSW, Australia
[b] Department of Animal Science, Njala University, Njala, Sierra Leone
[c] Rural Health Research Institute, Charles Sturt University, Orange, Australia
[d] Federal University of Health Sciences, Ila-Orangun, Osun State, Nigeria
[e] Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, Queensland, Australia
[f] Department of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria
[g] University of Pretoria, Department of Veterinary Tropical Diseases, Faculty of Veterinary Sciences, Pretoria, South Africa
[h] College of Forestry, Wildlife & Environment, College of Veterinary Medicine, Auburn University, Auburn, AL, United States
[i] HEAL Global Research Centre, Health Research Institute, Faculty of Health, University of Canberra, Bruce 2617, Australia
[j] National Centre for Epidemiology and Population Health, Australian National University, Canberra, Acton 2601, Australia

ARTICLE INFO

Keywords:
Sierra leone
Rabies
Dog
Bite
Canine bites
Exposures
Traditional
Modelling
Remedies
Factors
Bayesian
Zoonoses

ABSTRACT

Evidence suggests a rising incidence of dog bites in Sierra Leone despite ongoing efforts to prevent rabies. However, little is known about the factors influencing the decision to seek medical care following a dog bite. To address this gap, we developed a probabilistic model to examine factors associated with the likelihood of seeking traditional care in Sierra Leone. Among the 2558 respondents who completed the survey, 31 % (782/2558) indicated that they would seek traditional care after a dog bite. The posterior distributions of our model estimates indicated that the probability of seeking traditional care was higher among respondents with lower levels of education, those residing in rural areas, individuals lacking knowledge about rabies virus transmission and its hosts, and those who owned vaccinated dogs. Conversely, respondents living in locations with a livestock officer or veterinary establishment had lower odds of seeking traditional remedies compared with those uncertain about access. We observed a negative relationship between the percentage of health facilities and the probability of seeking traditional care, with higher percentages associated with a decreased likelihood of seeking traditional remedies. We also found regional variation in the probability of seeking traditional care. Respondents in the Eastern and Western Area were less likely to seek traditional remedies than those in the Northern and Southern Provinces. These findings highlight the need for targeted educational campaigns to raise awareness about rabies and the importance of timely medical care after exposure. Improving healthcare access in rural areas and fostering collaboration with traditional healers are also essential for reducing reliance on traditional care and strengthening rabies prevention and control efforts.

1. Introduction

Rabies remains a critical public health challenge, particularly in low- and middle-income countries (LMICs) where dog-mediated transmission accounts for nearly all human cases (Knobel et al., 2005; Hampson et al., 2015). Globally, tens of thousands of human deaths occur annually, with the highest rabies burden concentrated in Africa and Asia (Knobel et al., 2005; Hampson et al., 2015). Despite the near-universal fatality of the disease once clinical symptoms appear, rabies is entirely preventable through timely administration of post-exposure prophylaxis (PEP), which includes immediate wound washing, vaccination, and where indicated, rabies immune globulin (RIG) or monoclonal antibodies (World Health Organization, 2018). However, in many resource-limited settings, access to modern medical care is constrained by geographic and

* Corresponding author.
E-mail address: p.mshelbwala@uq.net.au (P.P. Mshelbwala).

https://doi.org/10.1016/j.prevetmed.2026.106803
Received 7 October 2025; Received in revised form 30 January 2026; Accepted 1 February 2026
Available online 3 February 2026

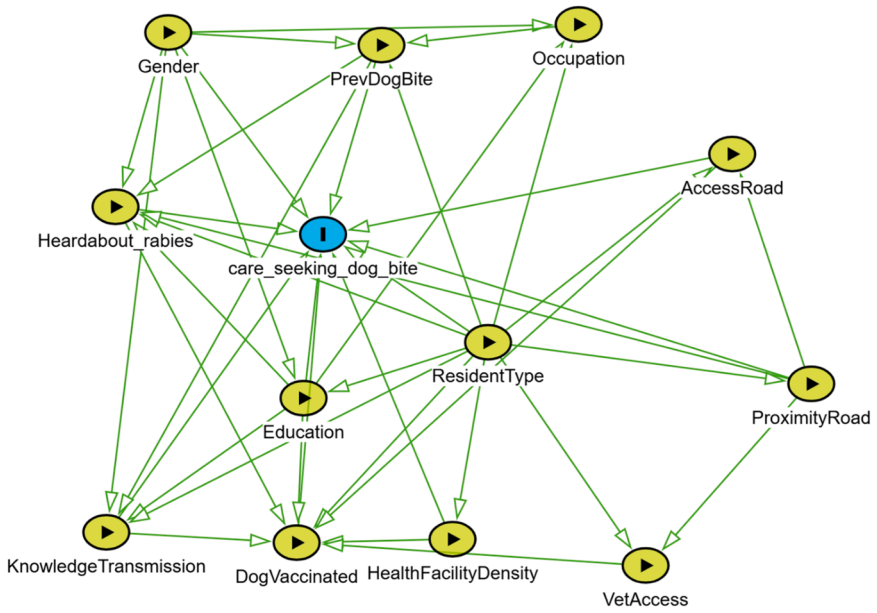


Fig. 1. Directed Acyclic Graph (DAG) informing regression models, illustrating postulated causal relationships between the outcome (**care_seeking_dog_bite)** and predictors.

financial barriers (Mshelbwala et al., 2024). Consequently, traditional medicine is frequently sought as an alternative which often involves spiritual rituals and/or application of herbal concoctions after dog bites (Audu et al., 2019; Mukasa et al., 2023). There are reports of human rabies deaths following the use of traditional remedies after a dog bite in Sierra Leone (Kumoji et al., 2018). The World Health Organization (WHO) defines traditional medicine as "the knowledge, skills, and practices based on the theories, beliefs, and experiences indigenous to different cultures used in the maintenance of health and in the prevention, diagnosis, improvement or treatment of physical and mental illness" (World Health Organization, 2019). A systematic review of the literature across multiple countries found no consistent traditional remedy, and no controlled trials demonstrating effectiveness against rabies (Beasley et al., 2022). This reliance on unproven remedies poses significant risks, particularly given the urgency of timely intervention following viral exposure. Understanding reasons why individuals choose traditional over allopathic care is essential for designing effective health education. The choice in seeking traditional or allopathic care is shaped by interplay of education, cultural beliefs, past experiences, and structural constraints (Mshelbwala et al., 2025a). In Sierra Leone, rabies remains underreported and poorly controlled (Suluku et al., 2022a). Dog ownership is widespread, yet canine vaccination coverage is low, creating conditions for sustained viral transmission in the event of a dog bite (Mshelbwala et al., 2024, 2025b). Understanding the intended choice of seeking care after exposure is critical for rabies control efforts, especially around public education on the need to of seek allopathic care in the event of dog bite. While previous studies in the region have explored general awareness and vaccination uptake (Suluku et al., 2022a; Hatch et al., 2004), they have largely overlooked the geographic and infrastructural dimensions of health-seeking behaviors. This study addresses that gap by examining both individual and contextual factors associated with the likelihood of seeking traditional medicine. We constructed random effect Bayesian regression model to examine the role of sociodemographic, socioeconomic, and infrastructural covariates on the probability of seeking traditional remedy across selected dog owning households in Sierra Leone. The insights generated from this analysis are intended to inform public health policy and guide targeted interventions to support rabies prevention and control efforts.

2. Materials and methods

2.1. Study area

Sierra Leone is a West African nation situated along the Atlantic Ocean, spanning approximately 72,000 km^2 between latitudes 6° 55' and 10° 00' N and longitudes 10° 16' and 13° 18' W. It borders the Republic of Guinea to the north and northeast, Liberia to the southeast, and the Atlantic Ocean to the south and southwest. The country is administratively divided into five provinces and 16 districts. There are 149 Chiefdoms in Sierra Leone, which are subdivisions of the country, constituting hereditary tribal units of local governance (Reed and Robinson, 2013). As of July 2021, Sierra Leone had an estimated population of 8141,343 with an average annual growth rate of 2.0 % recorded between 1990 and 2010. Dog ownership is widespread in Sierra Leone and dogs are often exposed to zoonoses, including rabies (Suluku et al., 2022a).

2.2. Sampling and data collection

We conducted a cross-sectional survey between July 2022 and December 2023 across the Eastern (1167 households), Southern (1180 households), Northwestern (92 households), and Western Area (119 households) provinces of Sierra Leone. (Supplementary File1). Rural and urban settlements were selected based on reported dog and cat bite cases. A multi-stage sampling method was used, beginning with the initial residences on both sides of selected streets and systematically selecting every tenth household for interviews with adult residents (Okoh, 1986). In areas where systematic sampling was impractical due to the absence of well-defined road networks, community members provided informal guidance to identify households with dogs (Mshelbwala et al., 2018). When the tenth household did not own dogs or declined to participate, we proceeded to the next household in sequence.

2.3. Sociodemographic, socioeconomic, and infrastructure variables

The methods of data collection were described in detail elsewhere (Mshelbwala et al., 2024). Briefly, we obtained information on the sociodemographic characteristics of dog owners, including age, gender,

Table 1
Distribution of treatment preferences (Traditional vs. Allopathic) by key demographic, socioeconomic, and awareness variables.

Characteristics	Traditional, n = 782 (%)	Allopathic, n = 1776 (%)
Gender		
Male	462 (59)	1029 (58)
Female	320 (41)	733 (42)
Occupation		
Students	103 (13.2)	294 (16.6)
Civil Servant	111 (14.2)	392 (22.1)
Private/NGOs	254 (32.5)	567 (31.9)
Artisan	314 (40.2)	523 (29.4)
Level of Education		
None	315 (40.3)	511(28.8)
Primary	145 (18.5)	247 (13.9)
Secondary	213 (27.2)	614 (34.6)
Tertiary	109 (13.9)	404 (22.7)
Is there any livestock officer or veterinary establishment in your location?		
Yes	119 (15.2)	385 (21.7)
No	472 (60.4)	1031 (58.1)
I don't know	191 (24.4)	360 (20.3)
To your knowledge, have you or any members of your household been bitten by a dog in the last two years?		
Yes	38 (4.9)	86 (4.8)
No	609 (77.9)	1461 (82.3)
I don't know	135 (17.3)	229 (12.9)
Have you heard of Rabies before?		
Yes	396 (50.6)	635 (35.8)
No	386 (49.4)	1141 (64.2)
Bites from an infected animal cannot spread Rabies to other animals.		
True	177 (22.6)	303 (17.1)
False	605 (77.4)	1473 (82.9)
Can Rabies infect the following?		
Only Humans	11 (1.4)	57 (3.2)
Only Animals	80 (10.2)	116 (6.5)
Humans and Animals	481 (61.5)	1444 (81.3)
I don't know	210 (26.9)	159 (9.0)

NGO- non-governmental organization;

level of education (categorical), and occupation (categorical). Respondents were also asked about their access to veterinary care, specifically whether a veterinary establishment existed in their location, with response options: "Yes," "No," or "I am not aware". Dog vaccination status was assessed through a binary response and verified by requesting owners to produce a valid vaccination certificate. We also asked a series of questions that targeted respondents' knowledge about rabies. These included whether they were familiar with the term "rabies" (binary), the mode of rabies virus transmission (binary), and the types of hosts susceptible to rabies virus (ordinal). Finally, respondents were asked about their preferred approach if a family member was bitten by a dog-choosing between traditional remedies or PEP. The survey can be assessed here.

We obtained additional information including: household coordinates (latitude and longitude), collected during the survey and geocoded into a spatial object using the World Geodetic System (WGS84) coordinate reference system (CRS); the road data network for Sierra Leone (obtained from DIVA-GIS)); the urban extent grid at 0.00833 ° (30 arc seconds) resolution, indicating the proportion of rural and urban areas in Sierra Leone (obtained from the Global Rural-Urban Mapping Project (GRUMP v1)(CIESIN, 2011); and the percentage of live births (or stillbirths) in the two (or three/five) years preceding a 2019 survey delivered at a health facility, as an indicator for the presence of a health facility (Health Facility) (obtained from the Demographic and Health Surveys (DHS) Program) (Burgert-Brucker et al., 2016). All surveyed households were geocoded and mapped onto raster datasets using the R programming language version 4.3.3 (Team, 2021). The raster package was used to extract the associated variables from the raster using the geographic coordinates of the households (Hijmans, 2018). Before statistical analysis, all continuous variables were standardized to unit variance to ensure comparability across regression coefficients. This

Table 2
Posterior estimates from Bayesian logistic regression for predicting the likelihood of seeking traditional medicine.

Variable	Posterior mean (95 % CrI)			Odds ratio (95 % CrI)
Gender				
Male	Reference	Reference	Reference	Reference
Female	-0.11	-0.30	0.07	0.9 (0.74–1.07)
Education				
None	Reference	Reference	Reference	Reference
Primary	-0.17	-0.39	0.06	0.84 (0.68–1.06)
Secondary	-0.61	-0.82	-0.41	0.54 (0.44–0.66)
Tertiary	-0.90	-1.14	0.22	0.41 (0.32–0.52)
Occupation				
Civil Servant	Reference	Reference	Reference	
Students	-0.35	-0.70	0.01	0.7 (0.5–1.01)
Private/NGOs	-0.06	-0.37	0.26	0.94 (0.69–1.3)
Artisan	-0.10	-0.41	0.22	0.9 (0.66–1.25)
Bites from an infected animal cannot spread Rabies to other animals.				
False	Reference	Reference	Reference	Reference
True	-0.41	-0.66	-0.16	
Have you heard of Rabies before?				
Yes	Reference	Reference	Reference	
No	-0.05	-0.27	0.17	0.95 (0.76–1.19)
Can Rabies infect the following?				
Both humans and animals	Reference	Reference	Reference	
Only humans and animals	0.24	-0.07	0.54	1.27 (0.93–1.72)
I Don't know	1.17	0.88	1.46	3.22 (2.41–4.31)
To your knowledge, have you or any members of your household been bitten by a dog in the last two years?				
Yes	Reference	Reference	Reference	Reference
No	-0.24	-0.67	0.19	0.79 (0.51–1.21)
Don't know	0.01	-0.49	0.50	1 (0.61–1.65)
Is your dog vaccinated against rabies				
Yes	Reference	Reference	Reference	Reference
No	0.62	0.29	0.97	1.86 (1.34–2.64)
Is there any livestock officer or Veterinary establishment in your location?				
I do not know	Reference	Reference	Reference	
No	-0.44	-0.64	-0.23	0.64 (0.53–0.79)
Yes	-0.34	-0.59	-0.09	0.71 (0.55–0.91)
Location				
Rural	Reference	Reference	Reference	Reference
Urban	-0.73	-1.19	-0.25	0.48 (0.3–0.78)
Mean distance to road	-10.67	-19.42	-1.77	< 0.01 (<0.01–0.17)
Health facility	-1.14	-2.42	0.10	0.32 (0.09–1.11

CrI- credible interval; NGOs- non-governmental organization

standardization was performed using the **scale** function in R. All shapefiles were imported into R (Version 4.3.3) and mapped using R package **sf** (1.0.16) (Pebesma et al., 2021). All raster and shapefiles used for this analysis are available in Supplementary File 1.

2.4. Statistical analysis

2.4.1. Causal framework

We constructed a directed acyclic graph (DAG) to represent hypothesized relationships among factors associated with intended care-seeking choice in a hypothetical dog-bite scenario (care_seeking_dog_bite) (Fig. 1).Previous research and expert opinions informed the DAG and was used as a conceptual tool to clarify assumed relationships among variables and to guide analysis, rather than to infer causality (Walwa et al.; Barbosa Costa et al., 2018; Mshelbwala et al., 2023). We used the DAG to identify sufficient adjustment sets for each exposure-outcome relationship of interest, applying the do-calculus method with DAGitty software (Textor et al., 2011). Resident type (urban vs. rural) was specified as an upstream contextual variable associated with differences in education, occupation, infrastructure-related variables (ProximityRoad and HealthFacilityDensity), and access to services (VetAccess). Education was

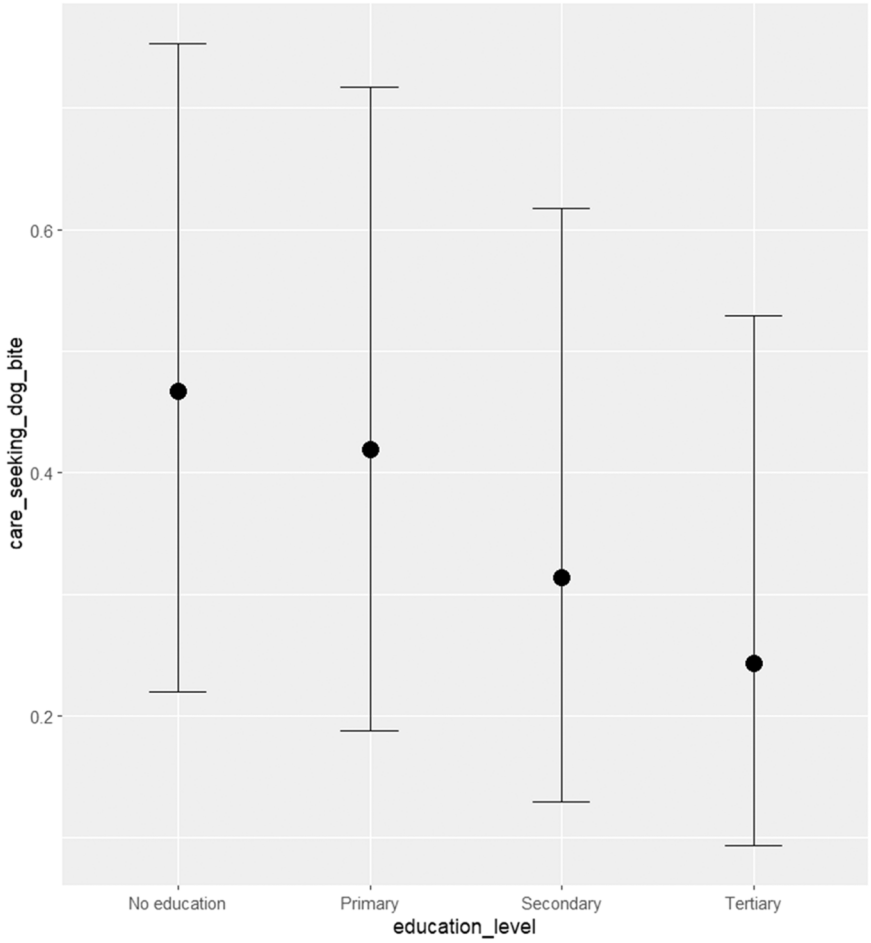


Fig. 2. Modelled conditional effect of education level on the predicted probability of seeking traditional care after a dog bite(care_seeking_dog_bite), with all other covariates held constant at their average values. The results indicate a clear decrease in the predicted probability of seeking traditional care as education level rises, with the highest probability observed among individuals with no education.

assumed to be associated with the outcome both directly and indirectly through rabies-related knowledge variables, including 'heard about rabies' (Heardabout_rabies) and knowledge of transmission host of rabies virus (KnowledgeTransmission). Rabies-related knowledge variables (Heardabout_rabies, KnowledgeTransmission) were treated as proximal factors associated with respondents stated treatment choice. Previous exposure to dog bite (PrevDogBite) was included to capture prior experience with dog bites and was assumed to be associated with both knowledge acquisition and intended care-seeking. Dog vaccination (DogVaccinated) was treated as an indicator of preventive orientation and perceived rabies risk and was assumed to be associated with knowledge, veterinary access (VetAccess), and intended care choice. Access-related variables were assumed to reflect perceived feasibility of seeking allopathic care. Proximity to road (ProximityRoad) was assumed to be associated with physical accessibility, while density of health facilities (HealthFacilityDensity) reflects availability of health services. VetAccess was assumed to be associated with DogVaccinated and preventive practices. Gender was treated as a baseline characteristic associated with multiple upstream variables, including education, occupation, and rabies-related knowledge, but not influenced by other variables in the framework. Because all variables were measured at a single point in time, the temporal ordering implied by the DAG reflects theoretical assumptions rather than observed sequencing.

2.5. Model definition

We developed two Bayesian regression models using the brms package in R (version 4.3.3), which interfaces with Stan (version 2.21.0), to perform full Bayesian inference (Bürkner, 2017; Team, 2021). The models investigated factors influencing whether dog owners in Sierra Leone would seek traditional medicine or allopathic care (i.e., PEP) in the event of a dog bite a dog bite. The primary outcome was respondents' intended care-seeking choice following a hypothetical dog-bite scenario, coded as "1" for traditional remedies and "0" for post-exposure prophylaxis (PEP). We coded the outcome as "1" if they would seek traditional remedies and "0" if they would seek PEP. The first model was constructed, assuming the observed vector of intended care seeking choice was drawn from a Bernoulli distribution with unknown parameters p (the unknown probability of seeking traditional care). We modelled p using a logit link function and a linear predictor to estimate the additive effects of covariates on the probability of care seeking choice including gender, education level, occupation, and response to questions about rabies, such as whether they were familiar with the term "rabies", the mode of rabies virus transmission, and the types of hosts susceptible to rabies virus, rural versus urban residence, access to veterinary care, mean distance to the nearest road, the percentage of health facilities, and elevation. Sierra Leone is home to more than 18 ethnic groups, reflecting substantial cultural diversity (Bash-Taqi and Crawford, 2021) and a previous study has shown that patterns of care seeking choice following a dog bite vary across regions (Mshelbwala et al., 2025a). To account for unobserved contextual factors such as ethnicity, religion, and other sociocultural influences that may affect care-seeking decisions, we extended the first model by including a random intercept for province in the second model. This hierarchical structure captures

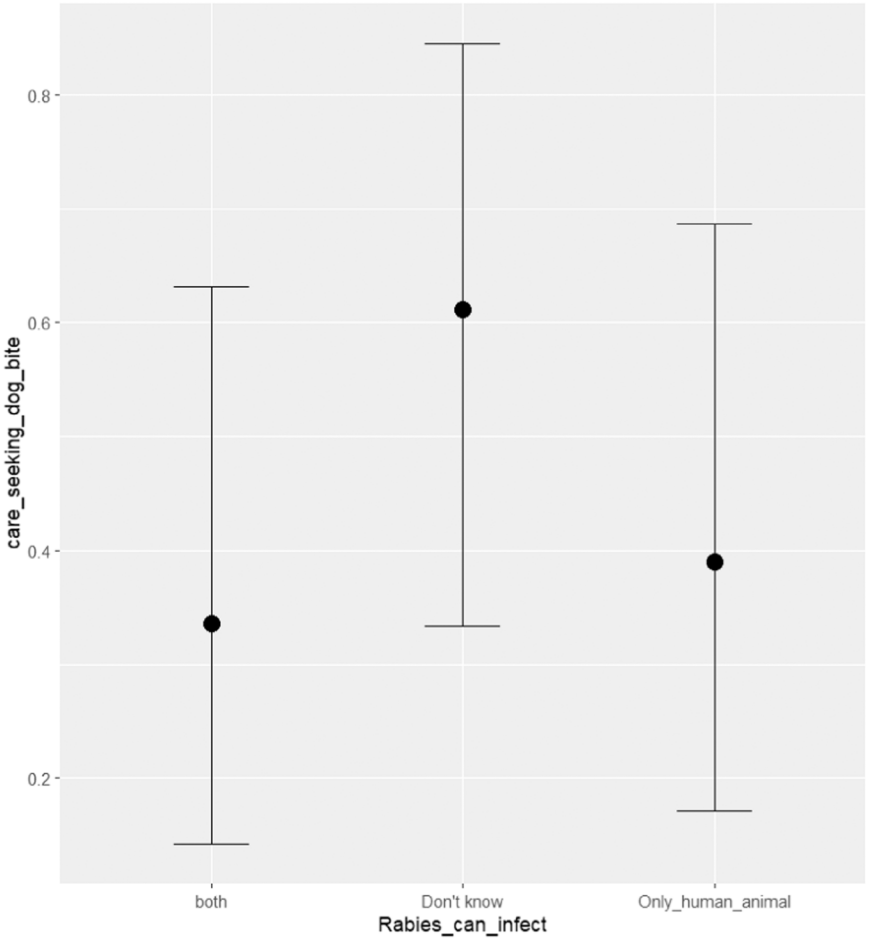


Fig. 3. The modeled conditional effect of understanding which hosts rabies virus infects shows that, holding all other covariates at their mean values, those respondents affects had a higher predicted probability of seeking traditional care after a dog bite compared with those who knew that rabies affects both humans and animals.

unmeasured province-level variation in baseline care-seeking choice in the event of a dog bite.

2.6. Prior specification

We specified informative priors for selected covariates based on local expert knowledge and existing literature, particularly for education level and availability of veterinary services, both modelled as categorical predictors. Individuals with no formal education served as the reference category (Barbosa Costa et al., 2018). Education effects were assigned normal priors reflecting progressively stronger negative associations with the probability of seeking traditional care; primary education ($\mu = -0.5, \sigma = 0.2$); secondary education ($\mu = -1.0, \sigma = 0.2$); and tertiary education ($\mu = -1.5, \sigma = 0.2$). These priors encoded the belief that higher educational attainment was associated with reduced reliance on traditional remedies in the event of a dog bite. Informative priors were also specified for the availability of veterinary services. Areas where veterinary services were reported as unavailable were assigned a normal prior with mean $\mu = -0.3$ and standard deviation $\sigma = 0.2$, indicating a slightly lower probability of seeking traditional medicine compared with respondents who were uncertain about service availability. In contrast, in areas where such facilities were available, we assigned a stronger negative prior ($\mu = -0.7, \sigma = 0.2$), reflecting the expectation that access to veterinary services substantially reduces the likelihood of seeking traditional care.

For all other fixed effects, we used weakly informative Normal (0, 2) priors, allowing the data to primarily drive posterior estimates while providing regularization against extreme values. We assigned a student-t (3, 0, 5) prior to the standard deviation of the province-level random intercepts to allow for moderate to strong regional variation in baseline care-seeking intentions while maintaining robustness to outliers:

$$\text{logit}\left(p_{ij}\right) = \log\left(\frac{pij}{1-pij}\right)$$

where $\log\left(\frac{pij}{1-pij}\right) = \beta0 + \beta1^{*}\ \text{Gender}_i + \beta2^{*}\ \text{Level of Education} + \beta3^{*}\text{Occupation}_i + \beta4^{*}\text{Rabies Host}_i + \beta5^{*}\text{Awareness}_i + \beta6^{*}\ \text{Residence}_i + \beta7^{*}\text{Veterinary Care}_i + \beta8^{*}\ \text{Mean Distance to Road}_i + \beta9^{*}\text{Percentage of health facilities}_i + \beta10^{*}\text{Previous exposure to dog bite}_i$

Where *pij* is the probability that an individual *i* in region *j* seeks traditional care, *β0* the intercept of the model, β1, β1,…, β10 the fixed effects of each covariate.

2.7. Model fitting and convergence diagnostics

Model fitting was conducted using the Hamiltonian Monte Carlo method, a form of Markov chain Monte Carlo, with four independent chains of 10,000 iterations, each implemented via Stan. The first 500 iterations of each chain were discarded as a warmup. The remaining 9500 iterations were retained for posterior sampling. We visually examined diagnostic trace plots to assess the stability of the simulation results and ensure model convergence. We also obtained summaries of the posterior draws, including group-level effects.

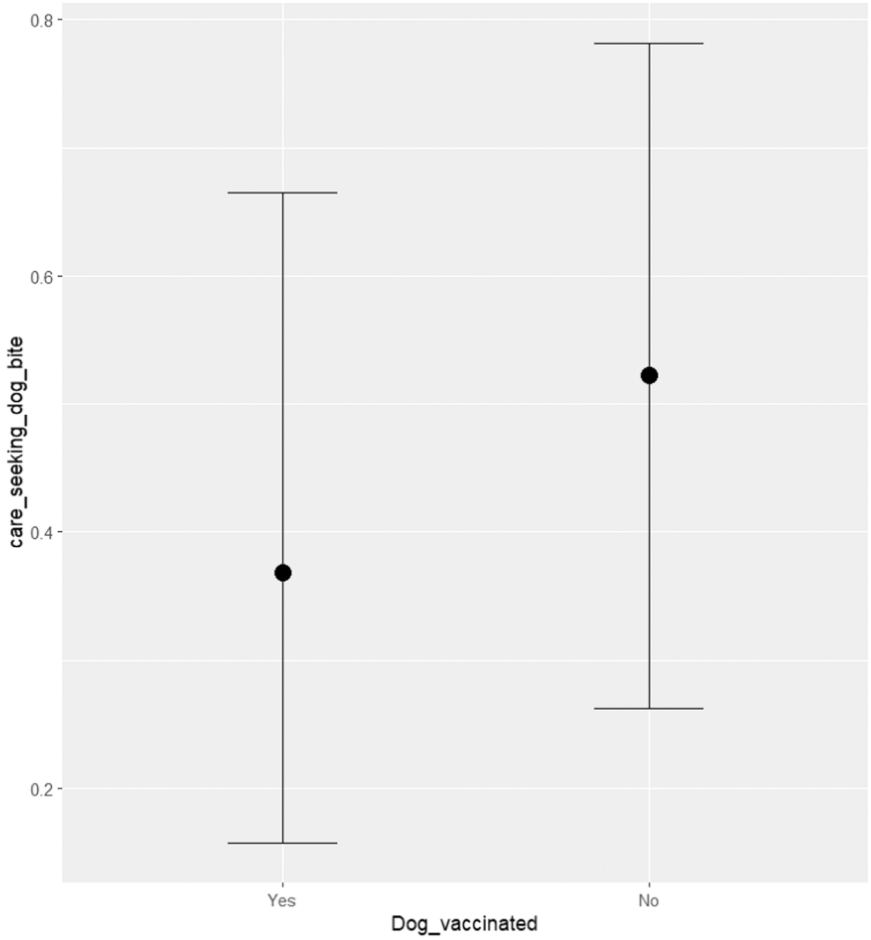


Fig. 4. Modelled conditional effects plot shows that, holding other covariates at their mean values, dog owners with unvaccinated dogs have a higher predicted probability of seeking traditional care after a dog bite than those with vaccinated dogs.

2.8. Posterior predictive checks and model selection

To evaluate the ability of the model to capture the pattern and variability in the observed data, we conducted posterior predictive checks. Finally, we compared the performance of our models using the leave-one-out cross-validation, which computes model weights via stacking (Vehtari et al., 2017). This method provided a weighted combination of models, giving more weight to models demonstrating better predictive accuracy for out-of-sample data. We compared models using log predictive density (ELPD), with the model exhibiting the lower ELPD or higher model weight deemed a better out-of-sample predictive performance. Posterior distributions were summarised using posterior means and 95 % CrI for all parameters. We classify regression coefficients as 'significant' if their 95 % posterior credible intervals did not include 0. We generated conditional plots using conditional effects () in brms, estimating posterior probabilities of seeking traditional care as each focal covariate varies while holding all other predictors constant at their posterior means and averaging over posterior draws.

2.9. Ethics statement

Research permission and ethical clearance were obtained from the Directorate of Livestock and Veterinary Services within the Ministry of Agriculture & Food Security, Sierra Leone, and the University of Abuja Ethics Committee (UAECAU/2023/004). All procedures were conducted in accordance with the Helsinki Declaration (World Medical Association, 2001). All survey participants gave verbally informed consent, were informed of the study's purpose, procedures, risks, and benefits, and were aware that their participation was voluntary. Participants were also made aware that they could withdraw from the study at any time without any consequence.

3. Results

Table 1 shows respondents' preferences for allopathic versus traditional intervention in the event of a dog bite by demographic, socioeconomic, and awareness factors. Most respondents who reported a preference for either traditional or allopathic care indicated that they did not have access to livestock officers or veterinary establishments in their locations, and neither they nor their household members had experienced a dog bite in the preceding two years. Similarly, a higher proportion of these participants believed that bites from an infected animal cannot transmit rabies virus to other animals but admitted that rabies virus can infect humans and animals. While most respondents (61.5 %) reported having heard of rabies, a larger proportion indicated limited awareness of biomedical management following dog bites.

3.1. Model selection

Regarding the relative fits of the models to our observed data, the model with the spatial random effect had a good mixing of chains for most of the parameters (Supplementary file1). Convergence diagnostics indicated high effective sample sizes (bulk ESS ≈ 8000–26,000) and $\hat{R}$ values consistently near 1. Also, the result of the posterior predictive check revealed that the model with the spatial random effect adequately reflected the variability in the observed data, suggesting a good model

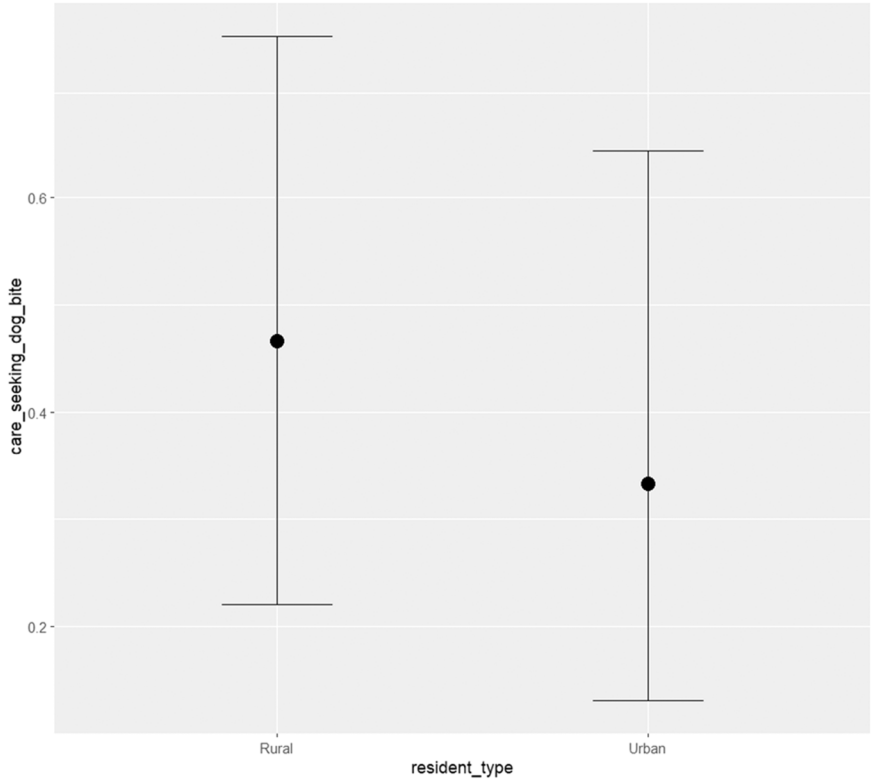


Fig. 5. The modeled conditional effects plot shows the predicted probability of seeking traditional care (care_seeking_dog_bite) after a dog bite, in both rural and urban areas, with all other covariates held constant at their average values, revealing a higher predicted probability of seeking traditional care for dog owners in rural areas compared to urban areas.

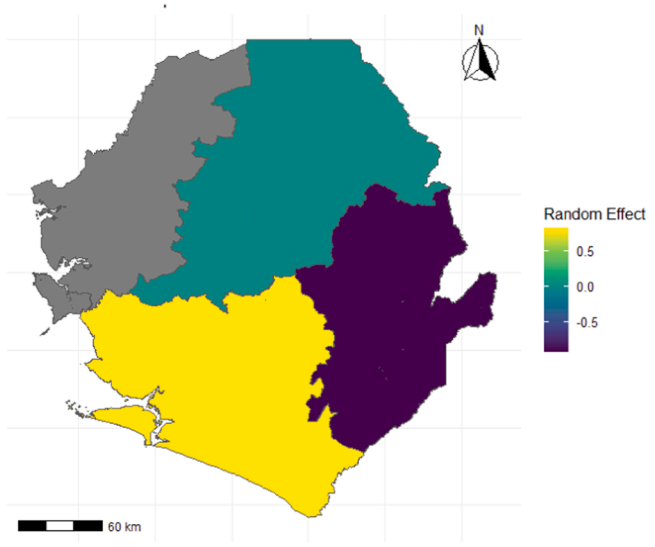


Fig. 6. Geographical distribution of estimated random effects for the likelihood of using traditional medicine across provinces in Sierra Leone. Respondents in the Eastern Western Area were less likely to seek traditional treatment compared to those in Northern and Southern Provinces.

fit (Supplementary File 1). The spatial random effect model received a stacking weight of 0.98, indicating that it accounted for approximately 98 % of the predictive weight. In contrast, the fixed effect model contributed only 1.5 % of the weight. Also, the model with the spatial random effect did not show a significant reduction in predictive accuracy, as indicated by the expected log predictive density (elpd_diff = 0). In contrast, the fixed-effect model exhibited a significant loss in fit (elpd_diff = −22.7), suggesting that including the spatial random effect significantly improved the model's fit to the data. This suggests that the spatial random effect model demonstrated superior predictive accuracy, making it the better-fitting model. Therefore, we used the model with the spatial random effect for inference and subsequent analyses.

3.2. Factors associated with the probability of seeking traditional care in the event of a dog bite

Table 2 presents the posterior estimates for predictors of the probability of seeking traditional remedies after a dog bite. The posterior distributions of the estimated effects (on the logit scale) indicate that respondents with secondary education had lower odds of reporting an intention to seek traditional remedies in a hypothetical dog-bite scenario compared with those with no formal education (odds ratio[OR] = 0.54; 95 % CrI: 0.44–0.66), as did those with tertiary education (OR = 0.41; 95 % CrI: 0.32–0.52). Respondents who did not correctly identify both humans and animals as susceptible to rabies virus infection had higher odds of reporting a preference for traditional remedies compared with those who correctly identified both humans and animals as susceptible (OR = 3.22; 95 % CrI: 2.41–4.31). Urban residence was associated with lower odds of reporting an intention to rely on traditional remedies compared with rural residence (OR = 0.48; 95 % CrI: 0.30–0.78). Similarly, respondents who reported that their dogs were unvaccinated against rabies had higher odds of seeking traditional remedies than those with vaccinated dogs (OR = 1.86; 95 % CrI: 1.34–2.64). Respondents living in locations without a livestock officer or veterinary establishment had lower odds of seeking traditional remedies compared with those who were uncertain about access (OR = 0.64; 95 % CrI: 0.53–0.79), as did those who reported having access to such services (OR = 0.71; 95 % CrI: 0.55–0.91). Finally, a greater distance to the nearest road was associated with lower odds of reporting an intention to seek traditional remedies (OR < 0.01; 95 % CrI: < 0.01–0.17). Spatial

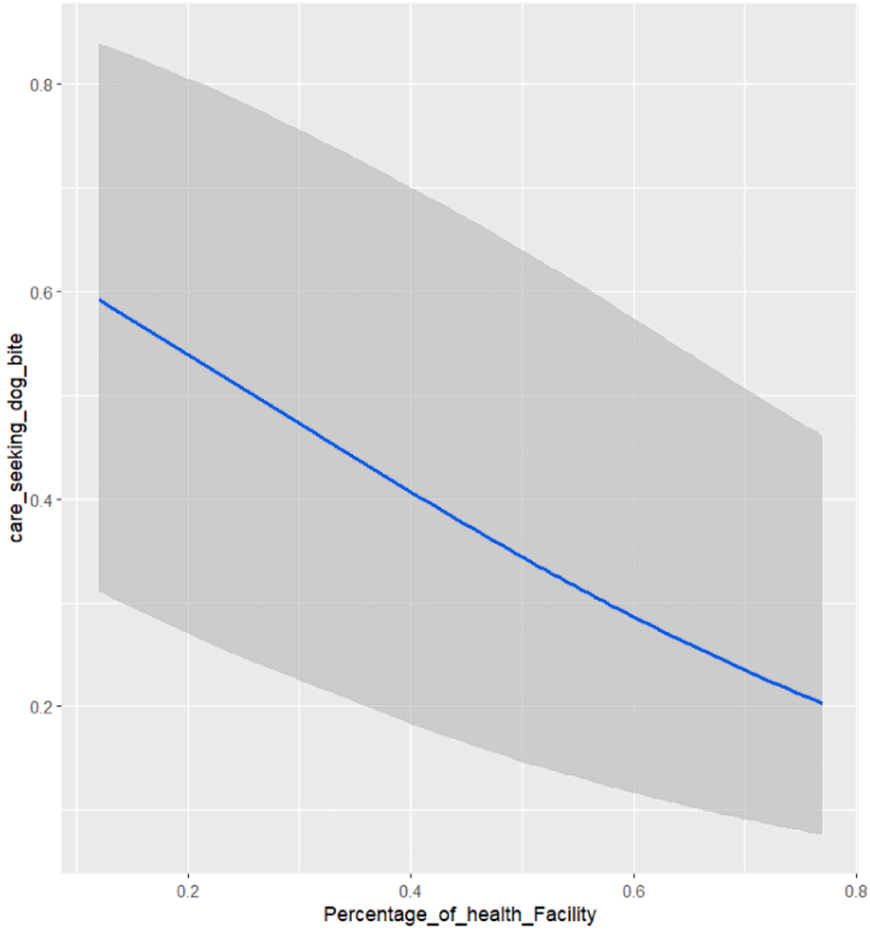


Fig. 7. Modelled conditional effect of the percentage of available health facilities on the predicted probability of seeking traditional care for a dog bite, based on a BRMS model, with all other covariates held constant at their average values. The results indicate a negative relationship, where an increase in the percentage of available health facilities is associated with a decrease in the probability of seeking traditional care. The shaded area around the blue line represents uncertainty in the estimate. The wide shaded area suggests a higher degree of uncertainty, meaning the predicted effect of health facility availability is less precise.

distribution of estimated random effects for the likelihood of using traditional remedies suggested that respondents in the Eastern and Western Area were less likely to report a preference for traditional approaches than those in the Northern and Southern Provinces (Fig. 3). The conditional plots of our model estimates, holding other variables constant, suggest that the predicted probability of seeking traditional care decreases with higher education, with the highest probability observed among individuals with no education (Fig. 2). Respondents who did not know which hosts rabies virus infects had a higher predicted probability of seeking traditional care compared with those aware that rabies affects both humans and animals (Fig. 3). Dog owners with unvaccinated dogs were more likely to seek traditional care than those with vaccinated dogs (Fig. 4). The predicted probability of seeking traditional care was higher for dog owners in rural areas compared with those in urban areas (Fig. 5). We also found regional variation in the probability of seeking traditional care. Respondents in the Eastern and Western Area were less likely to seek traditional remedies than those in the Northern and Southern Provinces(Fig. 6). Finally, an increase in the percentage of available health facilities was associated with a decrease in the predicted probability of seeking traditional care, although the effect estimates were less precise, as indicated by the wide uncertainty intervals (Fig. 7).

4. Discussion

This study examined factors associated with stated care-seeking preferences among dog owners, 2558, in Sierra Leone in response to a hypothetical dog-bite scenario. Approximately 30 % of respondents indicated that they would seek traditional care after a dog bite. This proportion is higher than that reported in a recent study from Nigeria, where approximately 27 % of respondents reported they would seek traditional care (Mshelbwala et al., 2025a) Limited access to formal healthcare services, particularly in rural areas of Sierra Leone, may be associated with these stated preferences, as awareness of the importance of timely seeking appropriate allopathic care is often shaped by prior interaction with the health system. Limited access to conventional healthcare services remains a key driver of reliance on traditional and complementary medicine, particularly in underserved areas (World Health Organization, 2019). Our results show that respondents residing in urban areas and in locations with more health facilities were less likely to report an intention to rely on traditional care, consistent with greater exposure to biomedical services. These findings are consistent with studies from other LMICs. For example, one study found that individuals in rural Nigeria were significantly more likely to use traditional remedies after dog bites, particularly in areas lacking veterinary services (Mshelbwala et al., 2025a). Strengthening primary healthcare infrastructure and ensuring consistent availability of PEP, particularly in rural and underserved areas, is critical to reducing reliance on traditional care.

Furthermore, our results indicated that respondents with lower levels of education and those who were unaware that rabies affect all warm-blooded animals were more likely to seek traditional remedies after a dog bite. This observation aligns with findings from studies in Uganda and Ethiopia (Bonaparte et al., 2021; Rago et al., 2024).

Respondents with lower education levels and those without a good understanding of the rabies virus transmission pathway might be unaware of its fatal nature. As a result, they might be more inclined to express a preference for lower-cost or familiar alternatives, rather than prioritizing allopathic care in a hypothetical exposure scenario This is of great public health concern considering that rabies is invariably fatal once clinical symptoms appear. Delays in receiving PEP significantly increase the risk of death. These findings highlight the urgent need for targeted awareness campaigns and community education programs to improve knowledge about rabies virus transmission and the importance of timely medical intervention. Moreover, there is the need for innovative, inclusive communication strategies, such as engaging trusted local leaders, using local languages, and incorporating visual or culturally relevant tools to effectively reach and educate respondents with lower education and low knowledge about rabies (Prevention; CDC, 2024; Pardhan et al., 2025).

Our results suggest that the association between dog vaccination status and stated care preferences likely reflects prior engagement with veterinary or public health systems, including exposure to risk communication and service delivery, rather than a causal influence of vaccination itself on post-bite decision-making. This finding may reflect prior experience with contemporary veterinary or medical services among owners who vaccinate their dogs. Such experience may have reinforced their understanding of the importance of timely, evidence-based care and increased their confidence in formal health systems, thereby reducing reliance on traditional remedies following a bite incident (Alyafei and Easton-Carr, 2024).

Our study also found a counterintuitive association between greater distance to the nearest road and reported reliance on traditional care following a dog bite. In many LMICs, living in remote areas is often associated with increased use of traditional medicine due to limited access to formal healthcare. However, our findings suggest that this relationship may be more complex in the present context. Distance to the nearest road may not accurately reflect healthcare accessibility, as previous research indicated that traditional healers and informal providers often operate in market-oriented, high-visibility locations influenced by population movement, economic activity, and privatized service delivery (Pfeiffer and Nichter, 2008; Onwujekwe et al., 2011). Importantly, this estimate was characterized by substantial uncertainty, as shown by a wide credible interval, indicating limited precision in the magnitude of the effect. Therefore, this finding should be interpreted with caution and highlights the need for further investigation into factors shaping health-seeking behaviour.

Lastly, we observed variation at the province level in the probability of seeking care after a dog bite, consistent with a report from Nigeria (Mshelbwala et al., 2025a). Respondents in the Eastern and Western Area were less likely to use traditional approaches than those in the Northern and Southern Provinces. The Eastern Province is known for gold mining, while the capital, Freetown, is in the Western Area (Thomas, 2021). Given that both areas are relatively resource-rich, more health facilities may be available, which could explain the lower use of traditional remedies in these regions. Alternatively, the Northern regions are known for their strong cultural ties to traditional rituals, which may explain why respondents in those areas were more likely to seek traditional approaches to healthcare (Nicol et al., 2025). The presence of ethnic groups, such as the Limba, Kuranko, Susu, and Yalunka, who maintain practices like the Poro society (especially for men) and complex initiation ceremonies, reflects a deep cultural heritage (Nicol et al., 2025).

While this study provides important insights for rabies control and program planning, several limitations should be acknowledged. First, the cross-sectional design limits the ability to establish causality. In addition, the sample was restricted to dog-owning households, which may minimize the generalizability of the findings to the wider population. Moreover, the primary outcome was respondents' intended care-seeking choice following a hypothetical dog-bite scenario, rather than actual behavior, which may not fully reflect real-world responses. Another limitation is the combination of systematic sampling (every tenth household) and informal selection by community members in areas without road networks may introduce selection bias. Furthermore, the absence of qualitative data limits deeper insight into cultural practices and personal experiences. Incorporating interviews with individuals or families affected by dog bites could provide richer context by revealing underlying beliefs and motivations influencing care-seeking behaviours. Although this study adopted the WHO definition of traditional medicine, the available data did not contain enough detail to classify specific subtypes such as herbal remedies, spiritual or faith-based interventions, or manual practices. As a result, it was not possible to quantitatively examine how each subtype influenced care seeking behavior following dog bites. Future studies should collect subtype-specific information to allow a more detailed assessment of the role of traditional medicine in post–dog bite care seeking behaviour. Finally, self-reported data are subject to social desirability bias, which may have caused respondents to underreport reliance on traditional remedies or overstate their engagement with formal healthcare services. Importantly, all findings should be interpreted as reflecting intentions and stated preferences, which may differ from actual behaviour during real exposure events Despite these limitations, the findings offer valuable evidence to guide rabies prevention and control programs in Sierra Leone

5. Conclusions

Our study revealed that 31 % of respondents in Sierra Leone indicated they would seek traditional care after a dog bite. The likelihood of relying on traditional remedies was higher among individuals with lower education levels, those living in rural areas, respondents lacking knowledge about rabies virus transmission and its hosts, and dog owners with vaccinated pets. Conversely, respondents with access to livestock officers or veterinary establishments, as well as those living near health facilities, were less likely to seek traditional care. Regional differences were observed, with respondents in the Eastern and Western Area less likely to rely on traditional remedies compared to those in the Northern and Southern Provinces. These findings highlight the influence of education, awareness, healthcare access, and geographic factors on health-seeking behaviour.

6. Recommendations

Based on our findings, the following targeted strategies are recommended to reduce reliance on traditional medicine and strengthen rabies control efforts in Sierra Leone:

1. Develop and deliver culturally appropriate education campaigns in local languages to improve public understanding of rabies virus transmission, the risks of traditional treatment, and the importance of prompt medical care after dog bites. These campaigns should especially target populations with lower formal education and limited rabies knowledge.
2. Strengthen healthcare infrastructure and services in rural and underserved regions, particularly in the Northern and Southern Provinces, where reliance on traditional medicine is higher. This includes increasing the availability of modern PEP and trained healthcare personnel.
3. Foster collaboration with traditional healers by integrating them into rabies control strategies. Training programs should equip traditional healers with basic rabies knowledge and encourage timely referrals of bite victims to medical facilities.
4. Trust traditional healers as critical first points of contact in underserved communities. Excluding them from rabies control strategies may delay PEP and weaken surveillance. A system oriented One Health approach recognizes traditional healers as critical community

actors, emphasizing strategic engagement through training to identify rabies risk, discourage harmful practices, and promptly refer victims to health facilities, consistent with WHO guidance on culturally appropriate community engagement.
5. Design province-specific interventions that reflect local cultural beliefs, healthcare access, and infrastructure. For example, strategies in the Western and Eastern Provinces may focus more on sustaining awareness, while those in the Northern and Southern Provinces should prioritize access and education.
6. Increase public awareness of the link between dog vaccination and reduced rabies risk.
7. Encourage responsible dog ownership through community outreach and subsidized vaccination programs, particularly targeting households with unvaccinated dogs.
8. Develop targeted messaging that considers gender and education level, as women and individuals with higher education were less likely to seek traditional treatment. These groups can also serve as community advocates for rabies prevention.
9. Involve communities through their community hierarchy/leadership to participate in the planning, organization of vaccination programs.

Declarations ethics approval and consent to participate

Directorate of Livestock and Veterinary Services and the University of Abuja Ethics Committee (UAECAU/2023/004).

CRediT authorship contribution statement

Roland Suluku: Writing – review & editing, Project administration, Methodology, Investigation, Conceptualization. **Philip P. Mshelbwala:** Writing – review & editing, Writing – original draft, Validation, Software, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Oyinkansola Fadiji:** Writing – review & editing. **Anayochukwu E. Anyasodor:** Writing – review & editing. **Solomon W Audu:** Writing – review & editing, Methodology. **Andrew M. Adamu:** Resources. **Charles E. Rupprecht:** Writing – review & editing. **Claude T Sabeta:** Writing – review & editing. **Kinley Wangdi:** Writing – review & editing.

Declaration of Competing Interest

The authors have declared that no competing interests exist.

Acknowledgements

We extend our heartfelt thanks to the dog owners who actively participated in this study and the Njala University students who assisted in data collection. KW is funded by the Australian National Health and Medical Research Council 2021 Investigator Grant (2008697).

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.prevetmed.2026.106803.

References

Alyafei, A., Easton-Carr, R., 2024. The health belief model of behavior change. StatPearls. StatPearls Publishing.
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. Clin. Case Rep. 7, 749.
Barbosa Costa, G., Gilbert, A., Monroe, B., Blanton, J., Ngam Ngam, S., Recuenco, S., Wallace, R., 2018. The influence of poverty and rabies knowledge on healthcare seeking behaviors and dog ownership, Cameroon. PLoS One 13, e0197330.
Bash-Taqi, R., Crawford, G.J., 2021. Ethnic Groups of Sierra Leone. Diversity and Cultural Competence in the Health Sector: Ebola-Affected Countries in West Africa, p. 27.
Beasley, E.A., Wallace, R.M., Coetzer, A., Nel, L.H., Pieracci, E.G., 2022. Roles of traditional medicine and traditional healers for rabies prevention and potential impacts on post-exposure prophylaxis: A literature review. Plos Negl. Trop. Dis. 16, e0010087.
Bonaparte, S.C., Adams, L., Bakamutumaho, B., Barbosa Costa, G., Cleaton, J.M., Gilbert, A.T., Osinubi, M., Pieracci, E.G., Recuenco, S., Tugumizemu, V., Wamala, J., Wallace, R.M., 2021. Rabies post-exposure healthcare-seeking behaviors and perceptions: Results from a knowledge, attitudes, and practices survey, Uganda, 2013. PLoS One 16, e0251702.
Burgert-Brucker, C.R., Dontamsetti, T., Marshall, A.M., Gething, P.W., 2016. Guidance for use of the DHS program modeled map surfaces. DHS Spat. Anal. Rep. (14), 14.
Bürkner, P.-C., 2017. brms: an R package for Bayesian multilevel models using Stan. J. Stat. Softw. 80, 1–28.
CDC, 2024. Culture and Language. ⟨https://www.cdc.gov/health-literacy/php/develop-materials/culture.html⟩.
CIESIN, I., 2011. CIAT (2011) Global rural-urban mapping project, version 1: population density grid. Center for International Earth Science Information Network—CIESIN—Columbia University, International Food Policy Research Institute—IFPRI, The World Bank, Centro Internacional de Agricultura Tropical—CIAT.
Hampson, K., Coudeville, L., Lembo, T., Sambo, M., Kieffer, A., Attlan, M., Barrat, J., Blanton, J.D., Briggs, D.J., Cleaveland, S., et al., 2015. Estimating the global burden of endemic canine rabies. PLoS Negl. Trop. Dis. 9, e0003709.
Hatch, C., Sneddon, J., Jalloh, G., 2004. A descriptive study of urban rabies during the civil war in Sierra Leone: 1995–2001. Trop. Anim. Health Prod. 36, 321–334.
Hijmans, R.J., 2018. raster: Geographic data analysis and modeling. R. Package Version 2 (8).
Knobel, D.L., Cleaveland, S., Coleman, P.G., Fevre, E.M., Meltzer, M.I., Miranda, M.E., Shaw, A., Zinsstag, J., Meslin, F.X., 2005. Re-evaluating the burden of rabies in Africa and Asia. Bull. World Health Organ 83, 360–368.
Kumoji, E.K., Oyenubi, O., Dickenson, T., Clayton, S., Helland, A., Fofanah, J., 2018. The Context of Rabies in Bombali District, Sierra Leone: Formative Research and Outcomes Monitoring Assessment Report. Johns Hopkins Center for Communication Programs, Baltimore, MD.
Mshelbwala, P., Akinwolemiwa, D., Maikai, B., Otolorin, R., Maurice, N., Weese, J., 2018. Dog ecology and its implications for rabies control in Gwagwalada, Federal Capital Territory, Abuja, Nigeria. Zoo. Publ. Health 65, 168–176.
Mshelbwala, P.P., J. Soares Magalhães, R., 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 Negl. Trop. Dis. 17, e0011147.
Mshelbwala, P.P., Wangdi, K., Bunting-Graden, J.A., Bamayange, S., Adamu, A.M., Gupta, S.D., Suluku, R., Adamu, C.S., Weese, J.S., Rupprecht, C.E., Clark, N.J., 2024. Insights into canine rabies vaccination Disparities in Sierra Leone: a cross-sectional household study. Plos Negl. Trop. Dis. 18, e0012332.
Mshelbwala, P.P., Wangdi, K., Idris, J., Hassan, M.M., Adamu, A.M., Rupprecht, C.E., Clark, N.J., 2025a. Traditional practices versus modern healthcare: determinants of traditional medicine use after potential dog bites among dog-owning households in Nigeria. Plos Negl. Trop. Dis. 19, e0012910.
Mshelbwala, P.P., Weese, J.S., Adegboye, O., Suluku, R., Akanbi, I., Jalloh, A.G., Bunting-Graden, J.A., Hassan, M.M., Rupprech, C.E., 2025b. Factors associated with perceived barriers to canine rabies vaccination among owners of unvaccinated dogs in Sierra Leone. Prev. Vet. Med, 106698.
Mukasa, P., Ogwang, P., Oriko, R., Lejju, J., Olet, E., Gumisiriza, H., Adaku, C., 2023. Medicinal plants used in the traditional management of dog bites by herbalists in Eastern, Western, and Central Uganda. Ethno Res Appl. 26, 1–15.
Nicol, D.S.H.W., Fyfe, C., Sesay, S.M., 2025. Sierra Leone. Encyclopedia Britannica.
Okoh, A., 1986. Dog ecology with reference to surveillance of rabies and characterization of rabies virus isolates in Plateau State, Nigeria. Ahmadu Bello University, Zaria.
Onwujekwe, O., Onoka, C., Uzochukwu, B., Hanson, K., 2011. Constraints to universal coverage: inequities in health service use and expenditures for different health conditions and providers. Int J. Equity Heal 10, 50.
Pardhan, S., Sehmbi, T., Wijewickrama, R., Onumajuru, H., Piyasena, M.P., 2025. Barriers and facilitators for engaging underrepresented ethnic minority populations in healthcare research: an umbrella review. Int. J. Equity Health 24, 70.
Pebesma, E., Bivand, R., Racine, E., Sumner, M., Cook, I., Keitt, T., Lovelace, R., Wickham, H., Ooms, J., Müller, K., 2021. sf: Simple Features for R. R. Package Version 1.
Pfeiffer, J., Nichter, M., 2008. What can critical medical anthropology contribute to global health? A health systems perspective. Med. Anthro Quart. 22, 410–415.
Prevention, Cf.D.Ca, Culture and Language. U.S. Department of Health & Human Services.
Rago, R., Abafaji, G., Abadura, S.Z., 2024. Investigating rabies prevention and control: a study of knowledge, attitudes, and practices in Jimma Town, South-Western Ethiopia. Small Anim. Adv. 3, 8–17.
Reed, T., Robinson, J., 2013. The Chiefdoms of Sierra Leone. Harvard Univ. ⟨http://people.fas.harvard.edu/treed/history.pdf⟩.
Suluku, R., Obukowho, E.B., Macavoray, A., 2022. Challenges and recommended solutions for elimination by 2030. Rabies Virus at the Beginning of 21st Century vol. 67.
Team, R.C., 2021. A language and environment for statistical computing.
Textor, J., Hardt, J., Knüppel, S., 2011. DAGitty: a graphical tool for analyzing causal diagrams. Epidem 22, 745.
Thomas, A.R., 2021. Massive illegal Chinese goldmining uncovered in Eastern Sierra Leone. The Sierra Leone Telegraph.

Vehtari, A., Gelman, A., Gabry, J., 2017. Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. Stat. Comp. 27, 1413–1432.
Walwa, B.W., Kimaro, E.G., Mpolya, E.A., Sambo, M., Factors associated with poor compliance to rabies post-exposure prophylaxis among dog bite victims in Maswa District in Tanzania: a cross-sectional study. Available at SSRN 4574216.
World Health Organization, 2018. Rabies vaccines: WHO position paper, April 2018–Recommendations. Vaccine 36, 5500–5503.
World Health Organization. 2019. WHO global report on traditional and complementary medicine 2019. World Health Organization. ⟨https://www.who.int/publications/i/item/978924151536⟩.
World Medical Association. 2001. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bulletin of the world health organization 79, 373.