AWARENESS, KNOWLEDGE, AND ATTITUDES ON RABIES AND PRIOR RABIES PREVENTIONS AMONG ADULTS LIVING ALONG THE BHUTAN–INDIA BORDER

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ABSTRACT

Background: Rabies is an almost universally fatal but entirely vaccine-preventable zoonotic disease, most commonly transmitted through dog bites. In Bhutan, rabies remains endemic in the southern districts along the porous Bhutan-India border due to free roaming dog populations and high human mobility. Objective: To assess the awareness, knowledge, and attitude on rabies and prior rabies preventions among adults aged 18 years or older living along the Bhutan-Indian border. Methods: A community-based, cross-sectional study was performed in seven high-risk rabies border districts. Participants were selected exploiting a multistage sampling method. Data were gathered through interviews managing a structured questionnaire. Factor analysis and descriptive statistical analyses were performed. Results: Among 728 participants, 69% had high level of overall awareness of which nearly all reported having heard of rabies (95%), followed by transmitted from animals to humans (92%), and rabies can be prevented (89%). High knowledge level in rabies prevention (68.0%) was higher than in cause of rabies (63.9%) and sign & symptom (57.3%), respectively. Standardized scores of awareness and attitude were higher than knowledge scores. Of 164 having history of dog bites in previous 12 months (22.5%), they reported that bite from unvaccinated animals (54.9%), washed bite wounds (76.8%), received PEP 69.6% with completed treatment (67.1%), and use traditional treatments (2.4%). Conclusion: Although awareness, attitudes, and access to care were generally good, rabies knowledge remained inadequate, with predominantly poor prevention practices among individuals with prior animal bites, underscoring the need for targeted education and prevention policies.

Keywords: Dog-mediated human rabies; Awareness; Attitude; Practice; Pre-Exposure Prophylaxis (PrEP); Wound care; Post-Exposure Prophylaxis (PEP); Rabies Immunoglobulin (RIG).

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INTRODUCTION

Rabies remains one of the most fatal zoonotic diseases globally, yet it is entirely vaccine-preventable, causing an estimated 59,000 to 60,000 human deaths worldwide, with 99% of cases resulting from dog bites. Children under 15 years account for nearly 40% of bite victims and 35 to 50% of deaths (Al-Mustapha et al., 2022; Subedi et al., 2022). Rabies is a extensive public health burden in low and middle income countries, predominantly narrated in South and Southeast Asia where dog vaccination coverage is insufficient, access to Post-Exposure Prophylaxis (PEP) is irregular, and community awareness remains inadequate (Chuchu et al., 2022). Confirmation from multiple settings features persistent deficiencies in knowledge, attitudes, and practices associated to rabies prevention. Previous studies report low levels of acceptable knowledge and preventive behavior in Mozambique, India, Cambodia, and Bhutan, with hindered care seeking often linked to underestimation of risk, exclusively following provoked bites (Mapatse et al., 2022; Penjor et al., 2019; Ramesh Masthi et al., 2019; Ung et al., 2021). These challenges are aggravated by limited accessibility of PEP and Rabies Immunoglobulin (RIG), principally in rural areas, with recognized shortages and prolonged universal stock outs (Chuchu et al., 2022).

Many border regions face delicate risk due to high human mobility, free roaming dog populations, and uneven health infrastructure. South Asia, exceptionally areas bordering Bhutan, remains rabies endemic, where hindered treatment seeking and dependance on traditional practices disseminate transmission (Leblanc et al., 2024; Lungten et al., 2022). Global creativities such as the “Zero by 30” strategy highlight mass dog vaccination, accessible PEP, desegregated surveillance, and strong community commitment. Evidence from Namibia and Tanzania endorses that community awareness directly impacts vaccination coverage and timely PEP uptake (Chen et al., 2023).

Bhutan’s topography, free-roaming dog populations, and frequent cross-border movement contribute to an unrelenting rabies risk. Surveillance data account for 20 human rabies deaths between 2006 and 2024 and 6,940 dog bite cases in 2024, primarily in southern districts bordering India. The Bhutan–India border is especially vulnerable to rabies due to permeable borders, recurrent cross-border movement of people and dogs, unrestricted free-roaming dog populations, dissimilar vaccination policies, disjointed surveillance, and mismatched access to timely PEP. Subsequently, assessing awareness, knowledge, attitudes, and prior practices among adults in these high-risk border communities is essential to inform targeted interventions, improve timely PEP access, and support Bhutan’s goal of eliminating dog-mediated human rabies deaths by 2030. The objective of this study was to assess awareness, knowledge, and attitudes toward rabies, as well as prior rabies prevention practices, among adults aged 18 years or older living along the Bhutan–India border.

LITERATURE REVIEW

The combination of the collected works highlights tenacious gaps across awareness, knowledge, attitudes, and rabies prevention practices, in conjunction to notable lack of evidence concentrating exclusively on adult populations dwelling in international border regions. Grasping such settings is therefore vital to inform context specific mediations and evolve progress toward the global “Zero by 30”, eliminating dog-mediated human rabies demises.

Awareness of Rabies

Awareness on rabies is extensively reported as moderate to high throughout endemic regions, the complexity and functional significance of this awareness diverge to a larger extent. The community-based reviews in South Asia and Africa found that 73% - 96% of respondents have heard of rabies (Kebede et al., 2024), of which elevated awareness was recognized in Bhutan, where outbreak associated surveys testified awareness levels of 94.5 to 100%.

Correspondingly, awareness surpassing 90% has been reported in Cambodia and including schoolchildren in southern Bhutan(Lungten et al., 2021). In distinction, a large multicentric Indian review across seven states obtained that only 60.4% of adults had heard of rabies. Utmost awareness studies are self reported and cross-sectional. Determining awareness using a binary indicator is likely to overvalue meaningful awareness because of social desirability bias and outbreak motivated sensitization. Grownups in rural and border settings remain underrepresented, signifying a critical gap in Bhutan-India border. Ever heard of rabies does not warrant the awareness and knowledge of other imperative characteristics of rabies. In Cambodia, 93.2% of respondents had heard of rabies, only 77.3% established it as universally fatal once symptoms progress. Misinformation, traditional beliefs, and frail risk communication tempered effective awareness (Mapatse et al., 2022). In Ethiopia, despite high awareness, only 21.7% of biting dogs were followed for the recommended 10 days observation period (Abdella et al., 2022).

Knowledge of Rabies

Understanding of rabies transmission, fatality, wound management, and appropriate PEP remains inconsistent and frequently inadequate despite relatively high awareness across endemic regions (Al-Mustapha et al., 2022). In India, only 0.2% of adults demonstrated comprehensive rabies knowledge, and awareness of PEP was as low as 3.7%. In Uganda, lower knowledge scores were significantly associated with poor healthcare seeking behavior, although more than 50% of bite victims sought some form of care, only 3% received PEP. Partial knowledge is frequently observed in many studies. In rural Nepal, 70% of respondents knew that wounds should be washed, yet nearly 60% would not report suspected rabies cases, and only 82.9% of dog owning households vaccinated their pets (Dhakal et al., 2023). In Bhutan, while 81.8% recognized vaccination as preventive, 67.3% believed antibiotics could prevent rabies and 20% thought wound dressing alone was sufficient. Socioeconomic gradients are evident, with better knowledge associated with higher education, male sex, younger age, and dog ownership (Lhendup & Wangdi, 2022). Knowledge deficits extend to healthcare providers; in Kenya, only 11% of healthcare workers were aware of WHO recommended intradermal vaccination, and fewer than 25% correctly classified exposure categories (Chuchu et al., 2022). Systematic reviews report pooled prevalences of good rabies knowledge of only 62.2% in Ethiopia (Woldegeorgis et al., 2023). The majority of cross-sectional layouts and heterogeneous knowledge scores limits comparability and fundamental inference, while interacted to cross border care seeking and animal movement remains largely uncharted.

Attitudes toward Rabies

Attitudes concerning rabies strongly impact risk perception, healthcare utilization, and adherence to preventive measures, yet indicators signifies that rabies severity is repeatedly undervalued. In Bangladesh, 59% of dog bite victims first pursued care from traditional healers, and only 29% established vaccination. Comparable reliance on traditional therapies has been stated in Peru, Nigeria, and Nepal, frequently leading to delayed or incomplete PEP (Al-Mustapha et al., 2022; Dhakal et al., 2023). Socioeconomic restraints further shape attitudes; in Cameroon, lesser wealth status was considerably associated with inclination for traditional healers ($p < 0.01$), irrespective of knowledge level. Contrarywise, constructive attitudes can be nurtured through withstood commitment. In Bhutan, outbreak response studies narrated that 78.2% of respondents seeming rabies as a thoughtful public health problem, and optimistic attitudes were extensively correlated with better preventive practices ($r = 0.4684$, $p < 0.001$) (Lhendup & Wangdi, 2022). However, favorable attitudes alone do not always translate into action, pooled analyses from Ethiopia indicate that only 56.7% of respondents demonstrated favorable attitudes toward rabies prevention (Woldegeorgis et al., 2023). Most attitudinal studies use non standardized tools and self reported measures, limiting generalizability, and

few explicitly focus on adult populations in border settings where mobility and cross border health systems may further influence attitudes.

Rabies prevention Practices

Rabies prevention practices remain markedly suboptimal across endemic regions. Dog vaccination coverage is low; in Addis Ababa, 73.1% of dogs involved in bite incidents were unvaccinated. In Rangjung, Bhutan, although all respondents stated they would seek medical care after a bite, only 61% washed wounds with soap and water, and 50% of dog owning households allowed dogs to roam freely (Tenzin et al., 2017). Individual prevention practices are equally lacking; in China, 81.2% performed unsuitable wound care and 35.3% deferred PEP initiation, with wrong wound management intensely associated with rabies risk (OR = 17.33, 95% CI: 6.39–60.83). Accomplishment of PEP remains a confront; in India, only 65.9% fulfilled intramuscular vaccination, and just 46.2% of Category III exposures obtained rabies immunoglobulin. Mechanical barriers comprising stock outs, cost, and geographic access further destabilize prevention, exceptionally in border and rural areas. Whereas modeling studies validate that achieving ≥70% dog vaccination shared with integrated bite case management could get rid of human rabies deaths by 2033 (Chen et al., 2023), utmost existing evidence is observational and facility based, likely underrepresenting adults who never seek care. This disparity is particularly noticeable for border populations, where prevention practices endure poorly documented.

RESEARCH METHODOLOGY

This community-based, cross-sectional study was ethically approved by Research Ethics Board of Health; Thimphu; Bhutan and the Human Research Ethics Committee of Faculty of Medicine, Prince of Songkla University (REC.68-349-18-1) that conducted during September to October 2025 in seven high-risk districts situated along the Bhutan-Indian border. The study population comprised of adults age 18 years or older, resided in the study area for at least six months existing within the catchment areas of 13 Hospitals and 15 Primary Health Centers. Persons who were inaccessible at the time of the household visit or who had communication hurdles were excluded. The sample range was computed employing the single population proportion formula, supposing a prevalence of 50%, and 95% confidence interval level, 5% margin of error, and a design effect of 1.5 account for clustering with estimate of 20% non-response rate.

Due to a minimum distance between health facilities approximately 10 kilometers (km), we decided to apply two 5 km strata for a catchment area of each study setting. A systematic sampling strategy was employed considering the two strata (≤5 km and >5 km from the health facility). Household patterns in the Bhutan-India border were scattered, thus the household nearby the facility was chosen to be the statting household to be approched and then next household was visited until 13 households were completed from each stratum. This resulted in 26 households per facility catchment. Only one eligible participant with a selected household who the interviewer first met was invited to participate in the study achieving a final sample size of 728 participants.

The questionnaire was in English and evaluated for content validity index by three experts ranging from 0.96 to 1.00. Trained one health personnel from each study site as an interviewer, and the tool was pretested among three eligible participants per site leading to 84 participants to ensure the reliability. The internal consistencies of awareness and attitudes were acceptable by Cronbach's alpha of 0.73 and 0.97, respectively. Interviewers explained the purpose of the study, and obtained verbal informed consent prior to participation. After verbal consent, the participants were interviewed using a valid, reliable structured questionnaire. Interviews were conducted individually with adequate privacy, in either the local dialect or the national language, and responses were recorded electronically using the KoboToolbox application.

Each interview lasted approximately 15 to 20 minutes, and participants were told of their privilege to withdraw at any time.

The collected data were exported, cleaned, and analyzed using R version 4.4.0. Descriptive statistics were used to review baseline characteristics of the participants. Overall awareness was measured by seven items with the responses of "yes" classified as *aware*, and "no" and "do not know" classified as *unaware*. A total of 20 knowledge scores on causes, sign & symptom, and prevention of rabies was measured. A total of 18-item attitude with Likert scale was evaluated for construct validity using exploratory factor analysis. Sampling adequacy was assessed with the KMO measure and Bartlett's test of sphericity. Factors with eigenvalues ≥1 were retained using varimax rotation, with loadings ≥0.40 considered acceptable. Internal consistency was then assessed using Cronbach's alpha. To ensure consistency and scale-independent interpretation across domains, a uniform 75% cut-off was applied to categorize awareness, knowledge, and attitude into low and high levels. To facilitate comparability across domains measured on different scales, awareness, knowledge, and attitude scores were standardized to a 0–100 scale by dividing each observed score by its maximum possible value and multiplying by 100. Higher scores indicate greater awareness, better knowledge, or more positive attitudes. Awareness, knowledge, and attitude scores were also stratified by those keeping dogs inside or within the vicinity of their homes and their animals vaccinated. History of dog bites and prior rabies prevention practices were summarized descriptively.

RESEARCH RESULTS

All participants approached were agreed to participate in the study resulting in 100% response rate. The average age of participants was 38.86 years (SD 13.38). Sex distribution was nearly equal, with 357 males (49.0%) and 371 females (51.0%). Approximately three-fourths of them were married. Around half was Buddhist (51.37%), followed by Hindu (42.72%). Farming was the most common primary occupation (42.04%), followed by civil service (19.37%) and unemployment (10.58%). Approximately one-fifth of them reported never went to school. One-third reported a monthly income below USD 54, while only 17.58% reported incomes exceeding USD 220. Virtually three fourths of them reported keeping animals inside or within vicinity of their home, including dogs (31.32%) and cats (43.82%). Slightly more than half of them reported vaccinating their animals against rabies. Geographic access to health facilities varied from less than 1 km (37.77%) to 1-6 km (43.27%) and more than 6 km (18.96%). Nearly two-thirds of them could reach nearest facility within 30 minutes and small proportion of participants reported a delay or avoidance of health facility visits due to transportation or distance barriers (7.14%) (Table 1).

Table 1 Animal-related Environment and Geography-related Health Facility

Variable	Participants (N = 728) n (%)
Keep animals inside or within the vicinity of home	
Dogs	228 (31.3)
Cats	319 (43.7)
Having animals vaccinated (mammals, canine and feline)	401 (55.1)
Distance to nearest health facility	
Less than 1 km	275 (37.8)
1 to 3 km	201 (27.6)
4 to 6 km	114 (15.6)
More than 6 km	138 (19.0)
Time taken to reach the nearest health facility	
Less than 15 minutes	252 (34.6)

15–30 minutes	199 (27.3)
31–60 minutes	141 (19.4)
More than 1 hour	136 (18.7)
Delayed or avoided visiting a health facility because of transportation or distance issues	52 (7.14)

The median awareness score was 6 (IQR: 5–7), with a high level of overall awareness observed in 69.0%. Nearly all participants (95%) reported having heard of rabies followed by transmitted from animals to humans (92%), and rabies can be prevented (89%). The lowest level of awareness (54%) was observed for familiarity with the symptoms of rabies in humans. The total rabies knowledge scores ranged from 4 to 20, with a median of 10 (IQR: 8-14) with high knowledge level of 22.9%. Knowledge on cause, sign and symptom, and prevention are presented in Table 2. High knowledge level in rabies prevention (68.0%) was higher than in cause of rabies (63.9%) and sign & symptom (38.9%), respectively.

Table 2 Knowledge scores on Cause, Sign and symptom, and Prevention

Knowledge	Range	Median (IQR)	Participants (N = 728) n (%)
Cause of Rabies: scores	0-5	3 (2,4)	
High knowledge level			217 (29.8)
Low knowledge level			511 (70.2)
Sign and symptom of Rabies: scores	2-7	3 (2,5)	
High knowledge level			111 (15.2)
Low knowledge level			617 (84.8)
Rabies prevention: scores	2-8	4 (3,6)	
High knowledge level			254 (34.9)
Low knowledge level			474 (65.1)

The attitude scale demonstrated excellent sampling adequacy (KMO = 0.94). Bartlett's test of sphericity was statistically significant ($p < 0.001$), indicating that the data were appropriate for factor analysis. One factor with an eigenvalue greater than 1 was extracted, explaining 47% of the total variance (Figure 1). The attitude scale also showed high internal consistency, with a Cronbach's alpha of ($\alpha = 0.93$), indicating good reliability. The median attitude score was 76 (IQR: 71-82), and 87.5% of participants had a positive attitude. Figure 2 presents the standardized scores of awareness, knowledge, and attitude of rabies and rabies prevention. Awareness scores were consistently high and attitude scores were similarly high but exhibited greater variability and low score outliers. In contrast, knowledge scores were substantially lower. Participants who kept animals inside or within the vicinity of their homes had significantly lower awareness ($p = 0.048$), but higher knowledge ($p = 0.013$) compared with those who did not. Attitude scores were significantly higher among participants whose animals were vaccinated ($p < 0.001$), while awareness and knowledge did not differ by vaccination status.

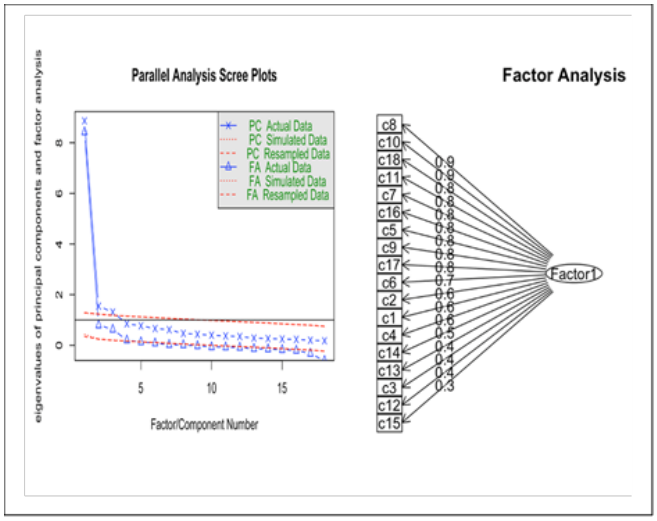

Figure 1 Attitude on Rabies

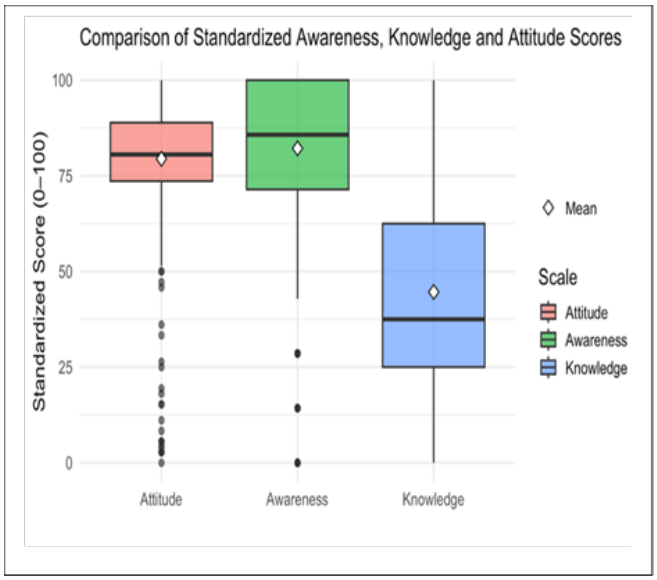

Figure 2 Standardized scores of awareness, knowledge, attitude

Among 728 participants, 164 had the history of dog bites and prior rabies prevention in the preceding 12 months (22.5%) and their history is shown in Table 3. Over half of these exposures involved stray animals (50.6%), and 54.9% of the biting animals were reportedly unvaccinated. Among exposed individuals, 76.8% washed the wound with soap and water immediately following the bite, but fewer than 40.24% sought prompt medical care. Pre-exposure prophylaxis was uncommon (22.2%). Following exposure, 69.6% received PEP, of whom 67.1% completed the full regimen, while 2.4% continued to use traditional treatments. Overall, 65.1% of participants reported receiving rabies related health education in the previous 12 months.

Table 3 History of dog bites and prior rabies prevention

Variable	Participants (N = 164) n (%)
The biting animal or dog a stray or a pet	
Stray	83 (50.6)
Pet (your own)	45 (27.4)

Pet (someone else's)	36 (22.0)
Animal or dog vaccinated against rabies in the past 12 months	74 (45.1)
Immediate action taken after the animal or dog bite	
Washed the wound with soap and water	126 (76.8)
Sought medical care	66 (40.2)
Received PEP	117 (69.6)
Traditional treatment	4 (2.4)
Received pre-exposure prophylaxis (PrEP) before being exposed to a bite in the past 12 months	37 (22.2)
Visited health center and received post-exposure prophylaxis (PEP) after a dog or other animal bite	117 (69.6)
Completed the course of PEP as recommended by treating physician	112 (67.1)
Received any information or health education on rabies in the past 12 months	110 (65.1)

DISCUSSION AND CONCLUSION

Nearly all adults aged ⩾18 years along the Bhutan-Indian border showed a striking contrast between high general awareness of rabies and persistent gaps in practical knowledge and prior protective behaviors. Although most participants were familiar with rabies, its animal to human transmission, and its preventability, knowledge of causes and clinical manifestations remained comparatively limited. Standardized scores further highlighted the disparity, showing consistently high awareness and attitude scores though attitudes displayed greater variability while knowledge scores lagged behind. Awareness and attitudes scored higher than factual knowledge, suggesting that positive perceptions do not always translate into comprehensive understanding. Notably, individuals keeping animals within their household vicinity had lower awareness but higher knowledge, and positive attitudes were significantly associated with animal vaccination status, whereas awareness and knowledge were not. Importantly, dog bites were common, frequently involving unvaccinated animals, and while most individuals reported appropriate wound washing and post-exposure prophylaxis, incomplete treatment and traditional practices, though uncommon, were still observed.

High level of awareness in popultion living in border of Bhutan in our study was aligned with findings from outbreak prone and border regions in Bhutan, Ethiopia, and Cambodia (Kebede et al., 2024; Tenzin et al., 2017). Such elevated awareness likely reflects repeated public health messaging, prior outbreak exposure, and proximity to endemic regions in India. Nevertheless, consistent with observations from Madagascar and China, high awareness alone does not guarantee adequate understanding or preventive behavior (Leblanc et al., 2024). When symptom recognition was considered, only about two-thirds of our participants revealed high overall awareness, and comprehensive knowledge remained moderate. Knowledge gaps were particularly evident regarding the causes and clinical manifestations of rabies in humans and well recognized in animal. Comparable misconceptions have been reported in Peru, Nigeria, and Ethiopia, where misunderstandings about rabies symptoms and progression hinder timely healthcare seeking (Al-Mustapha et al., 2022; Woldegeorgis et al., 2023). Analogues deficiencies among schoolchildren in Samtse, Bhutan, suggest persistent knowledge gaps across age groups and settings. The fervent correlations observed between knowledge domains in this study indicate that strengthening one area of knowledge may enhance overall understanding. Educational intermediations in India and Bhutan demonstrate that even brief, targeted programs can substantially improve rabies knowledge, although reinforcement is needed to sustain gains (Lhendup & Wangdi, 2022; Lungten et al., 2021).

In our study, attitudes toward rabies were generally positive and shaped a coherent construct, consistent with findings from Ethiopia and Bhutan linking positive attitudes with preventive intentions (Kebede et al., 2024; Lhendup & Wangdi, 2022). Nevertheless, variability and low

score outliers recommend that positive attitudes are not universal, possibly reflecting differences in education, socioeconomic status, and household decision making power, similar to the findings of the studies in Tanzania and Nepal (Dhakal et al., 2023). A clear gap between awareness and action was obvious in animal ownership and vaccination practices. While nearly one third of participants owned dogs, only 55% reported vaccinating them, comparable to low coverage in Cameroon, Ethiopia, and Madagascar (Abdella et al., 2022; Leblanc et al., 2024). Dog bites from free roaming and unvaccinated dogs reported in the study indicated inadequate dog vaccination and ongoing risk of rabies transmission. Moreover, post-bite practices were suboptimal; while most bite victims reported washing wounds, fewer than half sought timely medical care, and about one third did not receive or complete PEP. Related patterns of delayed or incomplete PEP have been reported in China, Uganda, India, and Bangladesh, often escorted by reliance on traditional remedies. Although most participants reported reasonable geographic access to health facilities and minimal transportation barriers, structural access alone does not fully explain suboptimal uptake of PEP. This is consistent with global evidence showing that multidimensional poverty, rather than national income or health expenditure alone, is strongly associated with rabies mortality and reduced access to life-saving care.

In general, rabies prevention failures appear to stem from interconnected gaps in knowledge depth, attitudes, and practices. Addressing these gaps requires integrated approaches, including sustained community education, improved dog vaccination coverage, strengthened Integrated Bite Case Management, and cross-sectoral collaboration. Granting awareness was widespread, significant deficiencies in comprehensive knowledge and timely post-exposure care represent missed prevention opportunities. This study has some limitations. First, the cross-sectional design, which aimed to describe levels of awareness, knowledge, and attitudes, precludes causal inference between these factors and rabies-related preventive practices. Second, the assessment of awareness, knowledge, and attitudes relied on structured questionnaire items, which may not fully capture the depth of participants' understanding. Third, the sample size for describing rabies prevention practices among participants with a history of dog bites was relatively small, as the sample size calculation was based on estimated proportions of overall awareness, knowledge, and attitudes rather than on dog bite history. Fourth, we could not perform household random sampling due to specific geographic and household contexts in the study areas which may be potential selection bias. Fifth, information on rabies prevention practices during the preceding 12 months was self-reported and may be subject to recall bias; however, dog bites are salient events that are typically well remembered, suggesting that the potential impact of recall bias is likely to be limited. Finally, the study was conducted in selected communities, which may limit the generalizability of the findings to other settings with different socio-cultural contexts or rabies risk profiles.

In conclusion, awareness of rabies was widespread among adults living along the Bhutan-Indian border; however, substantial gaps remain in comprehensive knowledge and appropriate post bite practices. Moderate knowledge particularly regarding causes and clinical signs and low uptake of timely medical care and prophylaxis highlight missed prevention opportunities. Future research should move beyond binary awareness measures to better capture depth of knowledge, risk perception, and intention or behavioral responses of rabies prevention, and to evaluate interventions that translate awareness into timely care seeking. Beginning a policy and health system perspective, strengthening cross border rabies control strategies, improving access to post-exposure services, and integrating targeted community education into primary care are indispensable to achieve effective rabies prevention and elimination.

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