ORIGINAL ARTICLE

Determinants of health seeking behaviour following rabies exposure in Ethiopia

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Summary

The objective of this study was to identify factors that determine medical treatment seeking behaviour following potential rabies exposure after being bitten by a suspected dog and the likelihood of compliance to receive sufficient doses of post-exposure prophylaxis after the visit to a health centre visit. A detailed survey based on case investigation was conducted on suspected rabid dog bite cases in three areas of Ethiopia. Two multivariable logistic regression models were created with a set of putative variables to explain treatment seeking and compliance outcomes. Based on the registered bite cases at each health centre and the set of unregistered bite cases derived by contact tracing, 655 bite victim cases were identified to have occurred between September 2013 and August 2014. Of these evaluated bite incidences, 465 cases were considered to have been caused by a potentially rabid dog. About 77% of these suspected rabid dog bite victims visited a health centre, while 57% received sufficient doses of PEP. The overall likelihood of seeking medical services following rabies exposure was higher for people bitten by dogs of unknown ownership, where the bite was severe, being bitten on the leg, spend of more than 100 USD per month and where the victim lived close to the nearest health centre, while the likelihood of receiving sufficient doses of PEP was sensitive to monthly spending and distance to health centre. However, the evaluated factors did only explain a part of the variation among the three districts. The district in which victims lived appeared to have a relevant influence on the likelihood of seeking medical treatment but did not improve the prediction on the likelihood of treatment compliance. Given the insights obtained from this study, improvements in the rural districts with regard to accessibility of post-exposure prophylaxis delivering health centres in shorter distance could improve health seeking behaviour. In addition, in rural districts, majority of exposed persons who seek medical treatment tend to comply with treatment regimen, indicating that the promotion of medical treatment through awareness creation campaigns could be beneficial.

KEYWORDS

Ethiopia, health seeking behaviour, post-exposure treatment, rabies

1 | INTRODUCTION

Rabies is considered to be one of these neglected tropical diseases, caused by a virus that affects all mammals including human beings (Garg, 2014). Domestic dogs serve as a reservoir and cause around 99% of all human deaths from rabies (WHO, 2013), while bats and wildlife contribute the remainder (Franka et al., 2013; WHO, 2005). Despite being a vaccine-preventable disease, rabies is still a significant public health problem in many developing countries within Asia and Africa (Sugiyama & Ito, 2007; WHO, 2013). Globally, canine rabies causes around 60,000 human deaths, over 3.7 million disability-adjusted life years (DALYs) and 8.6 billion USD economic losses annually. About 75% of these economic losses are due to premature death and costs associated with health seeking treatment (Hampson et al., 2015).

Once exposed by a bite from a rabid animal, human rabies can only be prevented through prompt post-exposure treatment, which includes wound washing, administration of an antibiotic, tetanus antitoxin (in severe bites) and active post-exposure prophylaxis (PEP) vaccine (Hemachudha, Laothamatas, & Rupprecht, 2002; WHO, 2013). Otherwise, rabies is invariably a fatal disease once clinical signs are manifested. This means that urgent post-exposure treatment with prophylaxis is needed to reduce the likelihood of human mortality (Hemachudha et al., 2013).

In Ethiopia, in a selected urban district, a rural highland district and a rural lowland district, the annual rabid dog exposures were estimated to be 135, 101 and 86 bites per 100,000 inhabitants, respectively (Beyene, Kidane, Mourits, & Hogeveen, 2017). That study revealed that 71% of bite victims reported to health centres seeking medical service upon exposure, while only 57% of the bite victims received sufficient doses of PEP. At the district levels, 97%, 64% and 66% of the victims reported to health centres seeking medical treatment, while 78%, 50% and 29% received sufficient doses of PEP in urban, rural highland and rural lowland districts, respectively. In Ethiopia, a complete PEP treatment consists of 17 doses of a nervous tissue vaccine, administered consecutively during the first 14 days after exposure, with the remaining three doses being given at intervals of 10 days, that is at day 24, 34 and 44.

Most of the studies concerning rabies in Ethiopia have focused on levels of public awareness, attitudes and practices in cases of rabies exposure (Digafe, Kifelew, & Mechesso, 2015; G/hiwot et al., 2016; Jemberu, Molla, Almaw, & Alemu, 2013; Kabeta, Deresa, Tigre, Ward, & Mor, 2015; Ramos et al., 2015; Teklu, Hailu, & Eshetu, 2017; Yibrah & Damtie, 2015). None of these studies specifically identified factors which explain the medical treatment seeking behaviour or the likelihood of receiving sufficient treatment doses among affected individuals. Understanding these factors is essential to support decisions in mitigating the hindrances to seek medical treatment that otherwise could lead to an increased burden of rabies.

The decision to engage with medical channels following exposure or illness is influenced by a variety of geographical, social, economic, cultural and organizational factors (Tipping & Segall, 1995).

Impacts

- The likelihood of seeking medical care following rabies exposure was higher in people bitten by dogs of unknown ownership, in those who received severe bites particularly on the leg, and lived only a short distance from the nearest health centre.

- Subsequent to a person who has been exposed to rabies making a visit to a health centre to seek medical treatment, the shorter the distance to the nearest health centre and the higher their income, the more likely they are to comply with the treatment regimen.

- Given the insights obtained from this study, policy directions that favour increasing accessibility to health centres delivering post-exposure services could improve health seeking behaviour in patients exposed to rabies.

Relevant factors described in the literature include age (Chibwana, Mathanga, Chinkhumba, & Campbell, 2009), gender and education level (Mwangome, Prentice, Plugge, & Nweneka, 2010), cultural beliefs and religion (Feyisetan, Asa, & Ebigbola, 1997), fate of person and of animal responsible for transmitting the disease (Tepsumethanon, Wilde, & Meslin, 2005). Specific to rabies, the severity of bite and the body part bitten has been shown to affect the likelihood of rabies disease development (Knobel et al., 2005). Source of income and knowledge about the vaccination status of the biting dog has also been described as factors influencing an individual's decision to seek medical treatment upon rabies exposure (Sambo et al., 2013). Anthropological studies have also shown that medical treatment seeking behaviours within communities in developing countries depend on the accessibility of health facilities (Bichmann, Diesfeld, Agboton, Gbaguidi, & SimshÄUser, 1991; Kroeger, 1983; Shaikh & Hatcher, 2004). Yet, there is not much knowledge about health seeking behaviour after dog bites in Ethiopia and about the differences between rural and urban areas.

The objective of this study was to identify factors that determine the likelihood of seeking medical treatment behaviour at a health centre following rabies exposure and the likelihood of compliance to the required PEP treatments in different districts in Ethiopia.

2 | MATERIAL AND METHODS

2.1 | Study design

An extensive survey based upon case investigation was conducted. Suspected rabid animal bite cases were identified in three districts of Ethiopia, namely Bishoftu, Lemuna-bilbilo and Yabelo. These districts represent urban, rural highland and rural lowland areas with populations of 140,039, 187,222 and 100,737 inhabitants,

respectively (CSA, 2013). Bishoftu is an urban district 45 km southeast of Addis Ababa, the capital of Ethiopia. Lemuna-bilbilo is a rural district located in the central highlands of Ethiopia where most people adopt a mixed crop-livestock farming system. Yabelo is a district in the lowlands of the southern part of Ethiopia where the majority of people are pastoralists. In Ethiopia, each district has at least one health centre delivering human post-exposure prophylaxis services to individuals exposed to rabies. These districts are the same districts for which the burden of rabies in Ethiopia was reported in an earlier paper (Beyene et al., 2017).

Data on animal bite victims who visited health centres after being bitten by an animal in the period between September 2013 and August 2014 were collected from the records of health centres in the three districts. The list of bite cases collected from the health centres was then sorted into victim's village and given to local health extension workers. Local health extension workers practicing in each village of the districts were trained on techniques to carry out interviews using a structured questionnaire as well as in searching for cases that were not reported to health centres, using the contact tracing method described in our previous work (Beyene et al., 2017). A local health extension worker went to each victim's house, asked for and confirmed the victim's oral consent to participate in the study, and then interviewed them using the structured questionnaire. In cases where the victim was deceased or was a child, an adult family member was interviewed. The questionnaire was pre-tested with 30 bite victims, 10 in each of the three districts. Based on these pre-tests, the questionnaire was adjusted mainly for language and clarity.

The questionnaire contained sections on: (i) demographics (age, sex, educational level), adulthood (if someone is older than 15 years of age s/he was considered responsible for the decision to visit a health centre, otherwise she/he was assumed to be cared for by other family members) and religion of the victim; (ii) average monthly spending of the victim (as it was not possible to obtain a reliable estimate of monthly income, the monthly spend data were collected and used as a proxy (Uzochukwu & Onwujekwe, 2004)); (iii) characteristics of the bite in terms of severity (classified according to WHO categories for exposure, that is category I: contact of intact skin with secretions or excretions of a rabid animal or human, category II: nibbling of uncovered skin, minor scratches or abrasions without bleeding and category III: single or multiple transdermal bites or scratches, licks on broken skin, contamination of mucous membrane with saliva from licks (WHO, 2013)) and body part bitten; (iv) behavioural manifestations ownership, and fate of the biting animal; (v) linear distance to the nearest health centre that could deliver PEP, (vi) whether the victim sought medical or traditional treatment or none at all, and (vii) if medical treatment was sought, the number of PEP doses subsequently received. The health extension workers also asked the bite victims and their families whether they knew of anyone who had been bitten by an animal within their community but reported this to another health centre or went to a traditional/spiritual healer or did nothing. Subsequently, any potential victims identified in this manner were contacted and interviewed using the same structured questionnaire that was used in earlier work (Beyene et al., 2017).

2.2 | Statistical analyses

The 655 collected questionnaires were checked for completeness and then entered into Microsoft Excel. Of these 655 cases, 23 were due to bites from animals other than dogs. Because of their low number, these bite cases were excluded from further analyses. The behavioural manifestation and signs of the biting dogs as described by the bite victims were used to categorize each dog as potentially rabid or non-rabid, based on the "six-step" method of Tepsumethanon et al. (2005) which considers the dog's age, health state, clinical course of the illness, and occurrence of any neurological signs. Only bite cases by dogs fulfilling all six criteria were retained for further analyses, leaving in total 465 observations of exposures by suspected rabid dogs.

To explore factors that predict the likelihoods of "a health centre visit" and "receiving sufficient doses of PEP," two separate multivariable logistic regression models were built. In the first model, the outcome variable was defined as follows: a victim bitten by a suspected rabid dog either visited a health centre or did not. In the second model, the outcome variable was defined as: given that the victim visited a health centre, either she/he received the minimum required PEP doses or did not. A treatment consisting of at least 14 of the advised 17 PEP doses was considered to be "sufficient," while any treatment consisting of <14 doses was considered to be "insufficient," based on the minimum required number of doses to produce the neutralizing antibody level (Ayele et al., 2001; Piyasirisilp, Hemachudha, & Griffin, 1999; WHO, 1984).

An important question to explore is whether these general determinants are able to explain the observed differences among districts in terms of health seeking behaviour (Beyene et al., 2017) or whether some differences are caused by district-specific features. To evaluate each dependent variable, two models were created. The first was using a set of 11 independent predictor variables, namely age, sex, educational level, adulthood, religion, monthly spending, ownership of biting dog, the severity of dog bite, body part bitten, the fate of the dog after bite and distance of the village from the nearest health centre delivering PEP services. The second model was using the set of 11 aforementioned variables to which a district variable was added to account for additional/other district-specific features.

As a first step, the association between the candidate variables and the outcome variables was evaluated using univariable logistic regression. Any variable that had a p-value of <.20 in this univariable analysis was considered for inclusion in the multivariable logistic regression model. Next, the candidate variables were checked for collinearity by means of variance inflation factors (VIF). Multicollinearity was considered to be present if VIF > 10 (Dohoo, Martin, & Stryhn, 2003) for any pair. As all VIF values were <2.1, all candidate variables were explored during the multivariable logistic regression modelling process. The final models were built using backward stepwise elimination of those variables which had a p-value >.05.

The goodness of fit of the final multivariable logistic models was assessed using the Hosmer and Lemeshow test, where p-values

TABLE 1 Description and comparisons on types of treatment sought, and level of PEP treatment by district and overall

Variables	Bishoftu		Lemuna-bilbilo		Yabelo		Overall		p-Value
	N	%	n	%	n	%	N	%	
Potentially rabies exposure cases	189		189		87		465		
Treatment types									
Medical by health centre	183	96.8	120	63.5	57	65.5	360	77.4	<.01
Traditional	5	2.6	67	35.4	27	31.0	99	21.3	
Neither medical nor traditional	1	0.5	2	1.1	3	3.4	6	1.3	
Sufficient doses of PEP									
Insufficient	36	19.6	18	15.0	31	54.6	85	23.6	<.01
Sufficient	147	80.3	95	79.2	25	43.6	267	74.2	
NA	0	0.0	7	5.8	1	1.8	8	2.2	

NA, number of potentially rabies exposure cases for which we could not ascertain the number of doses of PEP received.

higher than .05 indicating no evidence of poor fit, while their predictive power was assessed by means of the pseudo-R^2 measure (McFadden, 1978). All statistical analyses were performed using the R software package, version 3.2.1 (R Core Team).

3 | RESULTS

3.1 | Rabies exposures

In total 655 victims bitten by animals between Sept 2013 and August 2014 were found and interviewed with 210 cases in the urban district (Bishoftu), 262 cases in the rural highland district (Lemuna-bilbilo), and 183 cases in the rural lowland district (Yabelo). We identified a total of 465 suspected rabid dog bite cases of which 189, 189 and 87 cases were from Bishoftu, Lemuna-bilbilo and Yabelo districts, respectively. Overall, of the 465 people bitten by a suspected rabid dog, 360 (77.4%) visited a health centre, while 267 (57.4%) of the exposed persons received sufficient doses of PEP. The proportions in terms of type of treatment sought and doses of PEP received differed across evaluated districts ($p < .01$) (Table 1).

3.2 | Characteristics of variables across rabid dog bite victims

Table 2 compares the socioeconomic, demographic, geographic and exposure-related factors between variables within districts and across districts. There was no statistical difference between proportions of categories across the three districts for the variables adulthood ($p = .20$), monthly spending ($p = .1$), body part bitten ($p = .79$) and mean age at exposure ($p = .67$). The mean age of the bite victims was 23 years (range: 1–85, median = 19 years). There were significantly higher bite cases in males (259/465) than in females (206/465) ($p < .05$), but female exposures tended to be higher than male exposures in Bishoftu district. The monthly spending was found to be significantly different across categories of spending within the same

district as well as across districts ($p < .01$). The highest bite rates were recorded on the leg/thigh (324), followed by hands/arm (88), trunk (27) and head/neck (26). The majority of the bites were single bites, although multiple bites of the hand or leg were recorded in 13.5% of the cases. The average distance to the nearest health centre delivering PEP was 15 km, while 2.5 (0.4–4) km, 18.4 (3–60) km and 35.7 (0.5–70) km were the averages for the urban, rural highland and rural lowland districts, respectively.

3.2.1 | Predictors of health seeking behaviour after suspected rabid dog bite

Of the total 465 suspected rabid dogs, 14 entries missed a value for the variable "Educational level" while another seven entries were missing data from the variable "Fate of the biting dog." Thus, the logistic model for the likelihood of seeking treatment at a health centre was based on 444 observations. Of the first set of eleven variables considered as putative determinants of whether a visit would be made to a health centre after exposure to a suspected rabid dog, the univariate logistic regression analysis indicated no significance for the variables age, adulthood and religion ($p > .2$). The final multivariable logistic regression model indicated that victims bitten by a suspected dog with "unknown" ownership status were more likely (OR = 2.40, 95% CI = 1.22–4.83) to visit a health centre compared to those bitten by a dog that was considered to be their "own." Victims of "severe" and "moderate" dog bites were almost two times more likely to visit a health centre than people with "minor" bite. Victims bitten on the "head/neck" were less likely (OR = 0.35, 95% CI = 0.14–0.95) to visit a health centre compared to those bitten on the "leg." Victims with higher monthly spending (>100 USD) were also found to be around two times more likely (OR = 2.06, 95% CI = 1.08–4.03) to visit health centre compared to those spend a lower amount (<20 USD) of monthly spending. Distance to the health centre was shown to be negatively correlated to the likelihood of a visit to the health centre (OR = 0.96, 95% CI = 0.94–0.97), that is for every one km

TABLE 2 Description and comparisons on socioeconomic, demographic, geographic and exposure-related factors explaining likelihoods of visiting health centre and compliance with receiving sufficient doses of PEP upon potential rabies exposure by district and overall

Variables	Bishoftu		Lemuna-bilbilo		Yabelo		Overall	
	n	%	*n*	%	*n*	%	N	*p*-Value[a]
Potentially rabid cases (*n*)	189		189		87		465	
Adulthood								.2
Below 15	60	31.7	64	33.9	37	42.5	161	
Above including 15	129	68.3	125	66.1	50	57.5	304	
Sex								<.05*
Female	100	52.9	80	42.3	26	29.9	206	
Male	89	47.1	109	57.7	61	70.1	259	
Religion								<.01**
Catholic	8	4.2	0	0.0	1	1.1	9	
Muslim	12	6.3	53	28.0	9	10.3	74	
Orthodox	89	47.1	66	34.9	11	12.6	166	
Protestant	60	31.7	19	10.1	22	25.3	101	
Others/traditional	20	10.6	51	27.0	44	50.6	155	
Educational level								<.01**
Under school age	20	10.6	27	14.3	13	14.9	60	
Elementary	45	23.8	53	28.0	25	28.7	123	
Junior and high school	62	32.8	29	15.3	4	4.6	95	
College/university	37	19.6	6	3.2	1	1.1	44	
Illiterate	25	13.2	60	31.7	44	50.6	129	
NA	0	0.0	14	7.4	0	0.0	14	
Monthly spending (in USD)								<.05*
<20	49	25.9	38	20.1	33	37.9	120	
20–100	82	43.4	93	49.2	33	37.9	208	
>100	58	30.7	58	30.7	21	24.1	137	
Severity of bite								<.01**
Minor	60	31.7	82	43.4	22	25.3	164	
Moderate	103	54.5	74	39.2	52	59.8	229	
Severe	26	13.8	33	17.5	13	14.9	72	
Body part bitten								.79
Head/neck	10	5.3	9	4.8	7	8.0	26	
Hands/arm	34	18.0	41	21.7	13	54.0	88	
Trunk	11	5.8	10	5.3	6	37.9	27	
Legs/thigh	134	70.9	129	68.3	61	70.1	324	
Dog ownership								<.01**
Own	53	28.0	61	32.3	7	8.0	121	
Known/neighbour	100	52.9	62	32.8	47	54.0	209	
Unknown	36	19.0	66	34.9	33	37.9	135	
Fate of the dog after bite								<.01**
Disappeared	105	55.6	54	28.6	26	29.9	185	
Killed	84	44.4	128	67.7	61	70.1	273	
NA	0	0.0	7	3.7	0	0.0	7	
Age at exposure (mean, years)	22.9		24.0		22.6		23.3	.67
Distance to health centre (mean, km)	2.5		18.4		35.7		15.1	<.01**

NA, number of potentially rabies exposure cases under the category for which we could not ascertain.

Signif. codes: 0; "****" 0.001; "***" 0.01; "**" 0.05; "." 0.1; " " 1.

[a]Chi-square (*p* value) comparisons across categories between districts, with one-way ANOVA comparisons of means in the two cases of continuous measures (Age and Distance).

TABLE 3 Predictor variables for the likelihood of visiting health centre

	Model excluding district				Model including district			
	Coeff	*SE*	Pr (>|z|)		OR	Coeff	*SE*	Pr (>|z|)	OR
(Intercept)	0.94	0.34	0.01	**	2.56	3.03	0.52	0.00**	20.74
Ownership of biting dog									
Own[a]									
Known/Neighbour	0.62	0.30	0.04	*	1.86	0.53	0.33	0.11	1.69
Unknown	0.88	0.35	0.01	*	2.40	0.97	0.37	0.01**	2.63
Severity of the bite									
Minor[a]									
Moderate	0.69	0.27	0.01	**	1.99	0.64	0.29	0.03*	1.89
Severe	0.71	0.38	0.05	*	2.03	0.77	0.39	0.05*	2.16
Body part bitten									
Leg[a]									
Arm/hand	−0.44	0.31	0.16		0.65				
Head/neck	−1.06	0.50	0.03	*	0.35				
Trunk	0.80	0.71	0.26		2.23				
Monthly spending (USD)									
<20[a]									
20–100	0.27	0.30	0.36		1.31				
>100	0.72	0.34	0.03	*	2.06				
Distance from health centre (km)	−0.04	0.01	0.00	***	0.96				
District									
Bishoftu[a]									
Lemuna-bilbilo						−2.77	0.48	0.00**	0.06
Yabelo						−2.77	0.57	0.00**	0.06
	McFadden Pseudo R^2 = .12					McFadden Pseudo R^2 = .22			
	Hosmer and Lemeshow goodness of fit (GOF) test, p-value = .18					Hosmer and Lemeshow goodness of fit (GOF) test, p-value = .46			

Signif. codes: 0; "****" 0.001; "***" 0.01; "**" 0.05; "." 0.1; " " 1.
[a]The value in the row represents the reference category of the categorical variable.

distance closer to the health centre, the likelihood of completing the PEP treatment increased by 4%. The fitted multivariable model had acceptable goodness of fit (a Hosmer and Lemeshow goodness of fit p-value of .18) but low predictive value (a McFadden Pseudo R^2 of .12) (Table 3).

After including district as an explanatory variable in the model, the variables ownership of the biting dog and severity of the bite were still significant; however, monthly spending, body part bitten and distance to the nearest health centre were no longer significant (p > .05). The added district variable was highly significant (p < .01); that is, those living in an urban district (Bishoftu) were much more likely to visit a health centre compared to those living in rural districts (both in Lemuna-bilbilo and Yabelo, with an OR = 0.06, 95% CI = 0.02–0.19). The model fit indices after the inclusion of the district variable improved significantly as indicated by a Hosmer and Lemeshow goodness of fit p-value of .46 and a McFadden Pseudo R^2 of .22 (Table 3).

3.2.2 | Predictors of likelihood of receiving sufficient doses of PEP after a suspected rabid dog bite

Almost 80% (360/465) of the suspected rabid dog bite victims visited a health centre. After excluding cases with missing values, data on 342 bite victim observations were used to identify determinants of likelihood to receive sufficient doses of PEP. Of the set of 11 predictive variables as run in the first model, the univariate logistic regression analysis revealed no significant effect on the likelihood of receiving sufficient PEP for the variables sex, religion, adulthood, fate of the biting dog or body part bitten (p > .2). The inclusion of the remaining six variables in the multivariable logistic regression model indicated that only monthly spending and distance to the health centre were significant determinants of the likelihood of receiving sufficient doses of PEP (p < .05) (Table 4). Victims with higher monthly spending (>100 USD) were also found to be almost three times more

TABLE 4 Predictor variables for the likelihood of receiving sufficient doses PEP

	Model excluding district				Model including district			
	Coeff	SE	Pr (>|z|)		OR	Coeff	SE	Pr (>|z|)	OR
(Intercept)	0.92	0.33	0.00	***	2.53	0.77	0.35	0.03*	2.16
Ownership of biting dog									
Own[a]									
Known/Neighbour						0.21	0.33	0.52	1.24
Unknown						0.96	0.43	0.03*	2.61
Distance from the health centre (in KM)	−0.04	0.01	0.00	***	0.96	−0.03	0.01	0.02*	0.97
Monthly spending									
<20[a]									
20–100	0.59	0.31	0.06	.	1.79	0.45	0.33	0.17	1.57
>100	0.99	0.36	0.01	**	2.72	0.90	0.38	0.02*	2.45
District									
Bishoftu[a]									
Lemuna-bilbilo						0.55	0.39	0.16	1.73
Yabelo						−0.99	0.48	0.04*	0.37
	McFadden Pseudo R^2 = .08					McFadden Pseudo R^2 = .12			
	Hosmer and Lemeshow goodness of fit (GOF) test, p-value = .00					Hosmer and Lemeshow goodness of fit (GOF) test, p-value = .00			

Signif. codes: 0; "***" 0.001; "**" 0.01; "*" 0.05; "." 0.1; " ".
[a]The value in the row represents the reference category of the categorical variable.

likely (OR = 2.72, 95% CI = 1.33–5.71) to receive sufficient doses of PEP compared to those having a low level of monthly spending (<20 USD). The multivariable logistic regression model was found to have a poor goodness of fit (Hosmer and Lemeshow p-value of .00) as well as limited predictive power (McFadden Pseudo R^2 of .08).

When the multivariable model was extended to include the district variable, ownership of the biting dog became significant predictors (p < .05). There were also significant differences among districts. Living is Yabelo district was linked to a significantly lower likelihood of receiving sufficient PEP when compared to the Bishoftu district (OR = 0.37, 95% CI = 0.14–0.96). The model fit indicated no improvement with a Hosmer and Lemeshow goodness of fit p-value of .00, while the McFadden Pseudo R^2 increased to .12 (Table 4).

4 | DISCUSSION

Our data indicate that not everyone exposed to rabies seeks medical treatment, nor do those who do necessarily comply with recommended treatment doses. Consequently, rabies caused 1, 4 and 3 human deaths per 100,000 inhabitants in Bishoftu, Lemuna-bilbilo and Yabelo districts (Beyene et al., 2017) during the year under study.

In our study, the number of exposed victims looking for medical treatment was based on the number of cases registered by the health centre, while the number of victims who did not seek for medical treatment was derived by contact tracing. Due to the difference in study design, the comparison of these two groups of victims might have been biased, resulting in an under-estimation of the exposure cases and in an overestimation of the proportion of cases who visited health centres. An alternative to our approach could be to engage data collectors to go from door-to-door, looking for bite victims and asking them whether they visited health centres. The later approach may have resulted in a more accurate estimate on the number of exposure cases as well as in the proportion of cases who visited health centres. However, given the relatively low prevalence within the population, such an approach would likely have been prohibitively expensive in terms of logistics.

In this study, the selection of relevant factors that might explain health seeking behaviour (i.e., sex, age, educational level, adulthood, religion, monthly spending, severity of bite, body part bitten, ownership and fate of the biting dog and distance from the nearest health centre delivering PEP) was based on literature findings. Of these factors, ownership status of the biting dog, the severity of the bite, body part bitten, monthly spending and the distance to the nearest health centre delivering PEP were found to significantly influence the likelihood that a victim would visit a health centre after being bitten by a suspected rabid dog.

Being bitten by a dog of "unknown" ownership more than doubled the likelihood that a victim would visit a health centre. It is intuitive that a person bitten by a dog of unknown ownership will be less confident regarding the history and health status of the dog compared to a bite from a dog that they own or of one owned by their neighbour of whom they could make an enquiry regarding, for

example, vaccination status. Moreover, victims of "known" biting dogs may decide to observe the dog's health status after the bite incident; in cases where the dog does not show any clinical symptoms in the subsequent days, they exclude the possibility of being exposed to rabies and hence the need for being treated at the health centre. This is of course a very risky approach and not one that would be support by medical advice; however, it may help explain why this particular variable was seen to have such a clear affect in our study. On the other hand, victims might also discontinue treatments if the health of the biting dog becomes better. In the cases where victims received either "severe" or "moderate" grade bites, they were around twice as likely to visit a health centre visit compared to those receiving only "minor" grade bites. This practice should be encouraged as bites graded as "severe" create a favourable environment for the rabies virus to penetrate the skin barrier and increase the likelihood of developing the disease. Therefore, the World Health Organization recommends immediate medical attention that includes administration of rabies immunoglobulin for severe bites. Such wounds are also liable to other microbial infection and often require antibiotic treatment and tetanus antitoxin (WHO, 2016). The fact that "moderate" bites were also much more likely to be associated with a health centre visit could also be seen as a positive outcome particularly in terms of public awareness, as a "better safe than sorry" policy makes good sense if there is any doubt as to the severity of the bite.

Differing from our expectations, based on the perceived high risk of developing rabies when a bite is made to the head/neck, and in contrast to findings elsewhere (Cleaveland, Fevre, Kaare, & Coleman, 2002; Knobel et al., 2005; Shim, Hampson, Cleaveland, & Galvani, 2009), it appeared that being bitten on the head/neck was actually associated with a lower likelihood (OR = 0.35) that a visit would be made to a health centre when compared to a bite on the leg. This finding that people bitten on head/neck were less likely to seek for PEP sounds alarming. However, the contribution of head/neck bites to the total number of cases was minor (5.7% of the total exposure cases) and as such is rather sensitive to small changes in number of data entries.

The logistic regression model predicting that the likelihood that a visit would be made to a health centre reduced by 4% for each additional km of distance from the victim's place of residence. Reports in the literature have also noted geographic accessibility, in terms of the physical distance or travel time to the health services delivery point, to be a major hindering factor to accessing health care in developing countries (Peters et al., 2008; Sambo et al., 2013).

The multivariable models excluding district had a poor model fit for both likelihood of health centre visit and likelihood of receiving sufficient doses PEP, indicating that the evaluated combination of factors is not able to explain the situation sufficiently. Interestingly, upon inclusion of district as a variable in our models, the predictive effect of distance to the nearest health centre became non-significant. In addition, the goodness of fit, as well as the predictive power of the model improved, indicating that the district-specific information led to more robust model. This could be due to the fact that variables, such as the availability of traditional healers, attitudes towards PEP treatment or knowledge about rabies, may differ among districts but this variability is not adequately captured in the other specific case-level variables. Traditional and spiritual treatments against rabies are generally more common in rural than in urban communities (Digafe et al., 2015; Kabeta et al., 2015; Teklu et al., 2017; Tolossa et al., 2013). This difference was also found in our study. However, as only minor variations were seen in the proportion of followers of different religions across districts, visiting a traditional healer can, most probably, be seen to be a cultural rather than a religious practice.

People in urban areas have better access to mass media such as television, radio and newspapers, which could increase their awareness about the disease and the necessity of seeking medical treatment subsequent to possible exposure. Infrastructures such as road and transportation facilities from rural areas to health centres delivering PEP will also tend not to be as developed as is the case in urban areas. Furthermore, the perceived effectiveness of rabies treatment by people from rural areas may be lower as these people tend to arrive at health centres later than is the case for those in urban areas, due to the longer distances and reduced transportation facilities. This could lead to a higher likelihood that rabies will develop, despite the PEP treatment (WHO, 2016).

The variables monthly spending and distance to health centre were found to significantly influence the likelihood of receiving sufficient doses of PEP. This indicates that once a victim has visited a health centre to seek medical treatment, a shorter distance to that centre, and a higher level of monthly spending remain factors that increase the likelihood of compliance with the PEP regimen. The inclusion of the district variable did not have such a marked effect on model performance for this outcome, although the effect of distance was reduced, while ownership of the biting dog became significant. In contrast to the results for likelihood of seeking medical treatment, we found difference between the two rural districts, Lemuna-bilbilo and Yabelo, in terms of likelihood of receiving sufficient doses of PEP. Victims from Lemuna-bilbilo demonstrated similar likelihoods to those from the urban district (Bishoftu) and were found to be three times more likely to receive sufficient doses of PEP than were those from Yabelo. The difference between these two rural districts in terms of completion rates may be explained by differences in the means of livelihoods. In the pastoral rural lowland district, people move often in search of feed and water for their livestock, while in the rural highlands people are relatively permanently resident, growing crops and keeping livestock in permanent place (Desta & Coppock, 2004). The mobile nature of victims in the rural lowlands may have reduced the likelihood that they would receive sufficient doses of PEP.

Increasing the coverage of PEP delivering services by involving private health centres may improve medical treatment seeking and PEP compliance rates (personal communication with Dr. Abraham Haile Kidane, head of zoonosis research at the Ethiopian Public Health Institute), mostly by reducing the average distance that a victim would need to travel to receive medical treatment and hence of the time to the start of treatment.

In the present study, the highest level (>100 USD) of monthly spending was found to double the odds of visiting a health centre;

however, it tripled the odds of PEP compliance, compared to the lowest level (<20 USD) of monthly spending. Before a victim visits a health centre upon exposure, she/he may not be aware that at least 14 doses of PEP are required as part of the treatment (EHNRI, 2012). Visiting a health centre with such frequency may be economically challenging, as the average total cost of post-exposure treatment (21 USD per dog bite case) is comparable to 4% of the average annual Ethiopian income, which would explain the influence of income level on the odds of treatment compliance. Of the total costs associated with post-exposure treatment, non-health related expenses (mainly travel and time) contribute up to 70% of the total cost (Beyene et al., 2017). Relaxation of the non-health-related expenses could be achieved by introducing the five dose WHO-recommended PEP vaccine. However, as the WHO-recommended vaccine is more expensive than the nervous tissue vaccine which is currently used, the total costs would be around three times higher (Beyene et al., 2017).

Besides the variables we tested, length of treatment days—which is 14–17 doses over as many days for medical treatment, as opposed to 1–3 days for traditional/spiritual treatment—as well as vaccine availability at the time of visit, may have influenced/impacted the likelihood of seeking medical treatment and receiving sufficient doses of PEP (Deressa et al., 2010; Ramos et al., 2015). However, due to the lack of relevant records, it was not possible to retrospectively check vaccine availability for the times at which the victims sought treatment in the various health centres. Relatively more victims were bitten by suspected rabid dogs in Bishoftu than in the rural districts, that is 189 of 210 bite cases (90%) in Bishoftu district, 189 of 262 bite cases (72%) in Lemuna-bilbilo district and only 87 of 183 bite cases (48%) in Yabelo district. It seems unlikely that this difference was due purely to chance and could be due to the level of exposure to unfriendly or aggressive biting dogs (those not under ownership) but still not rabid while evaluated based on the six criteria for assessing the rabid status retrospectively. For instance, of the total bite cases, the proportion of bites from dogs of unknown ownership in rural districts (Yabelo and Lemuna-bilbilo) was much higher than was the case for bites in Bishoftu (urban district).

In this study, we identified important factors influencing people's medical treatment seeking and treatment regimen behaviour. However, the factors we considered only partly explain the variability in the data, especially with respect to the likelihood of treatment compliance. A part of the unknown factors appears to be linked to district, particularly in terms of the probability of making a visit to the health centre. As most socio-demographic variables described in the literature were accounted for in this study, the factors that might explain the likelihood to go to a health centre or to complete the treatment might be sought in perceived psychological factors, such as attitudes or social norms. Further exploration of these factors could be carried out using methods such as the theory of planned behaviour or health belief theory (Askelson et al., 2010; Gerend & Shepherd, 2012).

In conclusion, about 77% of the suspected rabid dog bite victims visited a health centre while 57% received sufficient doses of PEP. Due to the set-up of the study, the proportion of people who seek treatment could be inflated and thus overestimated, as the denominator, that is the list of bite cases, could be incomplete. The important factors that influence victim's medical treatment seeking behaviour were found to be ownership status of the biting dog, the severity of the bite, body part bitten, monthly spending and distance to the nearest health centre delivering PEP, whereas the likelihood of receiving sufficient doses of PEP was determined by monthly spending and distance to health centre. However, these factors did not explain all the variation among the three districts. The district in which victims lived appeared to have a relevant influence on the likelihood of seeking medical treatment but did not improve the prediction on the likelihood of treatment compliance. Given the insights obtained from this study, policy should be directed towards an increased accessibility of health centres delivering PEP services and awareness creation to improve health seeking behaviour. In urban and rural highland districts, the majority of the exposed persons who seek medical treatment comply with treatment regimen, indicating that the promotion of medical treatment through awareness creation campaigns tends to be beneficial. Furthermore, medical treatment seeking and supplementary treatments should be exceptionally promoted upon exposure through severe bites on body parts that lead to a higher likelihood of developing the disease, such as head and neck.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

TJB, MCMM, CWR, HH conceived of the study, designed the study measures and methods. TJB collected the data. TJB, CWR performed the data analyses. TJB, MCMM, CWR, HH wrote and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by the scientific and ethical review committee of Ethiopian Public Health Institute (Reference No. EPHI-6-13-824). Oral consent was obtained from participants prior to data collection.

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REFERENCES

Askelson, N. M., Campo, S., Lowe, J. B., Smith, S., Dennis, L. K., & Andsager, J. (2010). Using the theory of planned behavior to predict mothers' intentions to vaccinate their daughters against HPV. *The Journal of School Nursing*, *26*(3), 194–202. https://doi.org/10.1177/1059840510366022

Ayele, W., Fekadu, M., Zewdie, B., Beyene, M., Bogale, Y., Mocha, K., & Egziabher, F. (2001). Immunogenicity and efficacy of Fermi-type

nerve tissue rabies vaccine in mice and in humans undergoing post-exposure prophylaxis for rabies in Ethiopia. *Ethiopian Medical Journal*, *39*(4), 313–321.

Beyene, T.J., Mourits, M. C. M., Kidane, A. H., & Hogeveen, H. (2018). Estimating the burden of rabies in Ethiopia by tracing dog bite victims. *PLoS ONE*, 13(2), e0192313. https://doi.org/10.1371/ journal. pone.0192313.

Bichmann, W., Diesfeld, H.-J., Agboton, Y., Gbaguidi, E. A., & SimshÄUser, U. (1991). District health systems: Users' preferences for services in Benin. *Health Policy and Planning*, 6(4), 361–370. https://doi. org/10.1093/heapol/6.4.361

Chibwana, A. I., Mathanga, D. P., Chinkhumba, J., & Campbell, C. H. (2009). Socio-cultural predictors of health-seeking behaviour for febrile under-five children in Mwanza-Neno district, Malawi. *Malaria Journal*, 8(1), 219. https://doi.org/10.1186/1475-2875-8-219

Cleaveland, S., Fevre, E. M., Kaare, M., & Coleman, P. G. (2002). Estimating human rabies mortality in the United Republic of Tanzania from dog bite injuries. *Bulletin of the World Health Organization*, 80(4), 304–310.

CSA (2013). *Population projection of Ethiopia for all regions at wereda level from 2014–2017*. Addis Ababa, Ethiopia: Federal Democratic Republic of Ethiopia Central Statistical Agency.

Deressa, A., Ali, A., Bayene, M., Selassie, B. N., Yimer, E., & Hussen, K. (2010). The status of rabies in Ethiopia: A retrospective record review. *Ethiopian Journal of Health Development*, 24(2), 127–132.

Desta, S., & Coppock, D. L. (2004). Pastoralism under pressure: Tracking system change in southern Ethiopia. *Human Ecology*, 32(4), 465–486. https://doi.org/10.1023/B:HUEC.0000043516.56037.6b

Digafe, R. T., Kifelew, L. G., & Mechesso, A. F. (2015). Knowledge, attitudes and practices towards rabies: Questionnaire survey in rural household heads of Gondar Zuria District, Ethiopia. *BMC Research Notes*, 8(1), 400. https://doi.org/10.1186/s13104-015-1357-8

Dohoo, I. R., Martin, W., & Stryhn, H. E. (2003). *Veterinary epidemiologic research*. Charlottetown, PEI: University of Prince Edward Island.

EHNRI (2012). *Proceeding of the national workshop on Rabies prevention and control in Ethiopia*, Oct 18-19, 2012, Addis ababa.

Feyisetan, B. J., Asa, S., & Ebigbola, J. A. (1997). Mothers' management of childhood diseases in Yorubaland: The influence of cultural beliefs. *Health Transition Review*, 7(2), 221–234.

Franka, R., Smith, T. G., Dyer, J. L., Wu, X., Niezgoda, M., & Rupprecht, C. E. (2013). Current and future tools for global canine rabies elimination. *Antiviral Research*, 100(1), 220–225. https://doi.org/doi: 10.1016/j.antiviral.2013.07.004

G/hiwot, T. T., Sime, A. G., Deresa, B., Tafese, W., Hajito, K. W., & Gemeda, D. H. (2016). Community health seeking behaviour for suspected human and animal rabies cases, Gomma District, Southwest Ethiopia. *Plos One*, 11(3), e0149363. https://doi.org/10.1371/journal. pone.0149363

Garg, S. R. (2014). *Rabies in man and animals*. New Delhi: Springer. https:// doi.org/10.1007/978-81-322-1605-6

Gerend, M. A., & Shepherd, J. E. (2012). Predicting human papilloma virus vaccine uptake in young adult women: Comparing the health belief model and theory of planned behavior. *Annals of Behavioral Medicine*, 44(2), 171–180. https://doi.org/10.1007/s12160-012-9366-5

Hampson, K., Coudeville, L., Lembo, T., Sambo, M., Kieffer, A., Attlan, M., & Cleaveland, S. (2015). Estimating the global burden of endemic canine rabies. *PLoS Neglected Tropical Diseases*, 9, e0003709. https:// doi.org/10.1371/journal.pntd.0003709

Hemachudha, T., Laothamatas, J., & Rupprecht, C. E. (2002). Human rabies: A disease of complex neuropathogenetic mechanisms and diagnostic challenges. *The Lancet Neurology*, 1(2), 101–109. https://doi. org/10.1016/S1474-4422(02)00041-8

Hemachudha, T., Ugolini, G., Wacharapluesadee, S., Sungkarat, W., Shuangshoti, S., & Laothamatas, J. (2013). Human rabies: Neuropathogenesis, diagnosis, and management. *The Lancet Neurology*, 12(5), 498–513. https://doi.org/10.1016/S1474-4422(13)70038-3

Jemberu, W. T., Molla, W., Almaw, G., & Alemu, S. (2013). Incidence of rabies in humans and domestic animals and people's awareness in North Gondar Zone, Ethiopia. *PLoS Neglected Tropical Diseases*, 7(5), e2216. https://doi.org/10.1371/journal.pntd.0002216

Kabeta, T., Deresa, B., Tigre, W., Ward, M. P., & Mor, S. M. (2015). Knowledge, attitudes and practices of animal bite victims attending an anti-rabies health centre in Jimma Town, Ethiopia. *PLoS Neglected Tropical Diseases*, 9(6), e0003867.

Knobel, D. L., Cleaveland, S., Coleman, P. G., Fèvre, E. M., Meltzer, M. I., Miranda, M. E. G., ... Meslin, F.-X. (2005). Re-evaluating the burden of rabies in Africa and Asia. *Bulletin of the World Health Organization*, 83(5), 360–368.

Kroeger, A. (1983). Anthropological and socio-medical health care research in developing countries. *Social Science & Medicine*, 17(3), 147–161. https://doi.org/doi: 10.1016/0277-9536(83)90248-4

McFadden, D. (1978). Quantitative methods for analysing travel behaviour of individuals: Some recent developments. In D. A. Hensher, & P. R. Stopher (Eds.), *Behavioural travel modelling* (pp. 279–318). London: Croom Helm.

Mwangome, M., Prentice, A., Plugge, E., & Nweneka, C. (2010). Determinants of appropriate child health and nutrition practices among women in rural Gambia. *Journal of Health*, *Population and Nutrition*, 28, 167–172.

Peters, D. H., Garg, A., Bloom, G., Walker, D. G., Brieger, W. R., & Rahman, M. H. (2008). Poverty and access to health care in developing countries. *Annals of the New York Academy of Sciences*, 1136, 161–171. https://doi.org/10.1196/annals.1425.011

Piyasirisilp, S., Hemachudha, T., & Griffin, D. E. (1999). B-cell responses to myelin basic protein and its epitopes in autoimmune encephalomyelitis induced by Semple rabies vaccine. *Journal of Neuroimmunology*, 98(2), 96–104. https://doi.org/10.1016/S0165-5728(99)00065-X

Ramos, J. M., Melendez, N., Reyes, F., Gudiso, G., Biru, D., Fano, G., ... Balcha, S. (2015). Epidemiology of animal bites and other potential rabies exposures and anti-rabies vaccine utilization in a rural area in Southern Ethiopia. *Annals of Agricultural and Environmental Medicine: AAEM*, 22(1), 76–79. https://doi. org/10.5604/12321966.1141372

Sambo, M., Cleaveland, S., Ferguson, H., Lembo, T., Simon, C., Urassa, H., & Hampson, K. (2013). The burden of rabies in Tanzania and Its impact on local communities. *Plos Neglected Tropical Diseases*, 7(11), e2510. https://doi.org/10.1371/journal.pntd.0002510

Shaikh, B. T., & Hatcher, J. (2004). Health seeking behaviour and health service utilization in Pakistan: Challenging the policy makers. *Journal of Public Health*, 27(1), 49–54.

Shim, E., Hampson, K., Cleaveland, S., & Galvani, A. P. (2009). Evaluating the cost-effectiveness of rabies post-exposure prophylaxis: A case study in Tanzania. *Vaccine*, 27(51), 7167–7172. https://doi. org/10.1016/j.vaccine.2009.09.027

Sugiyama, M., & Ito, N. (2007). Control of rabies: Epidemiology of rabies in Asia and development of new-generation vaccines for rabies. *Comparative Immunology, Microbiology and Infectious Diseases*, 30(5), 273–286. https://doi.org/10.1016/j.cimid.2007.05.007

Teklu, G. G., Hailu, T. G., & Eshetu, G. R. (2017). High incidence of human rabies exposure in Northwestern Tigray, Ethiopia: A four-year retrospective study. *Plos Neglected Tropical Diseases*, 11(1), e0005271.

Tepsumethanon, V., Wilde, H., & Meslin, F. X. (2005). Six criteria for rabies diagnosis in living dogs. *Journal of the Medical Association of Thailand*, 88(3), 419–422.

Tipping, G., & Segall, M. (1995). *Health care seeking behaviour in developing countries: An annotated bibliography and literature review*. Brighton, UK: Health Unit, Institute of Development Studies at the University of Sussex.

Tolossa, K., Debela, E., Athanasiadou, S., Tolera, A., Ganga, G., & Houdijk, J. G. (2013). Ethno-medicinal study of plants used for treatment of human and livestock ailments by traditional healers in South Omo,

Southern Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, *9*(1), 32. https://doi.org/10.1186/1746-4269-9-32

Uzochukwu, B. S., & Onwujekwe, O. E. (2004). Socio-economic differences and health seeking behaviour for the diagnosis and treatment of malaria: A case study of four local government areas operating the Bamako initiative programme in south-east Nigeria. *International Journal for Equity in Health*, *3*(1), 6. https://doi.org/10.1186/1475-9276-3-6

WHO (1984). *WHO expert committee on rabies*. WHO Technical report series 709, Geneve: WHO.

WHO (2005). *WHO technical report series 931: WHO expert consultation on rabies; first report* (p. 13). Geneva, Switzerland: WHO.

WHO (2013). *WHO expert consultation on rabies*. Second report. World Health Organization technical report series (982), 1.

WHO (2016). *World Health Organization*. Retrieved from http://www.who.int/mediacentre/factsheets/fs099/en/. accessed date 15/4/2016.

Yibrah, M., & Damtie, D. (2015). Incidence of human rabies exposure and associated factors at the Gondar Health Centre, Ethiopia: A three-year retrospective study. *Infectious Diseases of Poverty*, *4*(1), 3. https://doi.org/10.1186/2049-9957-4-3