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# Epidemiology of suspected rabies cases in Ethiopia: 2018–2022

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## Abstract

Rabies is a zoonotic disease affecting both public health and the livestock industry in Ethiopia. However, there is limited national-level information on the extent of the disease. Therefore, we studied the national burden and distribution of Rabies on both humans and animals. We conducted a retrospective descriptive study on rabies by obtaining five years (2018–2022) data from the Ethiopian Public Health Institute (EPHI) and the Ministry of Agriculture. We analyzed the incidence, mortalities, temporal and spatial patterns. Microsoft Excel and ArcGIS version 10.2 were used for descriptive and spatial analysis respectively. A total of 37,989 Rabies suspected human exposure cases and 297 deaths were reported with a mean annual number of 7,598 human exposure cases and 59 deaths. The exposure case and mortality incidence rates were 6 and 0.05 per 100,000 populations respectively. Suspected human exposure cases significantly increased from 5,217 (2018) to 11,298 (2022) at a rate of 2.2. In the same period, 2,094 animal suspected rabies cases and 1,682 deaths were reported predominantly in dogs (71.2%), followed by cattle (27.8%) and other domestic animals (1%). There is high rabies suspected human exposure cases at national level. Suspected rabid dogs were the major source of infection in humans. There were gaps in the reporting of animal cases and low dog vaccination coverage. Hence, it is important to strengthen One Health collaboration to enhance surveillance, information sharing, and diagnostic capacity and improve mass dog vaccination coverage.

**Keywords** Rabies, Surveillance data, Human, Animal, Ethiopia

## Introduction

Rabies is among the 20 Neglected Tropical Diseases (NTDs) prioritized by the World Health Organization (WHO) due to its devastating impact on impoverished communities [1], and it is the top priority zoonotic disease in Ethiopia [2]. It is also categorized under immediately reportable disease through Public Health

Emergency Management (PHEM) [3]. The causative agent is a neurotropic rabies virus in the genus *Lyssavirus*, family *Rhabdoviridae*. All mammals including dogs and humans are susceptible to infection and the reservoir is among wild mammals, particularly foxes. Transmission to humans or animals occurs as a result of a bite from a rabid animal [4]. The risk of becoming infected depends on the nature and location of the bite, and the virus concentration in the saliva is important [5]. The diagnosis is verified by biopsies from the skin, cornea impressions, or postmortem examination of brain tissue [6].

Epidemiologically, rabies is reported in many countries throughout the world and has been documented in all continents except Australia, New Zealand, the United Kingdom, Japan, Scandinavian and Caribbean countries,

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some islands, and Antarctica; where the major vectors of rabies are absent [7]. The disease is estimated to cause 59,000–60,000 human deaths annually in over 150 countries, with 95% of cases occurring in Africa and Asia. Globally, it causes an estimated cost of 8.6 billion US dollars. On the other hand, the annual rabies-associated livestock losses in the world are estimated above 50 million (USD), making rabies important to both human and animal health [8].

In developing countries, the major rabies reservoir remains unvaccinated domestic dogs and the primary route of transmission is the bites of rabid dogs [4]. The disease is endemic in Ethiopia and is well known in domestic dog populations all over the country [9], where 88% of the exposure cases in humans were due to dog bites [10], with an estimated 2,771 human deaths annually [11]. The annual post-exposure treatment costs around 1.6–2.5 million USD, and the corresponding health losses were estimated to be 193,748 DALYs per year [12]. The impact is also massive in the Ethiopia livestock sector and affected cattle herds, with an average of 228 USD losses per year in the mixed crop-livestock system and 477 USD in the pastoral system [13].

Prevention and control of the disease requires joint collaborative efforts of several sectors and mainly involves strict quarantine measures, control of stray dogs, extension programs, control of rabies in wildlife, registration, and prophylactic dog vaccination [5]. Human rabies deaths are almost entirely preventable through prompt delivery of post-exposure prophylaxis (PEP) to victims bitten by rabid animals [14]. Ethiopia is implementing an Integrated Rabies Control and Elimination Strategy (2018–2030) with a focus on mass dog vaccination. The other major components of the strategy are dog population management, Rabies prevention and control in wildlife, strengthening surveillance, diagnostic capacity, information sharing among sectors, and prevention in humans through awareness, and provision of post-exposure prophylaxis [15]. The strategy was developed

considering WHO’s Roadmap for Neglected Tropical Disease [1] and it was aligned with the global strategic plan to achieve the goal of ‘Rabies Zero by 2030’ [16].

Despite the availability of several human or animal-specific studies undertaken to target the capital city and some towns of the country, integrated national-level comprehensive studies both on human and animal rabies are lacking. This study aims to fill the existing information gap and avail scientific facts for informed decision-making. In addition, the findings would be an important input to gear the current national Rabies eradication program. Therefore, this study was undertaken to determine the national five-year human and animal Rabies burden and distribution thereby generating information for the national One-health actors for improved Rabies control program.

**Results**

**Summary of suspected rabies cases in humans and animals**

Rabies suspected human exposure and animal cases were found to increase from 2018 to 2022 with a minor decrease in animal cases during 2022. The possible factors that contributed to the increased human exposure cases could be due to higher animal cases resulting from the increased number of stray and free-roaming dogs. On the other hand, improved awareness of rabies also encouraged exposed people to visit health facilities (Table 1).

**Status of rabies in humans**

In the study period (2018–2022), a total of 37,989 suspected human rabies exposure cases and 297 deaths were reported from all parts of the country. The reports were received from 526 sites of which 440 were districts and towns while 86 were hospitals.

The number of suspected exposure cases showed an annual increment at a rate of 1.22 while the case fatalities were decreasing which could be due to improved awareness of the use of post-exposure prophylaxis.

**Table 1** Suspected rabies in humans and animals per year

Year	Rabies in humans			Rabies in animals		
	Suspected exposure cases	Death	Case fatality per 1,000 population	Suspected cases	Deaths	Case fatality (%)
2018	5,217	61	11.7	371	285	76.8
2019	6,069	96	15.8	308	243	78.9
2020	7,320	44	6.0	351	271	77.2
2021	8,085	42	5.2	551	441	80
2022	11,298	54	4.8	513	442	86.2
<b>Sum</b>	<b>37,989</b>	<b>297</b>	<b>7.8</b>	<b>2,094</b>	<b>1682</b>	<b>80.3</b>

The temporal pattern showed similarity except in 2022 where a significant increase in the number of suspected exposure cases was observed from September to December. May and December were the two peak seasons with a mean suspected human exposure cases of 687 and 757 respectively (Fig. 1).

There was variation among regions in terms of rabies burden. Amhara region reported the highest suspected exposure cases and deaths followed by Tigray, Addis Ababa, and Benishangul Gumuz regions as indicated in Table 2.

The spatial analysis showed the highest distribution of rabies in Amhara and Tigray regions and Addis Ababa city while Afar and Somale regions reported very few cases associated with the presence of few dog populations (Fig. 2).

**Rabies in animals**

From 2018–2022, a total of 2,094 animal suspected rabies cases and 1,682 (80.3%) deaths were reported. Among the total deaths, the highest was in dogs (73%) followed by cattle (17.3%), equine (6.8%), and others (2.9%). The annual mean mortality trend showed an increase with 336 animals dying every year (Table 3).

Among the animal species with suspected cases, dogs were predominant with 71.2% followed by cattle (19.7%), equine (6.2%), and camel, sheep, and goat collective comprising 2.9%. The cases in the other animals were attributed to the bite of a suspected rabid dog.

Among the total animal cases, only five reported from Addis Ababa, Amhara, and SWE regions were confirmed by the laboratory. The numbers were very few due to limited access and unavailability of rabies diagnostic tests in veterinary laboratories and also weak communication and information sharing with the Ethiopia Public Health

**Table 2** Rabies suspected human exposure cases and death per year and region

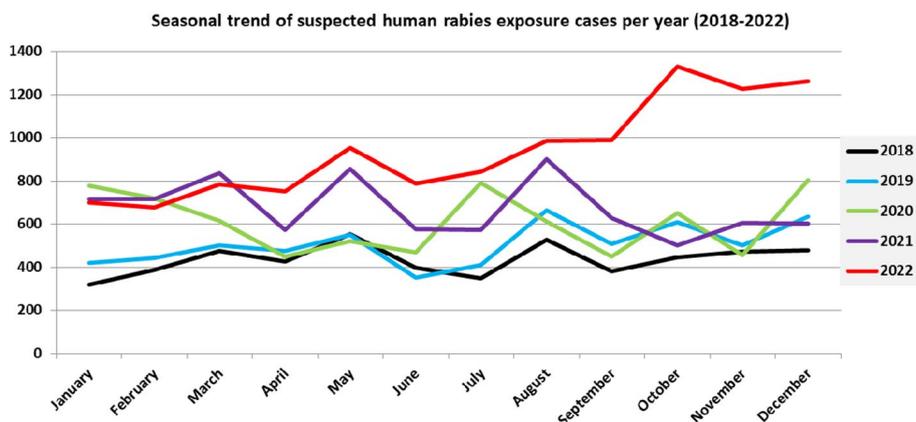
Region	Total case	Total death	Case fatality (per 1,000 population)
Addis Ababa	3,528	11	3.1
Afar	12	0	0.0
Amhara	19,436	114	5.9
Benishangul-Gumuz	2,561	12	4.7
Diredawa	7	0	0.0
Gambella	29	3	103.4
Harari	1	0	0.0
Oromia	1,762	66	37.5
SNNP	1,890	38	20.1
Somali	57	2	35.1
SWE	287	0	0.0
Tigray	8,419	51	6.1
<b>Sum</b>	<b>37,989</b>	<b>297</b>	<b>7.8</b>

Institute (EPHI) where rabies diagnosis for both humans and animals is undertaken.

The overall mean incidence rate of dog suspected rabies was 3.5 per 1,000 dog populations with annual increment and the case fatality specific to dogs was 82.4% while it was between 35.5 to 91.7% for other animals (Table 4).

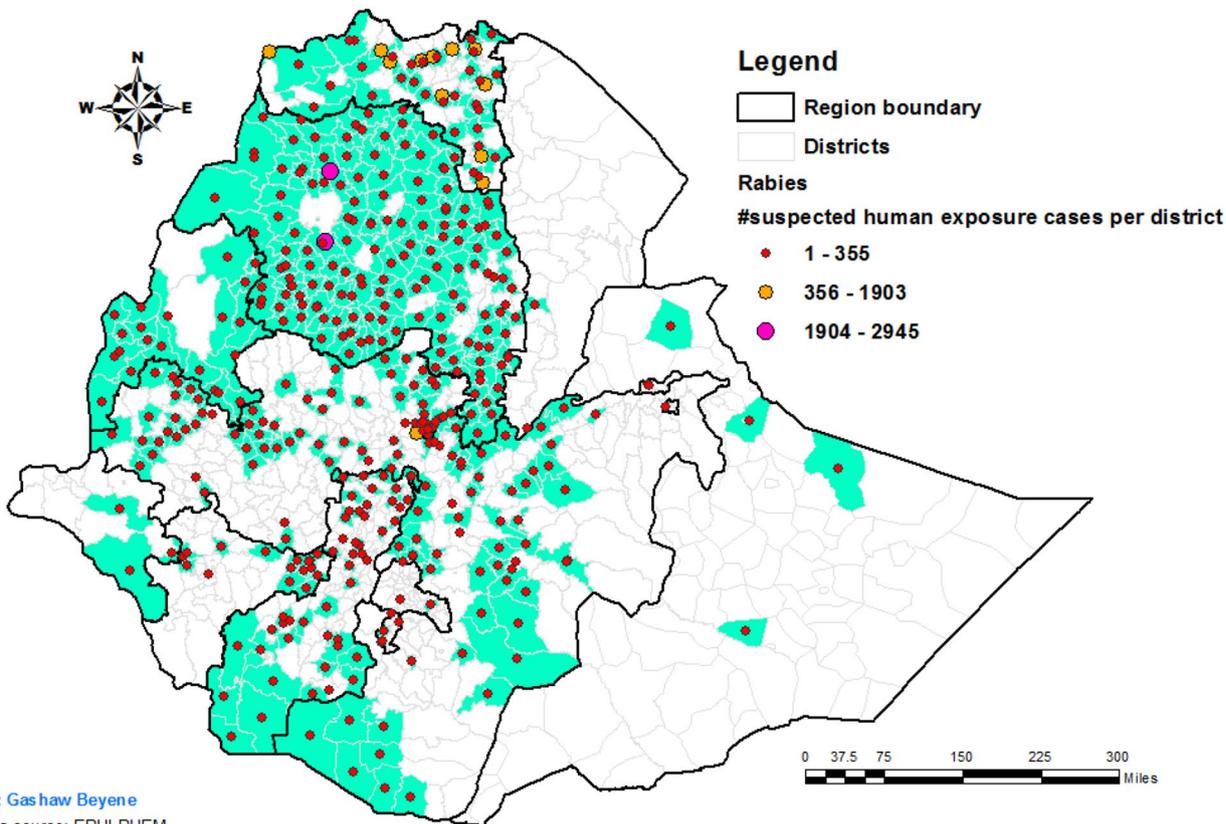
As shown in Fig. 3 below, the seasonal occurrence of dog rabies follows a uniform pattern from 2018–2020 while there were variations in 2021 and 2022. The highest cases were recorded in January 2021 and April and September during 2022.

In general, the five years monthly mean numbers of the highest cases were 37, 34, 32, and 31 reported in April, January February, and September respectively.



**Fig. 1** Temporal pattern of rabies suspected human exposure cases

Distributions of suspected rabies human exposure cases



By: Gashaw Beyene

Data source: EPHI PHEM

Fig. 2 Map showing distributions of suspected human rabies exposure cases in Ethiopia (2018–2022)

Table 3 Animal suspected rabies cases and deaths per year (2018–2022)

Year	Species												Sum	
	Cattle		Camel		Dog		Goat		Equine <sup>a</sup>		Sheep		Case	Death
	Case	Death	Case	Death	Case	Death	Case	Death	Case	Death	Case	Death		
2018	108	68			225	179	18	18	19	19	1	1	371	285
2019	82	66			175	129			47	45	4	3	308	243
2020	113	75	1	1	209	173	2	2	25	20	1	0	351	271
2021	62	51			463	364	2	2	7	7	17	17	551	441
2022	47	31	13	4	419	383	2	0	31	23	1	1	513	442
<b>Sum</b>	<b>412</b>	<b>291</b>	<b>14</b>	<b>5</b>	<b>1,491</b>	<b>1,228</b>	<b>24</b>	<b>22</b>	<b>129</b>	<b>114</b>	<b>24</b>	<b>22</b>	<b>2,094</b>	<b>1,682</b>

<sup>a</sup> Equine includes donkey, horse and mule

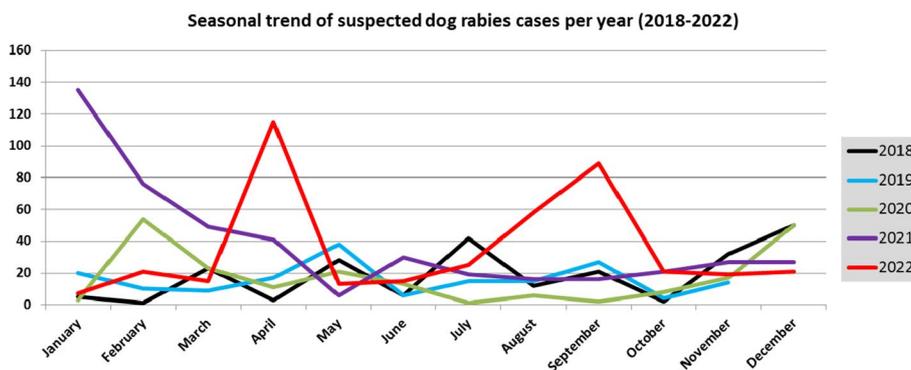
The map (Fig. 4) for five years of spatial distribution with count rendering of suspected dog rabid cases showed the highest distributions in Amahara, Tigray, Oromia, and South West Ethiopia regions.

The number of suspected dog rabies cases and deaths was higher in Amahara, Oromia, and SNNP regions (Table 5).

As part of prevention and control, there is an ongoing dog vaccination program against rabies. From 2018 to 2022, a total of 369,633 dogs were vaccinated in the country. The highest vaccination was in Amhara (107,541) region followed by Addis Ababa (91,647), Oromia (62,109), and SNNP (2,177), and in the remaining regions, it ranges from 1,094 to 15,013. There were no

**Table 4** Rabies suspected dog cases and deaths per year

Year	No. of Cases	No. of Deaths	Case fatality rate	Population at risk	Prevalence per 1000 dogs
2018	225	179	79.6	163,787	1.4
2019	175	129	73.7	41,958	4.2
2020	209	173	82.8	61,859	3.4
2021	463	364	78.6	92,953	5.0
2022	419	383	91.4	62,077	6.7
<b>Sum</b>	<b>1,491</b>	<b>1,228</b>	<b>82.4</b>	<b>422,634</b>	<b>3.5</b>



**Fig. 3** Temporal pattern for suspected rabies dog cases (2018–2022)

vaccination reports from the Afar and Harari regions associated with weak reporting (Fig. 5).

There was an annual increasing trend in the number of vaccinations with some decrease in 2020 associated with the COVID-19 outbreak in the country. The highest vaccination was in 2022 due to implementation of a national mass dog vaccination program in the country.

In 2022, out of the total estimated 7.5 million dogs in the country, only 222,480 were vaccinated against rabies with a very low national coverage of 3%. The coverage in regions varies ranging from 0 to 61.8%. The highest coverage of vaccinations was in Benishangul Gumuz region and Diredawa City Administration with 61.8% and 59.8% respectively. There were no vaccination reports from the Afar, Harari, Somale, and Tigray regions due to several factors including security and gaps in reporting (Table 6).

**Temporal and spatial analysis of rabies in humans and dogs**

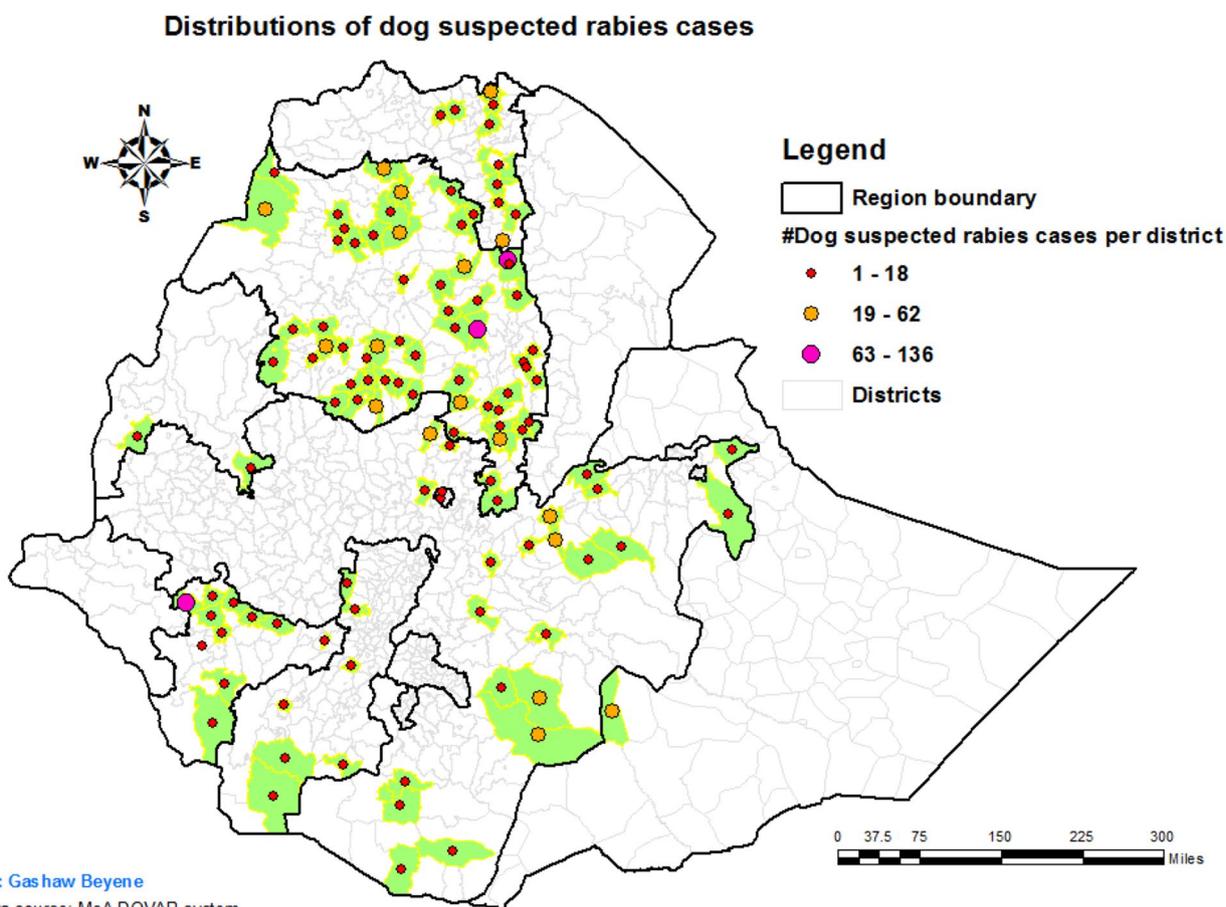
The five years temporal pattern showed that March/May and August/December were months with the highest mean suspected human exposure cases whereas January/February and September/December were seasons with higher suspected dog cases. This inconsistency could be associated with the fact that there was a gap in timeliness and underreporting of animal cases.

The spatial analysis of the five years trend also showed some mismatch between areas reporting suspected human exposure and dog rabies cases (Fig. 6).

Despite reports of human suspected exposure cases; there were no animal rabies reports from the Gambella region and Diredawa city administration and some parts of the other regions due to the reporting gap.

**Discussion**

The analysis of the data from 2018–2022 showed that Rabies is still a major challenge due to its impact on public health and the livestock sector. A total of 37,989 suspected rabies human exposure cases and 297 deaths with 7598 and 59 mean annual number of cases and deaths were reported respectively. Death of a person occurred from every 128 suspected exposure cases. In general, the study revealed an annual mean incidence rate of 6 suspected human exposure cases and 0.05 deaths per 100,000 populations. Among the total 2,094 animal suspected cases, dogs covered 71.2% of the total cases, and other species accounted for 28.8%. A suspected rabid dog was found to be responsible for 26 suspected human exposure cases. The exposure cases increased significantly from 5,217 in 2018 to 11,298 in 2022 at a rate of 2.2. This could be associated with limited dog vaccination



**Fig. 4** Map showing distributions of dog suspected rabies cases in Ethiopia (2018–2022)

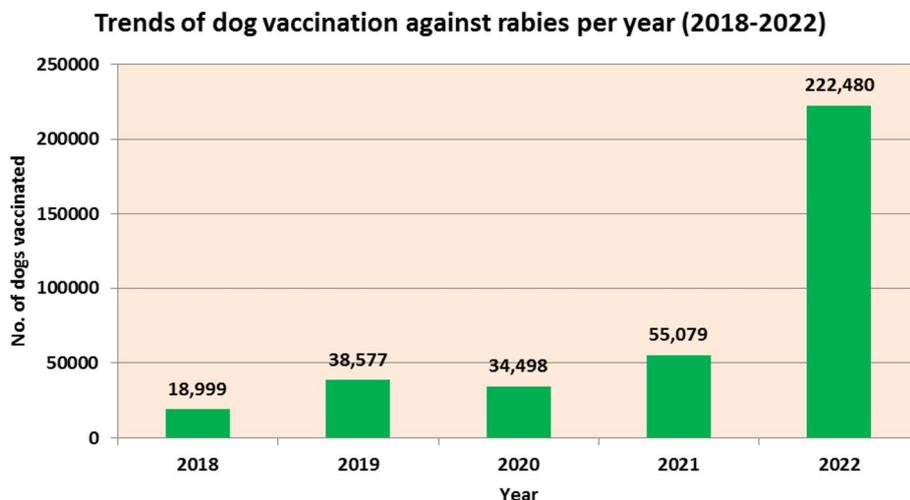
**Table 5** Dog rabies suspected cases and deaths per region

Region	Total case	Total death	Dog population at risk	Prevalence per 1000 dogs	Case fatality rate (%)
Addis Ababa	17	17	90	188.9	100
Amhara	802	623	289,542	2.8	77.7
B/Gumuz	3	3	70	42.9	100.0
Oromia	350	280	60,890	5.7	80.0
SNNP	209	200	56,346	3.7	95.7
SWE	23	22	1,269	18.1	95.7
Tigray	87	83	14,427	6.0	95.4
<b>Sum</b>	<b>1,491</b>	<b>1,228</b>	<b>422,634</b>	<b>3.5</b>	<b>82.4</b>

coverage, increased population of stray dogs in the major towns, and interaction of wildlife and domestic animals.

The incidence rate of suspected human exposure 6 per 100,000 populations of the current study was in agreement with a study conducted in the Amhara region [17]. However, it was relatively higher compared to the

national surveillance report of EHNRI [18] but lower than the incidence rate reported from Addis Ababa city [19], the National Rabies baseline survey [20], and Northern Tigray [21]. The variation could be due to the regional divergence in dog population including stray and free-roaming dogs, vaccine coverage, and awareness.



**Fig. 5** Dog rabies vaccination trend per year (Number vaccinated per year)

**Table 6** Dog rabies vaccination coverage per region in 2022

Region	Vaccination	Dog population estimate*	Vaccination coverage (%)
Afar	-	-	-
Addis Ababa	40,113	175,000	22.9
Amhara	71,637	1,100,000	6.5
Benishangul Gumuz	10,839	17,525	61.8
Diredawa	5,202	8,700	59.8
Gambella	2,840	283,256	1.0
Harari	-	11,000	-
Oromia	50,211	5647934	0.9
Sidama	6,176	21,745	28.4
SNNP	21,454	105,796	20.3
Somale	-	-	-
SWE	14,008	134,266	10.4
Tigrai	-	-	-
<b>Total</b>	<b>222,480</b>	<b>7,505,222</b>	<b>3.0</b>

Source: Ministry of Agriculture, Veterinary Public Health Desk

\* The estimated population received from regional veterinary services

The mean incidence of human deaths 0.05 per 100,000 populations was lower compared to 1.6/100,000 reported by the national rabies baseline survey report [20]. The deaths due to rabies were decreasing which could be due to increased awareness and use of post-exposure prophylaxis.

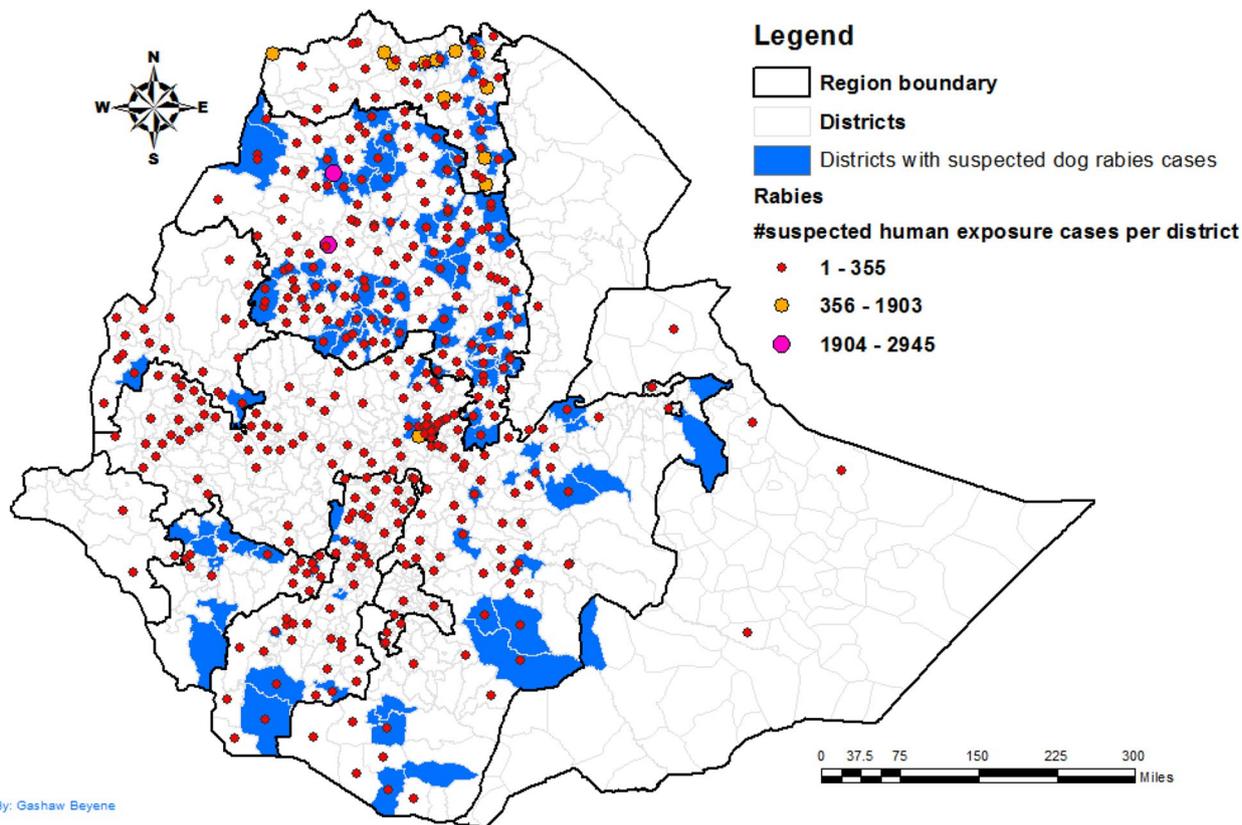
The current study revealed that 71.2% of the total animal suspected rabies cases were dogs out of which only five were confirmed whereas 1,122 confirmed dog Rabies cases were reported from Addis Ababa and surrounding regions [22]. In our study, there were no feline and

wildlife rabies cases whereas, human exposures attributed to cats and wild animals were reported from Addis Ababa and surrounding regions [22], and cats and donkeys from the Amhara region [17]. There were also reports of rabies cases from Bale Mountains National Park on human, dog, and other domestic animals exposure due to confirmed rabies outbreaks in Wolves [23]. This showed the transmission of rabies from wild to domestic animals and humans. The factors contributing to the variation could be gaps in sensitivity, and completeness of animal disease surveillance, and limited information sharing between animal and public health sectors mainly due to weak One Health in the country. One Health has become more important since many factors have changed interactions between people, animals, plants, and our environment. It is an approach that recognizes the health of people is closely connected to the health of animals and our shared environment [16].

The seasonal pattern for 2022 showed higher suspected rabies human exposure cases from September to December which is in agreement with the study conducted in Addis Ababa and surroundings [24]. The overall five-year mean seasonal pattern was characterized by two major peaks, which could be associated with the reproductive cycle of dogs. In humans, March/May and August/December, and in dogs January/February and September/December were the highest transmission periods.

The highest distribution of rabies was in Amhara and Tigrai regions and Addis Ababa city with 19,434, 8,419, and 3,528 suspected human exposure cases respectively. Among major towns, Gonder, Bahirdar, Mekelle, and Addis Ababa city and other towns from Amahara, Benishangul Gumuz, Gambella, Oromia, and Tigrai regions were hotspot areas because a considerably higher

### Distribution of suspected rabies in Ethiopia (2018-2022)



**Fig. 6** Map showing overlay analysis for distributions of suspected human rabies exposure and dog cases in Ethiopia (2018–2022)

number of human exposure cases and occurrence of consistent outbreaks were reported. The highest mortality was from the Amhara region (114) followed by Oromia (66), Tigray (51), and SNNP regions (38). However, despite few numbers of mortalities, the case fatality was significantly higher in Gambella region (10.3%) but was lower in Oromia (3.8%), Somale (3.5%), SNNP (2.1%), Amhara (0.6%), Tigray (0.6%), Benshangul region (0.5%) and Addis Ababa city (0.3%), whereas according to EPHI report, the highest case fatalities were from Oromia (58.6%) followed by Addis Ababa city (17.2%), Amhara (14.9%), and SNNP (9.2%) regions [22]. This could be associated with proximity to the Ethiopian Public Health Institute (EPHI) rabies diagnostic laboratory for testing where most cases were from Addis Ababa and surrounding regions.

A total of 11,014 suspected human exposure cases were reported from hospitals with the higher number of cases from Assosa (1,710), Debre Markos (2,097), and Addis Alem hospitals (2,640) with a mean of 496 cases per year. On the other hand, 26,975 exposure cases were reported from district/town health offices with a mean number of 5,395 cases per year. The

highest exposure cases ranging from 1,045–2,945 were reported from Gonder, Bahirdar, and Mekelle towns and relatively higher cases 500–700 were from Laelay Adiabo, Addis Ababa city Kirkose wereda 11, Axum, Maychew, Aheferom, Humer and Wukro towns and in others it was below 500.

Animal Rabies cases were reported from all regions except Afar, Gambella, Harari regions, and Diredawa city. Higher numbers of suspected dog rabies cases were from Amhara followed by Oromia, SNNP, and Tigray regions. The prevalence was highest in Addis Ababa city (189/1,000 dogs) followed by Banishangul Gumuz (43/1,000), and SWE (18/1,000). To control the disease, a total of 369,633 dogs were vaccinated with a mean annual 73,927 dog vaccination. The vaccination number was low since the data from private practitioners was not included. In the study period, the highest numbers of vaccinations were from Amhara followed by Addis Ababa, Oromia, and SNNP regions. The relatively higher number of vaccinations in Addis Ababa city is an indication of the awareness of dog management including a better understanding of vaccination supplemented with

accessibility where enormous privates are providing veterinary services in the city.

### Limitations

Our study was limited to analyzing suspected human exposure cases and deaths by place and time since data on Post Exposure Prophylaxis (PEP), and demography like age, sex, occupation, and other risk factors were not available. Thorough spatial analysis and interpolation were not undertaken since both human and animal surveillance data lack geographic coordinates (latitude and longitude). There were also data limitations on dog population, stray dog management, and vaccination data from privates.

### Conclusion and recommendations

The current study showed a higher burden and distribution of rabies at the national level in humans and animals. Suspected human rabies exposure cases and deaths were found higher attributed to the fact that outbreaks are continuously increasing in animals. Several animal species including dogs, cattle, camels, equine, and sheep were affected with the highest cases in dogs. Rabies was reported throughout the year from most parts of the country with two peak seasons. High exposure cases were from Amhara and Tigray regions and Addis Ababa city. In some areas, despite reports of suspected human exposure cases, there were no reports of Animal rabies cases. Very few suspected dogs were tested since there is limited capacity for Rabies diagnostic tests at the regional EPHI and veterinary laboratories. Despite the implementation of a national dog vaccination program to reduce the incidence and thereby achieve 'Zero by 2030', the coverage is low and limited to major towns. Therefore, further study should be conducted with special consideration in hotspot areas to determine the risk factors and source of infection. All stakeholders including the Ministry of Health, Ministry of Agriculture, Wildlife Conservation Authority, and Environment Protection Authority should work jointly in the One Health approach in the control program to improve dog vaccination coverage, surveillance, information sharing, awareness of communities, and funding. It is also important to capacitate national and regional public and veterinary laboratories on rabies diagnosis and testing.

### Methodology

#### Study design and duration

We conducted a retrospective descriptive study from 12 March–09 May 2023 by obtaining rabies surveillance data for five years from 2018 to 2022. The data for humans and animals were collected from the Ethiopia

Public Health Institute (EPHI) and the Ministry of Agriculture (MoA) respectively.

### Study area

Our study focused on assessing the burden of Rabies in Ethiopia at the national level both in humans and animals and hence all parts of the country were considered. The country is administratively categorized into 11 regional states (Afar, Amhara, Benishangul, Gambella, Harari, Oromia, Sidama, SNNP, Somale, South West Ethiopia (SWE) and Tigray regions) and two city administrations namely Addis Ababa and Direedawa. According to Worldometer 2023 data, the population of Ethiopia is estimated at 122,809,210 based on Worldometer elaboration of the latest United Nations data [25]. Ethiopian seasons consist of four phases: Autumn (Sept.—Nov.), Winter (Dec.—Feb.), Spring (Mar.—May) and Summer (Jun.—Aug.). The dry and cold season is winter and summer is an extremely rainy season [26].

### Data collection and analysis

We obtained the data extracted from the Ethiopian Public Health Institute Public Health Emergency Management (EPHI PHEM) and Ministry of Agriculture (MoA) Disease Outbreak and Vaccination Activity Reporting (DOVAR-II) systems of respective institutes. We reviewed the content and variables of the data and organized it after checking for outliers, consistency, completeness, and typing errors. Microsoft Excel 'Pivot Table' was used for summarizing and analysis of the data to describe the disease by person, time, place, and animal. Human population data from Worldometer and the animal population at risk from the report during the study period were used as denominators for epidemiological analysis. All administrative location data were corrected and aligned with the current Ethiopia shape file attributes for mapping retrieved from the Africa Geo-portal website (<https://www.africageoportal.com>). Spatial patterns and hotspot areas were identified using the ArcGIS 10.2 hotspot analysis tool through count rendering. Overlay analysis was also used for pooled human and dog rabies spatial data to demonstrate the pattern of both human and animal Rabies outbreaks in the country within the same period. We also reviewed literature and publications pertinent to our study to describe and make comparisons of Rabies status in the country.

### Operational rabies case definition

#### Suspected human rabies case

A person with more of the following: headache, neck pain, nausea, fever, fear of water (Hydrophobia), pharyngeal spasms, aerophobia, anxiety, agitation, abnormal

tingling sensations or pain at wound sites, when contact with the rabid animal is suspected.

#### **Confirmed human rabies case**

A suspected case confirmed by laboratory [3].

#### **Human rabies exposure as per the WHO definition**

##### **Suspected exposure**

A person presenting for health care with a history of a bite scratch or contact with infectious material from a suspected, probable, or confirmed rabid animal [14].

##### **Possible exposure**

A person who had close contact (usually a bite or scratch) with a rabies-susceptible animal in (or originating from) a rabies-infected area [14].

##### **Probable exposure**

A person who had close contact (usually a bite or scratch) with an animal displaying clinical signs consistent with rabies at the time of the exposure, or within 10 days following exposure in a rabies-infected area [14].

##### **Exposed**

A person who has had close contact (usually a bite or scratch) with a laboratory-confirmed rabid animal [14].

##### **The threshold for rabies**

A single exposure to a suspected rabid animal, suspected or confirmed human case is considered as an alert or action threshold [3].

##### **Animal suspected rabies case**

An animal that presents with any of the following signs: hypersalivation, paralysis, lethargy, unprovoked abnormal aggression (biting two or more people or animals and/or inanimate objects), abnormal vocalization and diurnal activity of nocturnal species [14].

##### **Animal-confirmed rabies case**

A suspected or probable animal case confirmed in a laboratory as described by WHO and WOAHA [14].

##### **Rabies outbreak in animals**

The occurrence of one or more rabies cases in an epidemiological unit [6].

#### **Abbreviations**

DALYs Disability Adjusted Life Years

DOVAR-II	Disease Outbreak and Vaccination Activity Reporting
ENHRI	Ethiopian Nutrition Health and Research Institute (former name for EPHI)
EPHI	Ethiopia Public Health Institute
FAB	Fluorescent Antibody
FAT	Fluorescent Antibody Test
GIS	Geographic Information System
MoA	Ministry of Agriculture
NTDs	Neglected Tropical Diseases
PEP	Post Exposure Prophylaxis
PHEM	Public Health Emergency Management
SNNP	Southern Nations Nationalities and Peoples
SWE	South West Ethiopia
USD	United States Dollar
WHO	World Health Organization
WOAH	World Organization for Animal Health

#### **Supplementary Information**

The online version contains supplementary material available at <https://doi.org/10.1186/s44280-023-00036-6>.

##### **Additional file 1.**

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#### **Authors' contributions**

G.B.A. designed the work, collected, analyzed, interpreted the data, and drafted the manuscript. Abduniasir Abagero contributed to the conception, was a major contributor to writing, and reviewed the work. Adamu Addissie designed the work, acquisition, and analysis. A.W.Y. reviewed the work. S.H.W. provided data and reviewed the manuscript. G.B.D. contributed in writing and substantively revised the work. M.A.A. contributed to the conception and reviewed the work. H.M. acquisition and analysis. Y.W.A. supported data analysis and reviewed the work. W.Z.W. contributed to the conception and review of the work. S.G.D. made contributions to the conception and data analysis. All authors read and approved the final manuscript.

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#### **Availability of data and materials**

The datasets during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

#### **Declarations**

##### **Ethics approval and consent to participate**

The study involved retrospective analysis of aggregate data and hence we obtained the required data by formally requesting the responsible Organizations (Ethiopian Public Health Institute and Ministry of Agriculture) using an official letter.

##### **Consent for publication**

Not Applicable.

##### **Competing interests**

The authors declare that they have no competing interests.

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