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Article

Retrospective Study of Human Rabies Exposure and Associated Risk Factors in North-West Ethiopia

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Abstract: Background: Rabies, a zoonotic disease caused by the lyssavirus genus, is widely distributed and a significant cause of human death in Africa and Asia. This study aimed to investigate human rabies exposure and associated risk factors in Northwest Ethiopia. **Methods:** The study encompassed four zones, seven districts, and four kebeles from each district. The research team developed a questionnaire for data collection. **Results:** A total of 642 households were interviewed. The current study rabies exposure was revealed 10.47%. Over 98% of respondents displayed a strong understanding of rabies, with 99.69% correctly identifying rabies as a zoonotic disease. However, 80% of the interviewees were trusted traditional medicine could treat rabies. Only 21.93% of victims were took post exposure prophylaxis. Dogs were the primary affected animals (87.73%), of this 48.70% was bites by own dogs. Metema district had higher risk ($p < 0.001$) compared to others six districts. Dog ownership ($p < 0.05$) and a higher number of households ($p < 0.01$) were also identified as risk factors for rabies exposure. **Conclusion:** Residence, low education levels, high household density, free-roaming dogs, and dog ownership as key risk factors for rabies exposure. Public health awareness campaigns are crucial to emphasise the risks associated with animal bites.

Keywords: dog-bite; epidemiology; ethiopia; exposure; human rabies; risk factor

1. Introduction

Rabies is caused by rabies virus of the genus *Lyssavirus*, family *Rhabdoviridae* and order Mononegavirales that affects the central nervous system of all mammals [1,2]. The virus is 100% fatal once clinical signs appear. Rabies is a widespread zoonotic disease causing a significant social and economic burden in many countries [3]

Rabies virus is transmitted mainly by the bite of rabid dogs. This virus can also be transmitted through direct contact of fresh wound or intact mucosal surface (eyes, nose) with infectious saliva or by licks of rabid animals, and transdermal scratches contaminated with infectious material [4,5].

After replication of the virus inside the bitten muscle tissue and then it travels towards the central nervous system [6]. The virus is travelling from a point of bite to the brain *via* the nerve cells. Once the virus reaches to the nervous system, it can manifest either of two forms: “dumb rabies” that results in paralysis of the affected one or the more common “furious rabies” that shows the clinical manifestation of excessive saliva production and in most cases, hydrophobia [7]. The entrance of virus inside tissues of the brain leads to death by causing respiratory dysfunction and secondary metabolic and circulatory defects [8].

Rabies disproportionately affects the poorest and under-resourced populations living in low- and middle-income countries, and its incidence is on the rise in several countries. In addition to its negative impact on mortality, rabies also causes a negative economic impact in already impoverished

populations. Rabies exposure also aggravated by the presence of different risk factors. The possible risk factors associated with the developing of rabies in humans are many; however, lower age is considered as a main risk factor in developing rabies ([9,10]. Occupational difference and level of education are additional known risk factors for rabies. Poor management of wounds and poor adherence to post-exposure prophylaxis are also associated with a higher risk for developing human rabies [10].

Epidemiologically, rabies is widely distributed and causes a high number of human deaths in the world especially, Africa and Asia. It is a public health threat to these regions [11,12]. More than 95% of all deaths associated with rabies happen in these continents. The disease claims the lives of 24,000 people in Africa annually [13]. Rural communities are especially impacted by rabies outbreaks, through the combination of limited access to health care and the threat to their livelihoods through rabies attacks on livestock [3,14].

Ethiopia is one of high rabies burden among African countries in regard to human rabies virus exposure since early 17th century [15,16]. The Ethiopian Health and Nutrition Research Institute, the current Ethiopian Public Health Institute, indicated that human rabies has been reported in Ethiopia in 1903 for the first time [17]. A national surveillance data conducted from 2007 to 2012 showed that 15,178 exposure cases, 272 fatal cases with more than 88% of the exposure cases were due to dog bites [15]. Most of the exposed cases (59.2%) were males. The majority of the exposure cases (98.9%) were from Addis Ababa, Oromia, Amhara, SNNPR, and Tigray regions. But now a days, in Ethiopia, approximately 97,000 people are exposed to rabies annually and approximately 3,000 deaths [18]. Despite this information, bite cases were not reported to the concerned body. Especially most of the rural communities should not go to health center after exposed to any bite; instead, they would go to traditional healers. Despite this information, no reliable data are available on the annual number of people exposed to rabies. Lack of reliable data on the real prevalence of dog bite and its associated risk factors of human rabies exposure is a critical challenge for the formulation of policies and strategies to control rabies. The aim of the study, therefore, is to estimate incidence of rabies exposure, identify associated risk factors and access to post exposure prophylaxis in humans in North West Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

Amhara region is located between 8°45'N and 13°45' N latitude and 35° 46' and 40° 25' E longitude with about 170,000 square kilometers land area in northwestern part of Ethiopia [19]. The region is known by diversified topography, climatic condition, agroecology and animal population. Regarding the climatic condition of Amhara region, 31% of the region with the altitude of 1500 m.a.s.l. is categorized as Kola (hot zone) 44% of the region with the altitude of 1500-2500 m.a.s.l is classified as Woyina Dega (warm zone) and 25% with elevation of 2500-4620 m.a.s.l is classified as Dega (cold zone) [20]. The mean annual temperature of the region is between 15 °C and 21 °C, while in the valleys and marginal areas the temperature exceeds 27 °C. Relatively high temperatures are observed at some valleys and marginal areas exhibiting arid climates. There are two distinct seasons, a short rainy season lasting three to four months and a long dry season of eight to nine months [21].

The total human population of the region is estimated around 22,877,365 of which about 88% is rural, while 12% are urban dwellers. The region is divided into 11 zones, and 167 districts with about 3,429 kebeles [19]. The study area has a total estimated human population of 5,464,079 and total livestock population of 5,474,545 cattle; 2,484,400 sheep; 2,461,942 goats; 44,860 horses, 847,780 donkeys and 6,609 dogs [22]. The current study was conducted in four zones of Gondar. From these zones we selected seven districts (East Dembia and Tach Armachiho from Central Gondar, Genda wuha and Metema from West Gondar, Fogera and Debre Tabor from South Gondar and Debark from North Gondar zones) of Amhara region, northwest Ethiopia (Figure 1).

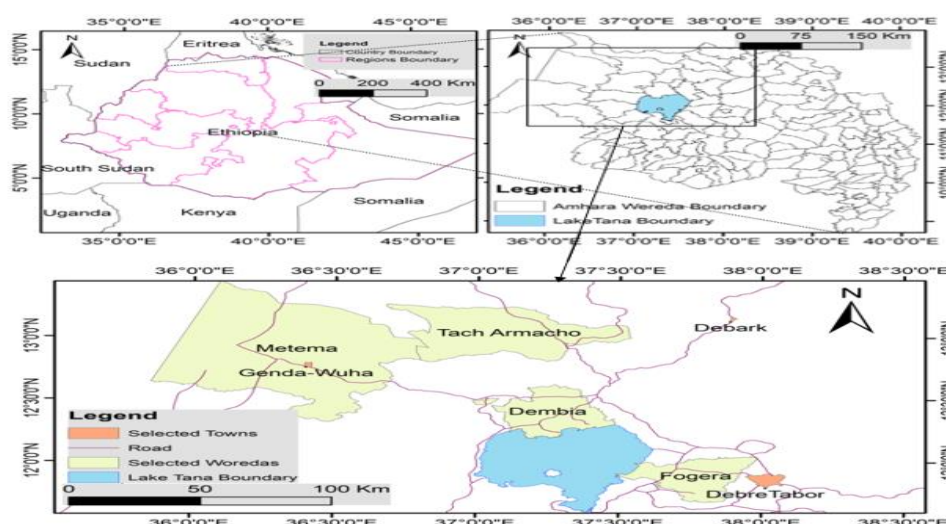


Figure 1. Map of study area.

2.2. Study Population

The study populations were total human populations in the Central, West, North, and South Gondar zones of the Amhara region, northwest Ethiopia. Due to lack of proper food access, most owned dogs are free-roaming. In Ethiopia, this free-roaming of dogs together with lack of regulations on dog breeding contributes to the presence of large number of stray dogs. These uncontrolled dog populations are reservoirs and transmitters of many zoonotic diseases, including rabies and could serve as an infection risk for livestock and humans. Ethiopia's urbanization rate is increasing rapidly and leading to increasing dog-human contact. These free-roaming dogs contribute to several public health concerns [23,24].

2.3. Sampling Methods

Three stage cluster sampling technique was used to select sampling units. First the four zones of Gondar were selected purposively because rabies is common in these zones. Then districts or towns that we think are representative of the zones were selected: East Dembia and Tach Armachiho from Central, Debarke from North, Metema and Genda-wuha from West and Debre Tabor and Fogera from South Gondar zones. Finally, four kebeles were randomly selected from each district making a total of 28 kebeles.

2.4. Design of the Questionnaire and Data Collection

A survey questionnaire was developed using the literature and our own experience. The questionnaire aimed to collect data on the occurrence and/or exposure of rabies, associated risk factors for exposure, and about post exposure treatment in the human population. The questions in the questionnaire had three categories. Questions asking demography of participants: such as age, gender, religion, educational level, family size; questions addressing knowledge and management of dogs related to rabies such as knowledge of rabies infection, rabies vaccination history, awareness of post-exposure vaccination, and understanding of the rabies virus (disease awareness, transmission to humans, and dog symptoms) and questions addressing previous dog bite exposure. The original questionnaire was prepared in English and then it was later translated into the local language (Amharic). The translated questionnaires were then back-translated into English to check consistency. The English version of the questionnaire is attached as supplementary file (Supplementary file 1). The final questionnaire was administered by face-to-face interviews. Data was collected by asking respondents whether they had rabies exposure in one or more of their family members in the last two years.

Table 1. Variables potentially associated to rabies exposure in North-wet Ethiopia.

Variable	Levels
Do you know rabies existence?	No/Yes
Do you know rabies affects human?	No/Yes
Do you know way of transmission of rabies?	No/Yes
Do you have a dog(s)?	No/Yes
Do you know dog as a predisposing risk factor of rabies?	No/Yes
Do you believe traditional medicine can treat rabies?	No/Yes
Do you vaccinate your dog against rabies?	No/Yes
Do you perceive rabies as severe/fatal?	No/Yes
Do you or member of family ever bitten by rabid animal	No/Yes
What was the species of the animal that bite you or your family?	Dog/cat/Equines/wild carnivore.
Do you wash the bite wound	No/Yes
Do you know presence of post exposure prophylaxis (PEP)?	No/Yes
Do you or your family ever take PEP	No/Yes
Do your dog contact with other dogs frequently	No/Yes
Do you castrate your dog (s)	No/Yes
Is there any wild carnivore nearby your area?	No/Yes

2.5. Sample Size Determination

Multistage cluster sampling was used to select study participants. The sample size was determined using sample size estimation formula for random sampling in infinite population from Thrusfield [25].

$$.n = 1.96^2 * \frac{p*(1-p)*D}{d^2}$$

Where:

n= number of the household

P =Proportion of the population taken as 50% since it is unknown in the study area

d²= Desired level of precision (margin of error) taken as 5%

D= design effect

Based on these assumptions, a sample of 385 households was required. However, the actual sampling method used was multistage cluster sampling. Therefore, the sample size was adjusted using the following formula $D = 1 + (b - 1)ICC$.

Where:

b= the number of household response at least one from the cluster

ICC= Intra correlation coefficient

D =design effect

Design effect (D) accounts for loss of precision in cluster surveys. It's calculated using the predetermined cluster size (28 kebeles) and the number of households selected per cluster; i. e. 23. In multistage cluster surveys, ICC reflects variability across all sampling stages. We used an ICC value of around 0.03 [26]. Considering these factors, the design effect for this sample size determination was calculated to be 1.67. This resulted in a final estimated sample size of 642 households.

2.6. Data Analysis

The data were entered into Microsoft Excel. Completeness of the data was checked, followed by calculations of descriptive statistics such as percentages and rates. Risk factor analysis was conducted using binary logistic regression models. A univariable analysis was performed first, followed by pairwise correlation for variables significantly associated in the univariable analysis. **Multivariable logistic regression models were then performed to identify factors associated with rabies exposure.** Model building considered variables that were statistically significant (p < 0.05) in the univariable analysis. Any variables with a p-value ≤ 0.05 were considered significant in the final

model. **The Hosmer-Lemeshow test was used to assess the model's goodness-of-fit.** This test evaluated the overall fit of the final logistic regression model. **The presence of confounding was checked by adding one variable at a time in the model building process.** Presence of interactions was checked for variables remained in the final model. Findings were presented with odds ratios (ORs), 95% confidence intervals (CIs), and p-values. **Stata release 17 (Stata Corp LP, USA) was used for the statistical analysis**

3. Results

3.1. Respondents’ Awareness and Management Of Rabies

A total of 642 respondents were interviewed in the survey. Majorities (94% to 99%) of respondents’ aware rabies exists, is a zoonotic disease, and one or more transmission methods of rabies. However, only a small proportion of them implement control measures such as vaccinating their dogs (41%) and taking PEP (23%). Table 2 summarizes demography of respondents’ and their awareness and management of rabies.

Table 2. Demography of respondents’ and their awareness and management of rabies in North-Western Ethiopia.

Variables		Number of respondents	Proportion in %
Zone	West Gondar	231	35.98
	Central Gondar	191	29.75
	South Gondar	166	25.86
	North Gondar	54	8.41
	Metema	159	24.76
	Debre tabor	73	11.37
District	East Dembia	138	21.50
	Fogera	93	15.42
	Genda wuha	72	81.94
	Debark	54	8.41
	Tach Armachiho	53	8.26
Sex of respondents	Male	467	72.74
	Female	175	27.26
Family size	1-3 family	107	16.67
	≤6 persons	293	45.63
	≥7 persons	242	37.69
Level of education	Non educated	280	43.61
	Basic	215	33.49
	Secondary	83	12.93
	Tertiary	64	9.97
Dog ownership	Owner	497	77.41
	Non dog owner	145	22.39
Knowledge rabies exists	Yes	635	98.44
	No	7	1.56
Knowledge rabies is zoonotic	Yes	640	99.69
	No	2	0.31
Know transmission of rabies	Yes	603	93.93
	No	39	6.07
Presence of dog in the house is a factor for rabies exposure	Yes	598	93.15
	No	44	6.85

Knowledge of ways of rabies transmission	Bite and saliva	574	89.41
	Salva only	47	7.32
	Other methods	21	3.27
Treatment by traditional healer	Treated	515	80.22
	Not treated	127	19.78
Vaccinating dogs in the last two years	Vaccinate	265	41.28
	No vaccinate	377	58.72
Rabies killer disease	Yes	634	98.75
	No	8	1.25
Washing bite wounds	Yes	236	87.73
	No	33	12.27
Knowledge of PEP	Yes	338	52.65
	No	304	47.35
Experience of taking PEP	Yes	59	21.93
	No	210	78.07
Own dog contact with other dogs	Yes	292	58.75
	No	205	41.15
Castrating/spaying dog(s)	yes	622	96.88
	No	20	3.12
Presence of wild carnivore nearby	yes	394	61.37
	No	248	38.63

3.2 Prevalence of Rabies Exposure and Associated Risk Factors

The incidence of rabies exposure was 10.47%. Rabies exposure had shown large variability between districts, zones, respondents’ level of education and family size, and between respondents who owned and didn’t own dogs. The level of rabies exposure is illustrated in Table 3.

Table 3. Number of rabies exposure among the study districts, zones and group of respondents in North-Western Ethiopia.

Variables	Levels	Number of respondents HHs	No of rabies exposed individuals	Percentage of rabies exposure	P -value
Zone	West Gondar	231	135	50.19	0.001
	Central Gondar	191	66	24.53	
	South Gondar	166	44	16.36	
	North Gondar	54	24	8.92	
	Metema	159	93	58.49	
District	Genda wuha	72	42	58.33	0.001
	Tach Armachiho	53	26	49.06	
	Debark	54	24	44.44	

	Fogera	93	33	35.48	
	East Dembia	138	40	28.99	
	Debre tabor	73	11	15.07	
Sex	Male	467	197	42.18	0.812
	Female	175	72	41.14	
Family Size	>6	242	117	48.35	0.036
	4-6	293	120	40.96	
	0-3	107	32	29.91	
Level of Education	No education	215	109	50.70	0.001
	Basic	280	118	42.14	
	Secondary	83	24	28.92	
	Tertiary	64	18	28.13	
	owner	497	193	71.75	
Dog ownership	Non dog owner	145	76	28.25	0.004
	Yes	377	96	35.69	
Vaccination history	No	265	173	64.31	0.015
	<1 day	553	217	39.24	
Distance from Hospital/ Health center	1-2days	55	37	62.27	0.000
	>2days	34	15	44.12	
	yes	292	133	68.91	0.000
Dogs free contact with others	No	205	60	31.09	
Presence of wildlife near to his/her area	yes	248	93	34.57	0.073
	No	394	176	65.43	
Presence of Forest near to the residence	yes	209	80	29.74	0.196
	No	433	189	70.26	
Presence of high road access	Yes	502	214	79.55	0.478
	No	140	55	20.45	

HHs = Households.

3.3. Sources of Rabies Exposure

The result showed that 87.73% of the victims were bitten by dog and 11.52% were bitten by equines (donkeys). In the case of ownership of the source animals, 48.70% were exposed by their own animals (dogs and donkeys), while 26.39% were exposed by stary dogs, the rest 24.91% were exposed by neighbors’ animals. Measures taken by respondents after rabies exposure 42.37 % of 269 victims washed the wound using plain water, 36.02% washed using water and soap, 12.29% apply other materials (antiseptics, benzene, kerosene, etc.) and 9.32% apply holy water (Table 4).

Table 4. source of exposure and measure of the respondents after bite(exposure).

Variables		Frequency	Percentage
Species of bitten animals	Dog	236	87.73
	Equine	31	11.52
	Cat	1	0.37
Ownership of bite animals	Own	131	48.70

Wound Washing materials	Stray	71	26.39
	Neighbors	67	24.91
	Water only	100	42.37
	Water and Soap	85	36.02
	Other material	29	12.29
	Holy water	22	9.32

3.4. Risk Factors Associated with Rabies Exposure

Twelve variables were tested for statistical association with rabies exposure. Nine of them were statistically significantly associated ($P<0.05$) with rabies exposure. Variables high educational background, being female and vaccinate their dogs reduce rabies exposure while high family size, free contact of the dog, presence of dog in the house and low level of education increased rabies exposure. The detail of univariable associations of rabies exposure and risk factors are summarized in Table 5.

Table 5. Univariable logistic regression analyses summarizing associations ($P<0.05$) between potential risk factors and rabies exposure.

Variables		Labels	OR	P- value	95% CI
District		Debre Tabor	Ref.		
		Metema	7.94	0.0001	3.89-16.23
		Genda Wuha	7.89	0.0001	3.57-17.46
		Tach Armachiho	5.43	0.0001	2.35-12.54
		Debark	4.50	0.0001	1.95-10.41
		Fogera	3.1	0.004	1.44-6.69
		East Dembia	2.30	0.027	1.10-4.82
Sex		Male	Ref.		
		Female	0.96	0.812	0.67-1.36
Family size		1-3 family	Ref.		
		7 and above	1.93	0.009	1.18-3.16
		4-6 Family	1.36	0.210	0.84-2.20
Education level		Non educated	Ref		
		Basic	0.71	0.059	0.50-1.01
		Secondary	0.40	0.001	0.23-0.68
		Tertiary	0..38	0.002	0.21-0.69
Dog ownership		Dog owner	Ref.		
		Non dog owner	0.58	0.004	0.397-0.84
Presence of wildlife nearby		yes	Ref		
		No	0.714	0.041	0.51-0.99
Free contact of dog		Yes	Ref		
		No	2.07	0.0001	1.42- 3.03
Forest Availability		Yes	Ref.		
		No	0.80	0.197	0.57-1.12
Vaccination history		yes	Ref.		
		No	0.67	0.015	0.49-0.92
Distance from Hospital/health center		< one day	Ref.		
		1-2day	3.18	0.000	1.77-5.73
		>2days	1.22	0.573	0.61-2.46
Have you ever castrated your dog/s		No	Ref.		
		Yes	0.24	0.022	0.07-0.81

Presence of high road access	Yes			
	Ref			
	No	1.15	0.478	0.78-1.68

OR= odd ratio, CI= confidence interval .

3.5. Multivariate Logistic Regression Model for Risk Association of Rabies Exposure

Stepwise multivariate logistic regression model of rabies exposure removes the variables which were not statistically significant ($p > 0.05$). The multivariable regression analysis demonstrated that the variables ‘district difference,’ ‘family size’ and ‘dog ownership’ and were strongly associated with rabies exposure in human. In the final logistic regression model analysis only three was significant ($P < 0.05$) from twelve variable i.e., residence(districts) family size, and dog ownership were all significantly associated with exposure of rabies in human. The logistic regression model exhibited a good overall fit (Hosmer and Lemeshow Chi-square value 43.76, $P = 0.064$) (Table 6).

Table. 6. Multivariate logistic regression model for risk association of rabies exposure and variables.

Variables		Odds ratio	P- value	95% CI
Districts	Debre Tabor		Ref	
	Debark	4.293	0.001	1.819-10.129
	Fogera	2.507	0.024	1.129-5.568
	Genda wuha	7.676	0.000	3.402-17.321
	East Dembia	2.146	0.052	0.994-4.631
	Metema	7.121	0.000	3.449-14.705
	Tach Armachiho	4.774	0.000	2.041-11.168
Family size	1-3 families		Ref	
	4-6 family	1.577	0.083	0.942-2.639
	7 and above	2.225	0.003	1.301-3.805
Dog ownership	Dog owner		Ref	
	Non dog owner	0.59	0.014	0.388- 0.898
	cons	0.173	0.000	0.078- 0.383

CI= Confidence interval.

4. Discussion

In this study, a number of factors associated with dog bites and risky behavior were investigated in conjunction with assessing the interviewee's knowledge about safe dog interaction. Regarding the interviewee's, more than 98% of the respondents very well knew the rabies disease, 99.69% answered that rabies is a zoonotic disease and 94% knew the transmission method of rabies. The result was supported by the previous study of Ntampaka et al. [27] They stated that 85% of the respondents were very well knew the rabies how rabies can be transmitted between dogs and other animals (bites, licking of wounds and skin scratches). Bahiru et al [28] stated that 98.4% of the respondents had a good understanding of the transmission of rabies. In this study more than 93% of the respondents answered that the presence of a dog in the house is one of the factors contributing to the rabies infection. Similar results were reported in Tanzania [29]. They were reported, most suspected rabies exposures were due to domestic animals (89%), particularly dogs. Eighty-point twenty-two percent of the respondents believed traditional medicaments could treat rabies, whereas the rest, 19.88%, did not believe traditional drugs could treat rabies or didn't knew about traditional medicine. Regarding the vaccination history, 41.28% of the households answered that they had vaccinated their dogs, while 58.72% of the respondents had no idea about the vaccine or not vaccinated due to lack of vaccine near to their area. In this study, 21.93% of exposed people were took PEP after exposure,

while 78.07% were either treated by a traditional healer or left as it is. This result is also similar to previous reports from different parts of Ethiopia [16,30]. Underreporting of rabies exposure in Ethiopia primarily occurs due to the deep-relationship of the traditional practice of treating rabies by healers, which as such interferes with assessing the real magnitude of the disease [30]. The other authors also found that about half of the bite victims they were contacted in rural areas did not report to health centers but visited traditional or spiritual healers [6]. This showed that lack of awareness or limited knowledge about PEP and low accessibility of the PEP may be one of the factors contributing to the low number of people using PEP. In addition to low awareness, economic background was also one of the bottleneck factors, especially for rural victims [3,31].

More than 58% of dog owners were releasing their dogs freely in day and night time while the rest were kept in door or release night time. This were had a chance to contact with any dog, as well as wild carnivores. This showed that more susceptible dogs were freely contacted by infected stary dogs. Therefore, roaming dogs provide ideal for transmission of the rabies virus between dogs and to other species [32,33]. In the current study, 3.12% of dog owners answered that they castrated or spayed their dogs. The result showed that one of the failures of WHO strategies [33] was that birth controls were adopted as one of the strategies for reducing and controlling rabies. Therefore, movement control and birth control are the main strategies to reduce rabies [31,34].

Regarding dog ownership, 77.41% of the interviewees had one or more dogs in their house. The results indicated that the relationship dog - human connection is stronger in the area. Out of this number, 71.91% of them had one or more rabies exposures. Due to this, the author stated that if there is a stronger attachment, the chance of getting bitten by rabid animals (bitten by dogs) might be higher when compared to non-dog owners. This is why the results revealed that 48.70% of the exposures were caused by their own dogs. The likelihood of being bitten by a family dog among dog - owners was higher than among children who reported not having no dogs in their household. Naturally, children with dogs in their household are more exposed to dogs, so the chances of getting bitten dramatically increase [35].

In this study, the prevalence of rabies exposure was 10.47%. The results were recorded as rabies exposure (either the household owner or his or her families were exposed) to rabid animals for the past two years. This result is almost similar to the previous results of [18] (10.1%) and Jemberu et al. [37] (12.1%) in different parts of Ethiopia [38]. In terms of zonal distribution, the west Gondar zone was the first exposed (50.19%) area in the current study, and the result showed a statistically highly significant ($P < 0.001$) difference among the zones. This might be due to the way of living together, the clustered settlement of villagers, and the attachment of the farmer with a dog to have close connections, resulting in the rapid spread and persistence of infection in the area. About the district distribution of victims, the highest records were found to be at Metema (58.49%), Genda wuha (58.33%), and Tach Armachiho (49.07%), respectively, whereas the lowest were recorded in Debre Tabor town (15.07%). This result showed that more exposure was found in districts or towns that were away from the center. This may be due to a lack of an enough amount of vaccine or because it is unavailable because of its distance from the vaccine center. Even though dog-human attachments are close to this area, dogs are important when farmers go to the farming area for ploughing and seeking pasture for their animals to use as guards from wild predators [38]. But, during data collection, we observed free-roaming dogs in the area because most of the respondents could not feed their dogs; so, dogs move freely to find their feed. So, free-roaming dogs may be provided with opportunities for infected dogs to transmit the virus to susceptible dogs and then to humans. Previously, the authors stated that the movement of free-roaming dogs may have been responsible for the spread of the disease and spillover infection to the community [31,39].

In terms of sex, males were exposed more than females' respondents. Similar results were stated for males (54%) and females (46%) [40]. Regarding family size (i.e., more household members), they were affected or exposed more. However, respondents who have fewer family members were recorded as having fewer victims than those with more family members. The result shows a statistically significant difference ($p < 0.05$) among family size groups. These results showed that if more family is found in the house, it is true that more children may be found. Salomão et al. [10]

stated that if more children were found in the house, it might have been a high risk for bites [41] and the presence of children in a household increased the probability of a dog bite incident [42]. In the case of educational background, non-educated interviewees were more victims (50.70%), either themselves or their families, than educated ones. The results were statistically highly significant ($p < 0.001$) among the educational background groups. This result showed that there may be an awareness difference between the groups because most educated people are taking care of their free-roaming dogs, or they may be vaccinating their dogs regularly. Non-educated people lived in rural areas, which might indicate the presence of a possible intimate relationship between farmers and their dogs. In addition to living behavior, there was also an awareness difference between educated and non-educated persons about rabies risk [3,43]. This finding was also similar to other scholar reports that stated that the rural and urban communities have different awareness about rabies. Rural areas far from the treatment centers could potentially have a higher incidence of rabies-associated death, which may increase their level of awareness and is additionally worthy of consideration. Voupawoe et al. [44] stated that the majority occur in rural communities in Asia (60%) and Africa (36%).

Similarly, in relation to dog ownership, 71.75% of the victims were dog owners, while 28.25% were non-dog owners. The results showed a statistically significant ($p < 0.01$) difference between dog owners and non-dog owners. Evangelio et al. [40] who stated the biting incidence involved with owned dogs was 98.1%, and the remaining 1.9% involved stray dogs. Seligsohn et al. [34] also stated that a majority of the children (55.9%) had been bitten by a family dog, 42.7% had been bitten by a stray dog, and the remaining 1.5% reported they had been bitten by both a family dog and a stray dog [44].

In terms of the source of the infection, 87.73% of the victims were bitten by dogs and 11.52% by equines (donkeys). The result was similar to that of Shwiff et al. [45], who reported that canine rabies is the biggest source of both human and livestock infections in the developing countries of Asia, Latin America and Africa [46]. It was also agreed with the past report in Asia and Africa, where dogs are responsible for 85%–95% bites [47–49]. In the case of ownership of the source animals, 48.70% were bitten by their own animals, while 26.39% were stray dogs, and the rest, 24.91%, by the neighbor dogs. This result is supported by Seligsohn [35] in Tamil Nadu, India. The likelihood of being bitten by a family dog among dog owners was higher than among those who have no dogs in their household. Regarding the immediate action to be taken after a bite, if they suspected it to be rabid, respondents had different practices, of this 42.37% of victims used plain water to wash the wound, 36.02% washed using water and soap, 12.29% used to pour other materials (antiseptics, benzene, kerosene, etc.), and 9.32% poured holy water. This type of practice was also performed in Namibia, Omusati region [50], where they stated that 41% of the respondents carried out good practices such as washing the wound with soap and water before seeking medical attention after the bite.

In this study, 98.19% of dog owners used dogs as a guard. The result supported by Kanutus et al., [50] is that 95% of the respondents keep dogs as guards. According to the feeding and keeping system of the dog owner information, 52.53% of dog owners were not tie their dogs totally, whereas 47.47% tied their dogs either at night or daytime only. In relation to the feeding system, 59.76% of dog owners were giving feed, and 38.63% of dogs were getting feed from both the roaming and hand feeding systems. These might aid to acquire infection such as rabies when they roam around to search feed and facilitate disease transmission. Tintinalli and Stapczynski, [51] stated that stray dogs account for about 99% of dog transmitted rabies in countries where dogs are the main mode of rabies transmission [52].

The univariable logistic regression showed that people who lived in Matema district were more likely to get sick (OR = 7.94, 95% CI= 3.89-16.23) (Table 5). According to this result, residence distance from the center was one of the risk factors for getting more victims than nearby districts. It may have been that the relationship between dogs and humans and the number of dog populations in the area were the main factors. This indicated that increased incidences due to dog population densities and the absence of a sustained vaccination program resulted in the maintenance of rabies endemicity in the area, as we observed [53]. Based on sex differences, women had a relatively lower risk than men. But the odd ratio was not significant (OR = 0.96, 95% CI= 0.673-1.363 at $p > 0.05$). As for educational

status, there was a statistically significant difference among educational groups. Tertiary level showed (62%) less risk than Secondary level ($p < 0.01$, 95% CI= 0.21-0.70), whereas secondary had (60%) less risk than basic and non-Educated one at ($p < 0.001$, 95% CI= 0.23-0.68). This might be due to having better awareness of the educated person (as the level of education increases, levels of awareness also increase) than the non-educated. The results were in line with Yalmebrat et al. [54] who stated that 51.1% of the illiterates, 69.0% secondary school preparatory students, and 91.3% of the Diploma and above education level students had good knowledge in a study conducted in the Debark district of North Gondar, Ethiopia. Hence, if the level of education is increased, the risk of being affected by rabies may decrease. Because educated people would have better access to information and could easily understand the disease and protected himself from stay dog as well as unnecessary contact of unvaccinated dogs [54,55].

In relation to dog ownership, the presence of dogs in the house was 58% more risky than a household living without dogs. The possible explanation could be that dog owners have more attachment to their dogs, children with greater possibility. In the current study about the number of households, if they had more family members. Households having more than 7 members were found to be at greater risk than households having 4-6 family members than households that had less than 3 family members (Table 4). This may be due to the presence of more children in the house. Increased dog bite incidents in children are considered behavioral risk because of their extreme curiosity, lack of inhibition, limited knowledge and experience about dog behavior, and inability to protect themselves from an attack [56,57,31].

In multivariate logistic regression of rabies exposure, the variables were not statistically significant ($p > 0.05$). The multivariable regression analysis demonstrated that the variables 'district', 'family size', 'educational status', 'dog ownership,' and 'free contact with the dog' were strongly associated with rabies exposure in humans. The final logistic regression analysis showed that residence (districts) (OR = 7.676, $p < 0.001$), family size (OR=2.225, $p < 0.001$), and dog ownership (OR = 0.591, $p < 0.05$) were associated with exposure to rabies in humans. (Table 6). The model showed that the presence of more family in the house and the presence of a dog in house had a strong association with rabies exposure. These show that the presence of more family in the house means the presence of more children in the house. This indicates an increase in rabies exposure in humans because children's (especially those less than 15 years old) are more exposed to rabies than adults and olds [58]. Evangelio et al. [40] Stated that they observed in the data that the percentage of severe rabies exposure is highest in the age group 5–15-years. In the case of dog ownership, most of exposed people were bite by their own dogs because of their close attachments of their own dogs. In multivariate logistic regression, people living away from the center districts had a strong association with rabies exposure. People living away from the center access to healthcare services may be limited. This can result in delays in receiving post-exposure prophylaxis (PEP) after a potential rabies exposure, increasing the risk of developing the disease. Remote regions may have less effective animal control measures, leading to higher populations of stray or unvaccinated domestic animals. These animals can also transmit rabies to humans.

5. Conclusion and Recommendations

In conclusion, this study has provided important information about rabies distribution, risk factors and practice of human in north west Ethiopia. The current study indicates rabies is still the basic human killer disease in the area. The study also showed that most of the border area was recorded more exposure. Finally, the residence difference, low level of educational background, presence of high number of households, free movement of the domestic dogs and being dog owners was the main risk factor for rabies exposure. In general, this study showed that rabies was an important zoonotic disease in the area and needs special public health attention. According the data of surveillance showed that communities who living in the study area still they tilted to the traditional medicaments than post exposure prophylaxis. Overall, while rabies is a global concern, its impact can be more pronounced in remote areas due to the interplay of wildlife interactions, healthcare accessibility, and community practices. Public health efforts in these regions often focus on

vaccination programs for pets, education about rabies prevention, and improving access to medical care.

Regarding, the above conclusion, we recommended the following suggestion for further studying as well as prevention of rabies.

Public educational programs on dog behavior, dog-child interaction, and the importance of responsible dog ownership, especially reduction of free contact of the dogs.

Teaching the communities about the importance of the vaccine and raising awareness about dog vaccination and improving access and affordability of the vaccine should be considered in control of the disease as dogs are the main reservoir of the disease.

Both the local government and the federal government take action for the availability of the dog vaccine for the especially inaccessible districts.

The disease is still continuing high communities' hazard in the study area; therefore, rabies needs continuous surveillance of dog bites to detect trends and evaluate the effect of prevention efforts.

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Informed Consent: Informed verbal consent was obtained from the respondents before the start of the interview. All the respondents were approached verbally and agreed to participate in the interview without any payment. Data were analyzed and reported anonymously (agreement written in the beginning of the questionnaire. We were proceed after the participant gave permission)

Data Sharing Statement: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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