

Knowledge and perception of rabies among school children in rabies endemic areas of south Bhutan

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Abstract:

Rabies is endemic in southern Bhutan and children were reported to be the most frequent victims. We surveyed the knowledge, attitude, and practices on rabies among school children in three schools located in southern Bhutan. Descriptive statistics and logistic regression were performed to analyze the level of knowledge and variation of perception towards rabies among secondary school children. A total of 701 students (57.9% female, 42.1% male) had participated in the survey of which 98.2% heard about rabies. Most of the students demonstrated a good level of knowledge (59.7%) and a favorable perception towards rabies (57.7%). Multivariable logistic regression analysis revealed the importance of previous rabies awareness campaign increasing the likelihood of positive knowledge about rabies at the individual student and the school level. Similarly, higher grades of students', employed mothers of the students, and students from villages were associated with more favorable perceptions. Overall, our study in rabies endemic areas of Southern Bhutan showed that most of the students have good knowledge and favorable perception towards rabies. However, we identified several knowledge gaps. Therefore, efforts should be made to address the knowledge gaps through regular awareness programs by actively engaging key stakeholders such as school-teachers and parents.

Keywords: Rabies; School children; Knowledge, Attitude, Practice, Education, Bhutan.

1. Introduction

Rabies, caused by Lyssavirus, is considered one of the most important Neglected Tropical Diseases [1]. Rabies is mainly transmitted through dog bites and cause about 59,000 human deaths every year in the world [2,3] It is endemic in Asia and Africa and most of the victims are children (40%) under the age of 15 years. The disease results in economic losses of upto 8.6 billion USD every year and about 3 billion people are at risk of getting the disease [2]

Rabies is 100% fatal once the victim has shown clinical signs. However, timely use of vaccine and rabies immunoglobulins, and following good post-exposure practices, can effectively prevent rabies infection [3]. The lifesaving post-exposure prophylaxis (PEP) is unfortunately not easily accessible, especially to poor people and to remote rural communities in rabies endemic countries. Even when the vaccine is available, the bite victims may not have the means to pay for the transports to the hospitals or clinics and cover the costs for post-exposure treatment [2]. Inefficient health-seeking behavior of dog bite victims, such as seeking the assistance of traditional healers for local treatment at home is also associated with a low level of knowledge and awareness about the health risk of rabies [4,5].

In Bhutan, rabies in animals is endemic in the southern part of the country that shares a border with India [6]. Sporadic outbreaks are also reported from the eastern parts of the

country [7,8]. Dog bites in humans are common and around 7000 bite incidents are reported every year in the country, for a population of 700,000 people. Every year, the government spends approximately Nu 9.3 million (USD 142,000) on post-exposure prophylaxis [9,10]. Seventeen human rabies death were reported between 2006 and 2016 [11] and one death was reported in 2020 in a three-year old girl child [12].

Rabies PEP is provided free of charge to the dog bite victims through a network of 240 health centers located across the country [9,11]. The general level of knowledge and awareness on rabies is thought to be high among the communities, which has been attributed to regular awareness programs [7,9,10,13]. However, children under the age of 15 years are at higher risk of experiencing dog bites and rabies deaths in Bhutan [10,14] and little is known about their knowledge and perceptions. It is important to understand the knowledge, attitudes, and practices (KAP) of school children regarding rabies and dog bite to design efficient prevention programs. In this study, we described the findings of a KAP survey on rabies among children in three secondary schools located in the rabies endemic zone of southern Bhutan and discuss possible prevention measures.

2. Materials and Methods

2.1. Study area

The study was conducted in the three border towns of southern and eastern Bhutan sharing a border with India: Phuntsholing, Gelephu, and Samdrup Jongkhar (Figure 1). These areas report frequent outbreaks of rabies in animals [6] and have recorded greater incidences of dog bites in humans compared to the rest of the country [9,14]

Approximately 44,328 people live in the three towns [15]: Phuntsholing (27,658), Gelephu (9,858) and Samdrup Jongkhar (10,545). There are 14 schools and approximately 7,809 students studying in these towns [15]. Of these, six are Higher Secondary Schools, four Middle Secondary Schools, two Lower Secondary Schools, and two Primary schools. Four Higher Secondary Schools from these three areas are private schools and all the rest are government public schools.

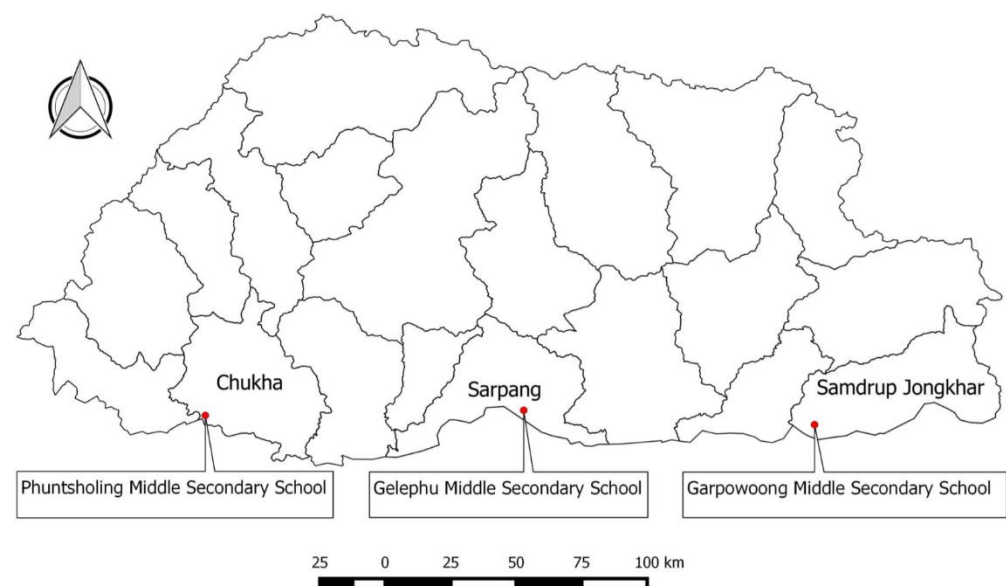


Figure 1. Map of Bhutan showing the location of three schools in which the study was conducted (Bhutan is located between China in the north and India in the south, east and west). The names and borders of the districts are indicated, and the location of the schools surveyed (red dots). The map was prepared using Quantum GIS, QGIS Development Team (2019), QGIS Geographic Information System, Open-Source Geospatial Foundation Project (<http://qgis.osgeo.org>) and was not taken from another source.

2.2. Study design and data collection

In Phuntsholing town, Phuntsholing Middle Secondary School (PMSS) was selected based on purpose and convenience since the school is located in the core town area and have a high-risk of dog bite incidents due to the large number of free-roaming dogs in the town. In Gelephu, since there is only one MSS, Gelephu Middle Secondary School (GMSS) was included in the study. Similarly, from Samdrup Jongkhar town, of the two MSS, Garpowoong Middle Secondary School (GaMSS) was selected for the study. Data were collected using an individual structured questionnaire. The questionnaire consisted of three sections: 1) demographic details of students; 2) knowledge, attitude, and practice of students regarding rabies; 3) dog bite incidences and health-seeking behaviors of the respondent students. Before the actual survey, the questionnaires were pre-tested with 10 students of Garpowoong Middle Secondary School and necessary changes were made to improve the clarity of the questions. All the students studying in grade VIII, IX, and X from the selected schools were enrolled in the study. Prior to school visits, approvals were obtained from both the school principals and class teachers. Before the actual collection of the data, students were clearly explained about the purpose of the study and were informed that participation was voluntary and that they were allowed to withdraw at any stage of the study. After obtaining verbal and written consent from the students, questionnaires were distributed for self-administration. The questionnaires were explained to the students and they were guided in answering each question.

2.3. Data management and analysis

The questionnaire survey data were entered into a database developed in EpiInfo software version 7.2.3.1 [16]. The data were then extracted into Microsoft excel 2013 (Microsoft Excel, USA) and checked for any errors before performing analysis (Table S1). Data analysis was performed in R statistical software version 3.6.1 using packages “dplyr”, “descr”, “forcats”, “LogisticDx”, and “ggplot2” [17]. Descriptive statistics were performed by calculating the proportions, frequency, mean, median, standard deviation, and ranges. For the purpose of analysis, variable age was categorized as “adolescent” for those students whose age was equal to or more than 15 years and “young” for those whose age was less than 15 using the median age. A number of dogs owned by the students was categorized as “> one dog” if the students household owned more than one dog and as “≤one dog” using the average value. The occupation of the father and mother of the students were collapsed into two categories using the “forcats” R package. Those working in military, government offices and corporations were categorized together as “employed” and those that were working as businessmen or businesswomen, farmers, and others were considered as “self-employed”. Frequencies of the categorical variables related to socio-demographic characteristics, dog ownership status, and dog bite incidences were compared between the three schools using Pearson's Chi-squared test with Yates' continuity correction and Fisher's Exact Test.

The knowledge of the students was assessed on sources of rabies, mode of transmissions, symptoms shown by rabid animals, and the preventive measures of rabies. For every correct answer to each question (i.e., in agreement with the conventional medical knowledge on rabies), a score of “1” was allotted, and ‘0’ was allotted for the wrong answers (not in agreement with the conventional medical knowledge on rabies). Knowledge scores were based on the scores that students obtained in identifying rabies source (1 point), susceptible host (5 points), mode of transmission of rabies (3 points), clinical signs (4 points) and knowledge on rabies prevention measures (3 points). A maximum total of 16 points was obtained if the students correctly answered all questions. The total scores obtained by each student was calculated and the total scores were then categorized into binary outcome variable using the mean score of knowledge [18,19]. The students that had a knowledge score more than the mean (≥ 7.1) were considered as “Good” and those that had less knowledge score than the mean (<7.1) was considered as having “Poor” knowledge on rabies. Similarly, for the perception related questions, a score of “1” was

allotted for the correct answers and “0” for the wrong answers. Perceptions were assessed on what they would do if they were bitten by the dogs (3 points) and what they would do if they saw the dog with abnormal behavior (2 points). A maximum total of five points were to be obtained if students correctly answered all the questions. If the perception scores were more than or equal to the mean (≥ 3.5), it was considered as “Favorable” and if scores were less than the mean score (<3.5), it was considered as “Unfavorable” perception to rabies.

Logistic regression models were built separately for knowledge and perception level of the students (binary outcome variables) to analyze if there was any association with the explanatory variables: socio-demographic characteristics, dog ownership status, dog bite incidences, and education status of the students (whether they have attended rabies awareness program previously). The explanatory variables that had a p-value ≤ 0.20 in the univariable analysis were selected and used for the multivariable analysis. Only those variables that had p value ≤ 0.05 were retained in the final model. The goodness-of-fit for the model was assessed using the Hosmer Lemeshow test.

2.4. Ethical approvals

The study was approved by the Research Ethics Board of Health, Ministry of Health (Ref. No. REBH/Approval/2019/113). Administrative approvals were also obtained from the city education officers, and from the three school principals and class teachers prior to the study.

3. Results

3.1. Socio-demographic characteristics of the students

Of the 712 students invited to participate in the study, 701 students completed the survey (98.0%), and the data from these completed questionnaires were used for analyses. The final group of students who completed the questionnaires comprised of 406 (57.9%) females and 295 (42.1%) males. The students’ age ranged from 12 to 21 years (median: 15 years). The participants included 234 (43.4%) students from PMSS, 237 (33.8%) from GaMSS and 160 (22.8%) from GMSS. The majority of study participants were studying in grade IX (n=291, 41.5%), followed by grade X (n=256, 36.5%), and VIII (n=154, 22.0%). Most of the students (n=490, 69.90%) resided in town with their parents and attended school as day-scholars. The socio-demographic details of the students are described in Table 1.

Table 1. Socio-demographic characteristics of the students that participated in the study from three middle secondary schools located in rabies endemic areas of Bhutan (PMSS: Phuntsholing Middle Secondary School; GMSS: Gelephu Middle Secondary School; GaMSS: Garpowoong Middle Secondary School).

Variables	Total (n%)	School name [n (%)]			χ^2 P-Value
		GMSS	PMSS	GaMSS	
Sex					0.258
Male	295(42.1)	59 (8.4)	129 (18.4)	107(15.3)	
Female	406(57.9)	101 (14.4)	175(25.0)	130(18.5)	
Age					0.001
Adolescent (≥ 15 yrs.)	463(66.1)	98(14.0)	187(26.7)	178(25.4)	
Young (<15 yrs.)	238(34.0)	62(8.8)	117(16.7)	59(8.4)	
Grade in which student study					<0.001
Grade VIII	154(22.0)	42(6.0)	34(4.9)	78(11.1)	
Grade IX	291(41.5)	65(9.3)	132(18.8)	94(13.4)	
Grade X	256(36.5)	53(7.6)	138(19.7)	65(9.3)	
Hometown of students					<0.001
Village	211(30.1)	77(11.0)	37(5.3)	97(13.8)	
Town	490(69.9)	83(11.8)	267(38.1)	140(20.0)	
Father's occupation					<0.001
Farmers	102(14.6)	31(4.4)	11(1.6)	60(8.6)	
Businessman	76(10.8)	29(4.1)	39(5.6)	8(1.1)	
Government employee	127(18.1)	30(4.3)	75(10.7)	22(3.1)	
Private/corporate employee	112(16.0)	17(2.4)	86(12.3)	9(1.3)	
Military	209(29.8)	27(3.9)	69(9.8)	113(16.1)	
Others	75(10.7)	26(3.7)	24(3.4)	25(3.6)	
Mother's occupation					<0.001
Farmers	103(14.7)	32(4.7)	11(1.6)	60(8.6)	
Businesswoman	64(9.1)	25(3.6)	33(4.7)	6(0.9)	
Government employee	59(8.4)	12(1.7)	40(5.7)	7(1.0)	
Private/corporate employee	27(3.9)	3(0.4)	22(3.1)	2(0.3)	
Military	2(0.3)	0(0.0)	1(0.1)	1(0.1)	
Housewife	431(61.5)	83(11.8)	190(27.1)	158(22.5)	
Others	15(2.1)	5(0.7)	7(1.0)	3(0.4)	
Dog ownership					<0.001
No	484(69.0)	89(12.7)	221(31.5)	174(24.8)	
Yes	217(31.0)	71(10.1)	83(11.8)	63(9.0)	

3.2. Socio-demographic characteristics of the students

Among the 701 participants, 31.0% of the students owned dogs at their house (n=217), with each household owing an average of 1.6 dogs. The proportion of households with dogs was significantly different between the schools ($\chi^2=17.5$, $df=2$, p -value < 0.001), highest for students from GMSS (n=83, 38.0%), and lowest in PMSS (n=63, 29.0%). The students reported that the dog that they owned were mostly given to them by neighbors (n=115, 53.0%), were vaccinated (n=163, 75.1%), and were let to always roam freely during

day and night (n=121, 55.8%). Only about one-third (n=74, 33.6%) of the students reported that their dogs were sterilized/neutered (Table 2).

Table 2. Characteristics and management of dogs owned by students' households in three rabies endemic towns of Bhutan (n=217; Phuntsholing, Gelephu, Garpowoong).

Characteristics of dog owning students	School				χ^2 P-Value
	Total	GMSS	PMSS	GaMSS	
Dog source					P<0.001
Adopted from street	31(14.3)	8(3.7)	8(3.7)	15(6.9)	
Given by neighbor/friends	115(53.0)	28(12.9)	54(24.9)	33(15.2)	
Purchased within Bhutan	28(12.9)	12(5.5)	11(5.1)	5(2.3)	
Purchased from outside country	4(1.8)	0(0.0)	4(1.8)	0(0.0)	
I don't know	37(17.1)	23(10.6)	5(2.3)	9(4.2)	
Missing	2(0.9)	0(0.0)	1(0.5)	1(0.5)	
Dog number					P=0.048
Less than or equal to one	154(71.0)	43(19.8)	65(30.0)	46(21.2)	
More than one	63(29.0)	28(1.9)	18(8.3)	17(7.8)	
Dog keeping practices					P<0.001
Free roaming all the time	54(24.9)	24(11.1)	14(6.5)	16(7.4)	
Keep inside house compound all the time	94(43.3)	26(12.0)	52(24.0)	16(7.4)	
Roam freely outside during day- time	65(30.0)	21(9.7)	16(7.4)	28(12.9)	
Roam freely during night-time	2(0.9)	0(0.0)	0(0.0)	2(0.9)	
Missing	2(0.9)	0(0.0)	1(0.5)	1(0.5)	
Dog vaccination status*					P=0.009
No	26(12.0)	14(6.5)	4(1.8)	8(3.7)	
Yes	163(75.1)	45(20.7)	67(30.9)	51(23.5)	
I don't know	26(12.0)	12(5.5)	11(5.1)	3(1.4)	
Missing	2(0.9)	0(0.0)	1(0.5)	1(0.5)	
Dog sterilized *					P=0.239
No	89(41.0)	33(15.2)	26(12.0)	30(13.8)	
Yes	73(33.6)	24(11.1)	30(13.8)	19(8.8)	
I don't know	53(24.4)	14(6.5)	26(12.0)	13(6.0)	
Missing	2(0.9)	0(0.0)	1(0.5)	1(0.5)	

Note: * The frequency and percentage are based on the student's responses

3.3. Dog bites incidences and health-seeking behaviour

The study found that 111 students (15.8%) had experienced dog bites in the last two years prior to the study period. Most of the bites were sustained from pet dogs (n=58, 52.3%), followed by stray dogs (n=44, 39.6%), while five students (4.5%) were not able to ascertain the status of the dog that bit them. The remaining four students (3.60%) did not respond to this question. Most of the bite victims (n= 64, 57.7%) reported that they were bitten without any disturbance or provocation of the dog. More than half (n=30, 52.0%) of the pet dogs that bit them belonged to their neighbors. Regarding the care given after

the bites, the majority of the students indicated that they washed the bite wound with soap and water (n=69, 62.2%), visited hospitals (n=49, 84.7%,) and received anti-rabies vaccination (n=92, 82.9%). However, adoption of risky practices like the application of local medicine and not visiting hospitals (n=13, 11.7%), and non-completion of the complete vaccine schedule (n=3, 3.2%) were also reported by few students following dog bites. When asked about the fate of the dog that had bitten them, the majority of the victims (n=56, 50.5%) reported that the dog was still alive, while twenty-three students (20.7%) could not ascertain the status of the dog (Table 3).

Table 3. Characteristics of dog bites and health seeking behaviors among students bitten by dogs (n=111)

Variables	Total	Schools			χ^2 P-Value
		GMSS	PMSS	GaMSS	
What type of dog bit you?					P=0.59
Pet dog	58(52.3)	15(13.5)	31(27.9)	12(10.8)	
Stray dog	44(39.6)	7(6.3)	27(24.3)	10(9.0)	
I don't know	5(4.5)	0(0.0)	4(3.6)	1(0.9)	
Missing	4(3.6)	0(0.0)	2(1.8)	2(1.8)	
What was the reason for the bite?					P=0.006
Provoked bite	43(38.7)	13(11.7)	27(24.3)	3(2.7)	
Unprovoked bite	64(57.7)	9(8.1)	35(31.5)	20(18.0)	
Missing	4(3.6)	0(0.0)	2(1.8)	2(1.8)	
What happened to the biting dog?					P=0.091
Died	18(16.2)	6(5.4)	9(8.1)	3(2.7)	
Disappeared	9(8.1)	0(0.0)	7(6.3)	2(1.8)	
dog still alive	56(50.5)	12(10.8)	28(25.2)	16(14.4)	
The dog was killed	1(0.9)	1(0.9)	0(0.0)	0(0.0)	
I don't know	23(20.7)	3(2.7)	18(16.2)	2(1.8)	
Missing	4(3.6)	0(0.0)	2(1.8)	2(1.8)	
What did you do to the bite wound?					P=0.130
Applied antiseptics to the wound	5(4.5)	1(0.9)	4(3.6)	0(0.0)	
Applied local herbs/medicine	13(11.7)	7(6.3)	3(2.7)	3(2.7)	
Washed bite wound with soap and water	69(62.2)	11(9.9)	41(36.9)	17(15.3)	
Washed bite wound with water only	12(10.8)	2(1.8)	8(7.2)	2(1.8)	
I did nothing	8(7.2)	1(0.9)	6(5.4)	1(0.9)	
Missing	4(3.6)	0(0.0)	2(1.8)	2(1.8)	
Have you visited a hospital after the bite?					P=0.098
Yes	94(84.7)	22(19.8)	51(46.0)	21(18.9)	
No	13(11.7)	0(0.0)	11(9.9)	2(1.8)	
Missing	4(3.6)	0(0.0)	2(1.8)	2(1.8)	
Did you receive rabies vaccine injections?					P=0.230
Yes	92(82.9)	21(18.9)	50(45.1)	21(18.9)	
No	15(13.5)	1(0.9)	12(10.8)	2(1.8)	
Missing	4(3.6)	0(0.0)	2(1.8)	2(1.8)	

3.4. Students' knowledge regarding rabies

Most of the students that participated in the survey had heard about rabies (n=688, 98.2%). The sources of information for most students (Figure 2) were from health workers (n=488, 70.9%), teachers (n=449, 65.3%) and friends(n=362,52.6%). Among those who had heard about rabies, the majority of the students (n=622, 90.4%,) knew that dog is the main source of rabies in Bhutan. However, few students mentioned that other animals such as bats (n=36, 5.2%), cats (n=3, 0.4%), cow (n=1, 0.1%) and birds (n=2, 0.3%) are the main source of rabies.

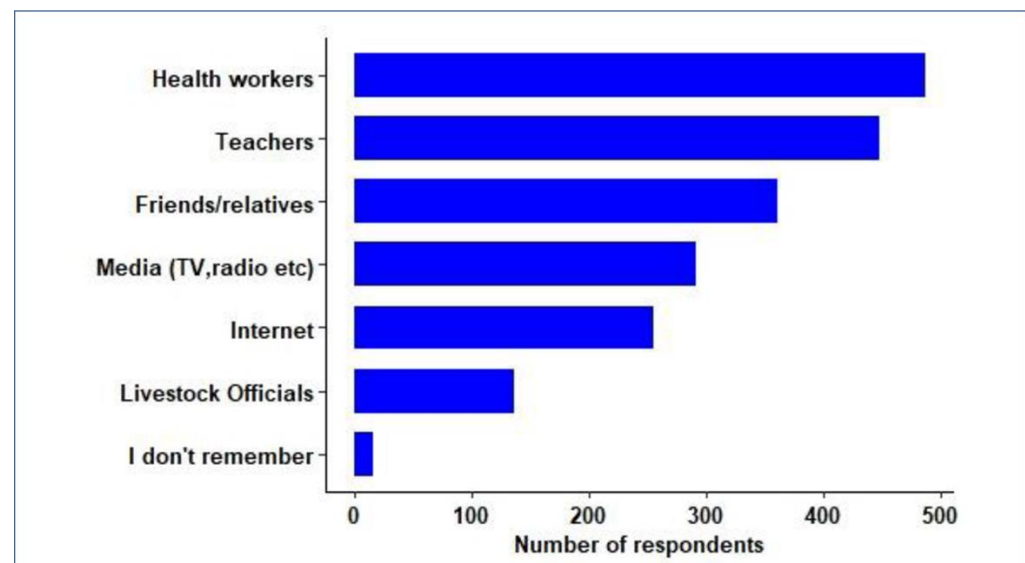


Figure 2. Sources of rabies information for the students of three secondary schools located in rabies endemic areas of south Bhutan (Phuntsholing, Gelephu, Garpowoong; n=701).

Regarding the causes of rabies (Figure 3a), most of the students (n=399, 58.0%) correctly identified viruses as cause of rabies (Table 4), although some students associated rabies to other factors such as bacteria (n=326, 47.4%), eating food or poison (n=256, 37.2%), psychological problems (n=189, 27.5%), starvation and thirst (n=109, 15.8%) and Spirits (n=28, 4.1%).

When asked about the susceptible host of rabies, almost all students (n=651, 94.6%) mentioned that dogs are the main susceptible host for rabies. They also correctly identified other domestic mammals like cattle, pig and horse (n=275, 40.0%), domestic cat (n=256, 37.5%), bats (n=140, 20.4%) and wild cats such as tigers and leopards (n=97, 14.1%) as susceptible host for rabies. However, some of the students surveyed also answered that wild birds (n=27, 3.9%), snakes (n=19, 2.8%), poultry birds (n=16, 2.3%), and insects (n=9, 1.3%) can also be affected by rabies (Table 4, Figure 3b), which is not in agreement with conventional veterinary knowledge. When asked if rabies can infect humans, six hundred thirty-six (92.4%) students knew that humans could get infected, but three hundred and ninety-seven (57.7%) students were not able to ascertain the fatal nature of the disease when symptoms have declared.

Regarding the transmission of rabies, 603 (87.7%) students understood that rabies can be transmitted through dog bites. Other possible transmission routes such as scratches due to animals and contact with saliva over broken skin were mentioned by 297 (43.2%) and 176 (25.6%) students respectively. Transmission routes through consumption of milk products (n=101, 14.7%), cooked meat (n=68, 9.9%), contact with dog urine and feces (n=190, 27.6%), contaminated water (n=23, 3.3%) and contaminated soil (n=8, 1.16%) were

also reported (Table 4, Figure 3c) although these transmission routes are not in agreement with conventional veterinary knowledge

Regarding clinical signs of rabies (Table 4, Figure 3d), most of the students mentioned that rabid animal is aggressive (n=470, 68.3%), fear water (n=341, 49.6%), and excessively salivate (n=262, 38.1%). Signs that were not usually associated with rabies such as coughing (n=102, 14.8%) and diarrhea (n=60, 8.7%) were also reported by some students.

Most students knew that rabies in dogs can be prevented by vaccination (n=452, 65.7%). Regarding the frequency of vaccination, 560 (81.4%) students mentioned that dogs should be vaccinated every year, while 105 (16.3%) students did not know the required frequency of vaccination. Few students (n=20, 2.9%) mentioned that only one-time vaccination was needed in the dog's lifetime, while three students (0.4%) mentioned that vaccination was not necessary. Other methods such as preventing dogs from contacting stray dogs (n=67, 9.7%), washing the dog with shampoo (n=67, 9.7%), not allowing the dogs to feed on garbage (n=54, 7.9%), and regular deworming (n=19, 2.8%) were also mentioned by some students as preventive measures for rabies.

Table 4. Student level of knowledge regarding rabies and perception towards dog bite management and rabid dog

Knowledge on rabies

Variable	Frequency (%)	School name			χ^2 P- Value
		GMSS	PMSS	GaMSS	
Knowledge on causes of rabies					
Psychological	189(27.5)	47(6.8)	78(11.3)	64(9.3)	0.678
Associated with spirit	28(4.1)	6(0.9)	7(1.0)	15(2.2)	0.065
Virus	399(58.0)	99(14.4)	150(21.8)	150(21.8)	0.002
Starvation and thirst	109(15.8)	31(4.5)	47(6.8)	31(5.5)	0.208
Bacteria	326(47.4)	78(11.3)	138(20.1)	110(16.0)	0.756
Eating bad food or poison	256(37.2)	62(9.0)	110(16.0)	84(12.2)	0.723
I don't know	87(12.7)	16(2.3)	55(8.0)	16(2.3)	<0.001
Knowledge on susceptible host of rabies					
Bat	140(20.4)	47(6.8)	49(7.1)	44(6.4)	0.002
Wild birds	27(3.9)	7(1.0)	15(2.2)	5(0.7)	0.208
Dog	651(94.6)	147(21.4)	280(40.7)	224(32.7)	0.843
Domestic animals (cow, pig, horse etc.)	275(40.0)	52(7.6)	80(11.6)	43(12.4)	<0.001
Cat	258(37.5)	70(10.2)	103(15.0)	85(12.4)	0.091
Insects	9(1.3)	1(0.1)	6(0.9)	2(0.3)	0.509
Poultry	16(2.3)	3(0.4)	12(1.7)	1(0.2)	0.014
Snake	19(2.8)	6(0.9)	9(1.3)	4(0.6)	0.396
Wild cats (tiger, leopard etc.)	97(14.1)	34(4.9)	38(5.5)	25(3.6)	0.006
Knowledge on mode of transmission of rabies					
Consumption of cooked meats	68(9.9)	10(1.5)	20(2.9)	38(5.5)	<0.001
Consumptions of milk products	101(14.7)	14(2.0)	17(2.5)	70(10.2)	<0.001
Contact with dog urine and feces	190(27.6)	33(4.8)	88(12.8)	69(10.0)	0.121

Contact with saliva over broken skin	176(25.6)	34(4.9)	62(9.0)	80(11.6)	0.001
Dog bites	603(87.7)	144(20.9)	244(35.5)	215(31.3)	<0.001
From contaminated water	23(3.3)	7(1.0)	6(0.9)	10(1.5)	0.241
From contaminated soil	8(1.2)	3(0.4)	4(0.6)	1(0.2)	0.383
Scratches of animals	297(43.2)	77(11.2)	127(18.5)	93(13.5)	0.158

Knowledge on clinical signs of rabies in dog

Aggressiveness and tendency to bite	470(68.3)	111(16.1)	215(31.3)	144(20.9)	0.016
Coughing	102(14.8)	22(3.2)	46(6.7)	34(4.9)	0.907
Diarrhea	60(8.7)	14(2.0)	31(4.5)	15(2.2)	0.256
Excessive salivation	262(38.1)	74(10.8)	94(13.7)	94(13.7)	0.003
Fear of water	341(49.6)	87(12.6)	112(16.3)	142(20.6)	<0.001
Paralysis of leg	103(15.0)	23(3.3)	49(7.1)	31(4.5)	0.567
Resting in the shade	98(14.2)	21(3.1)	49(7.1)	28(4.1)	0.308

Perception on post bite cares and rabid dogs

What should you do if you are bitten by dogs?

Wash with soap and water for 15 mins	598 (86.9)	124(18.0)	259(37.6)	215(31.3)	0.003
Go to the hospital and get vaccination	635(92.3)	149(21.7)	266(38.7)	220(32.0)	0.05
Do the local treatment	65(9.5)	14(2.0)	25(3.6)	26(3.8)	0.569
Do nothing and allow wound to heal	5(0.7)	2(0.3)	2(0.3)	1(0.1)	0.726

What will you do if you see dog with aggressive behavior?

Kill the dog	23(3.3)	8(1.2)	7(1.0)	8(1.2)	0.008
Report to teachers	104(15.1)	34(4.9)	48(3.2)	22(3.2)	0.002
Report to livestock officers	427(62.1)	108(15.7)	169(21.8)	150(21.8)	0.029
Take for treatments to animal hospital	472(68.6)	108(15.7)	197(28.6)	167(24.3)	0.496
Do nothing	72(10.5)	14(2.0)	43(6.3)	15(2.2)	0.008

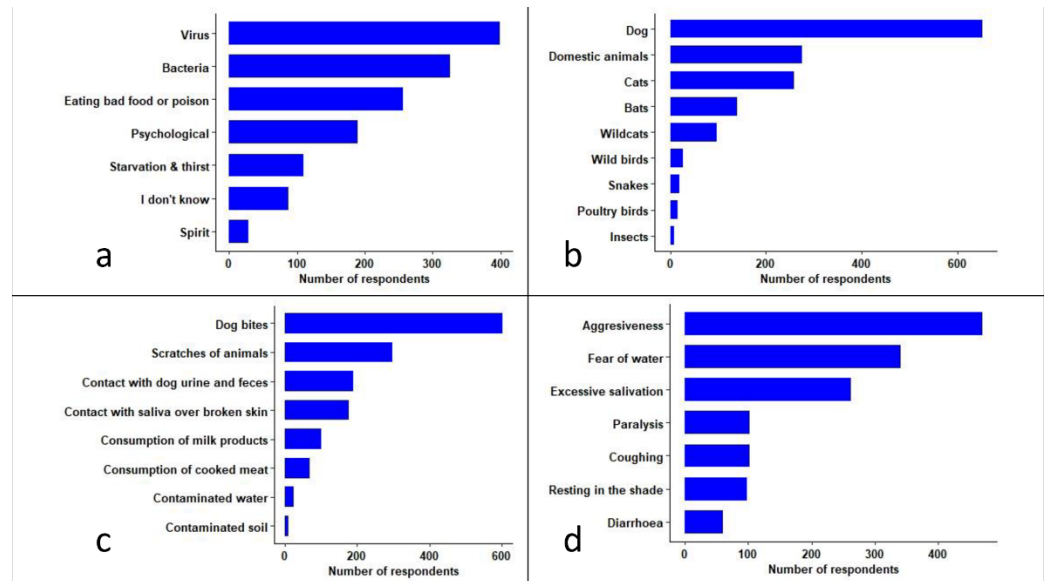


Figure 3. Knowledge on rabies among the students from study areas in South Bhutan: (a) knowledge on causes of rabies mentioned by the students; (b) knowledge on the susceptible hosts of rabies mentioned by the students; (c), knowledge on the mode of transmission of rabies mentioned by the students; and (d) knowledge on the clinical signs of rabies mentioned by the students.

3.5. Students' perception towards post-bite care and rabid dog

The details of what students would do if they were bitten by rabid dogs and what they would do if they saw a rabid dog in the streets are illustrated in Table 4 and Figure 4. Most of the students reported that they would wash the bite wound with soap and water ($n=598$, 86.9%) and go to the hospital to get anti-rabies vaccination ($n=635$, 92.3%). However, risky practices such as applying local medicines only ($n=65$, 9.5%) and doing nothing ($n=5$, 0.7%) to the bite wound were also reported by some of the students. If they saw a dog suspected of rabies in streets, 472 (68.6%) students indicated that they would try to catch the dog and take it to the animal hospital for treatment. Attitudes for other behaviors such as reporting to the livestock officers ($n=427$, 62.1%), reporting to their teachers ($n=104$, 12.0%), doing nothing ($n=72$, 10.5%), and killing the dogs ($n=23$, 3.3%) were also reported by some students

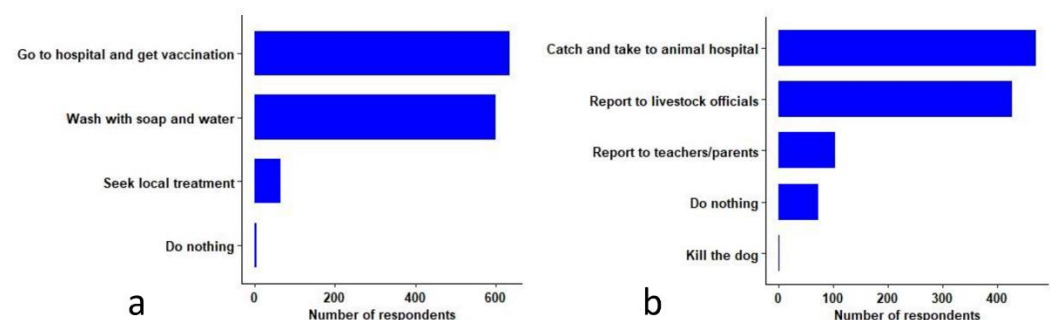


Figure 4. Students' perceptions on rabies: (a) what they would do if they were bitten by a rabid dog; (b) what they will do if they saw rabid dog in the streets.

The majority of the students ($n=546$, 79.4%) mentioned that they regularly play or have direct interaction with dogs, either every day or less frequently. Most of them mentioned interaction with their neighbor's dogs ($n=191$, 35.0%), followed by their own dogs (30.0%, $n=164$), with all the dogs that they see ($n=141$, 25.8%), and with stray dogs ($n=50$, 9.2%).

3.6. Logistic regression analyses

The results of the univariable and multivariable analysis of factors associated with the knowledge and perception of the students are presented in Table 5. The mean knowledge score of the students was 7.1 (SD = 2.0, median =7), with a minimum of 2 and a maximum of 13 points. The mean score of each grade in the different schools is given in Figure 5a. Significant differences were observed in the knowledge scores of the students between the three different schools, with students of GMSS (mean score=7.6) scoring higher than students of GaMSS (mean score= 7.2) and PMSS (mean score =6.6) ($P<0.001$). Using the cut-off score of ≥ 7.1 (mean), 411 out of 688 (59.7%) students were classified as having a “good” knowledge score and 277 (40.3%) as having a “poor” knowledge score on rabies. The final model indicated that students who had attended rabies awareness programs prior to the survey (Adjusted Odd Ratio: 1.5, 95% CI: 1.1-2.1) had higher odds of having good knowledge comparing to those that had not attended such rabies awareness program. Similarly, the students who were studying in grade IX (AOR:1.1,95% CI: 0.8-1.8) and grade X (AOR:1.7, 95%CI:1.1-2.6) were more likely to have a good rabies knowledge compared with students studying in grade VIII. Among the schools, students from PMSS (AOR: 0.7, 95% CI: 0.4-1.5) and from GaMSS (AOR: 0.5, 95% CI: 0.3-0.8) were less likely to have a good level of rabies knowledge compared to the students of GMSS.

The mean perception score was 3.5(SD: 0.8, median: 4) with a minimum score of 1 and a maximum of 5. No significant differences were observed in the perception scores by the students among the three different schools ($P=0.327$). The mean scores of each class in different schools are presented in Figure 5b. Using the cut-off score of ≥ 3.5 (mean) to classify into “favorable” and “unfavorable” perception score, 397 out of 688 (57.7 %) students were classified as having favorable perception on rabies, and 291 (42.3%) as unfavorable. Favorable attitudes and perceptions towards rabies were found to be significantly associated with: grades (higher for grade X; AOR: 1.9, 95%CI: 1.3-3.0); mother’s occupation (higher for employed mother; AOR: 1.7, 95%CI: 1.0-2.8) and hometown of the students (higher for students residing in villages; AOR:1.4,95%CI: 1.0-1.9).

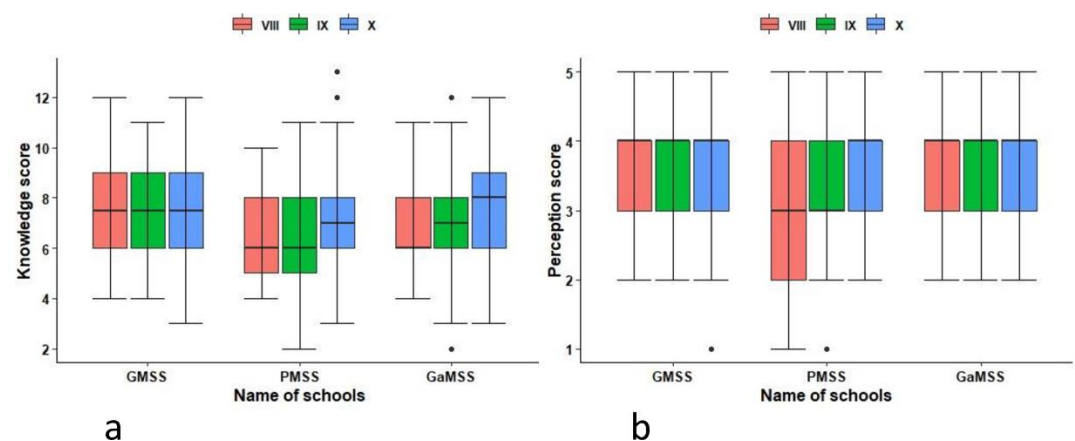


Figure 5. Boxplot showing total scores among students from the study areas: (a) knowledge scores; (b) perception scores.

Table 5. Logistic regression model showing the variables associated with the knowledge and perception level of the students on rabies (n=688)

Knowledge level of students on rabies						
Variables	Category	Adequate knowledge		Total	Univariable analysis OR (95%CI)	Multivariable analysis Adjusted OR (95%CI)
		No	Yes			
School	GMSS	78	78	156	Reference	Reference
	PMSS	192	105	297	0.6(0.4-0.8)	0.7(0.4-1.5)
	SMSS	141	94	235	0.7(0.4-1.0)	0.5(0.3-0.8)
Grade in which student study	Grade VIII	97	54	151	Reference	Reference
	Grade IX	177	107	284	1.1 (0.7-1.6)	1.1(0.8-1.8)
	Grade X	137	116	253	1.5(1.0-2.3)	1.7(1.1-2.6)
Attended rabies awareness program	No	268	151	419	Reference	Reference
	Yes	143	126	269	1.6(1.2-2.1)	1.5(1.1-2.1)
Age	Adolescent	258	196	454	Reference	
	Young	153	81	234	0.7(0.5-1.0)	
Perception level of students on rabies						
Variables	Category	Favorable perception		Total	Univariable analysis OR (95%CI)	Multivariable analysis Adjusted OR (95%CI)
		No	Yes			
Mother occupation	Self employed	264	339	603	Reference	Reference
	Employed	27	58	85	1.7(1.0-2.8)	1.7(1.0-2.8)
Grade in which student study	Grade VIII	72	79	151	Reference	Reference
	Grade IX	138	146	284	1.0 (0.7-1.4)	1.00 (0.7-1.5)
	Grade X	81	172	253	1.9(1.3-2.9)	1.9(1.3-3.0)
Hometown of the students	Town	213	267	480	Reference	Reference
	Village	78	130	208	1.3(1.0-1.9)	1.4(1.0-1.9)
Age	Adolescent	178	113	454	Reference	Reference
	Young	276	121	234	0.7(0.5-1.0)	

4. Discussion

Our study indicated that most of the students (98%) surveyed in rabies endemic areas of the country have heard about rabies and have a good level of knowledge on various aspect of rabies, including the source of the disease, susceptible hosts, route of transmission, clinical signs, and preventive measures. This high awareness level among students may be due to frequent reports of rabies outbreaks in the study areas, in addition to the rabies awareness campaign conducted by the government. In Bhutan, the animal and public health officials conduct an annual education campaign related to dog bite prevention and rabies, coinciding with World Rabies Day (28th September). In addition to the general awareness program broadcast by radio and television on rabies, the specific awareness education program is also organized in the schools. The school children also take part in the street walk in rabies endemic areas disseminating message on the importance of dog

vaccination, prevention of dog bites, among others. The level of knowledge on rabies among the students in this study is comparable to the adult population in the country [7,10,13] but higher than students from neighboring Sikkim state of India (81%) studying in similar grades [20]. Although a great majority of the students had a good level of general knowledge on rabies, some important knowledge gaps were identified by our study (Table 2). The students usually did not know the fatal nature of the disease, that dogs are the most important sources of rabies, and that they must visit a hospital for PEP following dogs' bites, whereas local treatments are not efficient alone to cure the disease. Studies conducted among students in India [20,21], Sri Lanka [22], the Philippines [23], and Nigeria [24] have reported similar knowledge gaps, underlining the associated risks and the need for the specific rabies education in school children in rabies endemic areas. The knowledge and awareness level of rabies was reported to be associated positively with several factors including the age of the respondents [25], sex [26,27], education level [20], dog ownership status [28], economic status [10], and religion [29]. Our study results showed that rabies knowledge level in endemic areas of Bhutan was associated with the education level (grades) of the students. This result was expected because students studying in higher grades tend to have greater academic knowledge and a better understanding of the subjects in biology and health compared to lower grades. Similar observations were also reported for school children in Sikkim State of India [20]. Among the three selected schools in southern Bhutan, students of Gelephu Middle Secondary School had comparatively a better knowledge than the two other towns, which may be associated with high incidences of rabies in animals, dog bites, and PEP events in Gelephu [10,14], and a higher percentage of dog ownership [30]. A KAP study carried among the adult population in Gelephu also demonstrated a higher understanding and knowledge of rabies compared to other areas of the country [10]. The higher level of knowledge demonstrated by students who had attended the rabies awareness program also indicated the importance of the awareness program as a means of rabies information dissemination, particularly for the school children. As discussed before, rabies awareness program is provided to the students on World Rabies Day, and also following rabies outbreaks in the area. The improvement in knowledge of the students after the rabies education has been reported in other countries [20,22,23,28,31].

Dog bites are responsible for more than 99% of rabies cases in the world [3]. Therefore, thorough washing of the bite wound with soap and water, administration of PEP, and infiltration of rabies immunoglobulins are the only efficient treatments to prevent humans from getting rabies after being bitten by a rabid dog [3,32]. Our study showed that the majority of the students had a favorable attitude and perceptions towards post-bite care and management. However, some students mentioned risky practices, such as not visiting the hospital and resorting to local practices (Table 3). It was also revealed that some students who had been bitten by dogs before our study had not visited the hospital but only sought local treatment (Table 3). This is of great concern since it would prove fatal if bitten by a rabid dog. Most of the human mortalities in rabies endemic countries occur following inefficient health-seeking behaviors by dog bite victims, who cannot, or do not want to, access appropriate medical treatment and resort to local treatments [4,19,21,33,34]. Furthermore, the students in our survey mentioned that they would try to catch and take a sick dog to a veterinary hospital for treatment. Although it is a good attitude on animal welfare grounds, this will put children at risk of contracting rabies infection. Therefore, it is important to educate children on the health risk of such practices and make them aware of whom to report the incidents should they encounter such cases in their locality or school premises. Our study also showed that children whose mothers are formally employed displayed a more favorable attitude towards post-bite care and rabid dogs. This suggests that mothers may play an important role in children's health education, which should be further targeted by the rabies education program. Lastly, more favorable perceptions were found for students from villages, compared to the urban origin, but this result needs further investigation.

In addition to the KAP of students on rabies, we also collected data/information related to dog ownership in the study area. Amongst various methods to estimate dog population, interviewing school children is also one of the methods to estimate the dog population and vaccination coverage [35]. Our survey found that 31.0 % (n=217) of the students owned one or more dogs at home, which is in agreement with previous community studies conducted in Bhutan [30]. Although most of the students reported that the dogs they owned were vaccinated (73.0%), dog management appeared poor since most dogs were allowed to roam day and night. Mixing with stray and free-roaming dogs increases the risk of rabies transmission and can result in an increase in dog populations through uncontrolled reproduction.

5. Conclusions

Overall, our study in rabies endemic areas of Southern Bhutan showed that most of the students have good knowledge and favorable perception towards rabies. However, some knowledge gaps and unfavorable perceptions were identified. We recommend to revise and update rabies awareness tools and materials since the rabies awareness program is one of the major sources of rabies information for the students. Inclusion of new educational materials, such as rabies ‘serious games’ as part of rabies education and awareness campaign would help to communicate the ideas in better ways to the students. Further, to increase the awareness level of the students, an awareness program should be also given to parents, especially targeting mothers, and young children. Since teachers are also one of the important sources of rabies knowledge/information for the students, educating and engagement of teachers in rabies preventive and control programs would enhance rabies education in school children.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Table S1: Knowledge, Attitude and Practice survey data.

Author Contributions: Conceptualization by L.L., T.T., W.P. and M.d.G.-W.; formal analysis by L.L., S.R. and T.T.; investigation by L.L. and M.d.G.-W.; data curation by L.L.; writing—original draft preparation by L.L.; writing—review and editing by L.L., S.R., T.T., W.P., and M.d. G.-W.; visualization by L.L.; supervision by L.L., S.R., T.T., W.P., and M.d. G.-W.; project administration by W.P. and M.d. G.-W. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was approved by the Research Ethics Board of Health, Ministry of Health, Bhutan (Ref. No. REBH/Approval/2019/113).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Supplementary materials, Table S1: Knowledge, Attitude and Practice survey data.

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