

*Full Length Research Paper*

# **Rabies virus in biting dogs and behaviour at risk of zoonotic transmission of rabies in Ouagadougou, Burkina Faso**

**Dieudonné Tialla<sup>1,2</sup>**

<sup>1</sup>Department Animal Health, National School of Livestock and Animal Health (ENESA), 03 BP 7026 Ouagadougou 03, Burkina Faso.

<sup>2</sup>Department of Biomedical and Public Health, Health Science Research Institute (IRSS), National Centre for Scientific and Technological Research (CNRST), 03 BP 7192 Ouagadougou 03, Burkina Faso.

Received 25 August, 2021; Accepted 8 October, 2021

**Rabies is an infectious, viral disease, usually inoculable by dog bite and common to humans and other mammals. It is a major zoonosis but neglected especially in Africa. However, it is the most serious and feared zoonosis in the world because once declared it leads inevitably to death. The objective of this study was to search for rabies virus in biting dogs received in 2020 at the veterinary clinic of the National School of Livestock and Animal Health and behaviour at risk of zoonotic transmission of rabies in Ouagadougou, Burkina Faso. To do this, all bite dogs conducted at the veterinary clinic of the National School of Livestock and Animal Health between January 1 and December 31, 2020 were included in the study. These dogs were observed for 15 days. The bite dogs that died during the observation were sampled. Their brains were collected aseptically and brain smears were prepared and subjected to fluorescent antibody testing. The virus was identified using the immunofluorescence technique as recommended by the World Organization for Animal Health. In total, 577 dog biters were recorded. Of the 577 biters observed, 246 42.6% [95% CI: 40.4-44.8]. Of the 246 bite dogs that died during observation 232 94.3% [95% CI: 92.1-96.5] were confirmed positive for immunofluorescence testing. Rabies virus was found in 40.2% (232/577) [95% CI: 38.2-42.2]. Test positivity was significantly associated with age, sex, breed, breeding conditions and vaccination status of the biting dog. The most common risk behaviours observed among bite dog owners were: letting children have fun with the stray and/or unvaccinated dog; letting the stray and/or unvaccinated dog lick the children's wounds; get the sores licked by the stray and/or unvaccinated dog; do not wash the sore thoroughly with soap and water after dog bite and eat the undercooked dog meat. Since rabies is a major zoonotic disease once reported, there is no treatment, adequate measures such as raising awareness among children and the general population are needed. Dog owners must vaccinate their dogs against rabies. Municipalities must be heavily involved in the fight against rabies by limiting the rambling of animals and put out of order stray dogs.**

**Key words:** Biting dogs, Burkina Faso, Ouagadougou, public health, rabies virus, rabies, risk behaviours, zoonotic transmission.

## **INTRODUCTION**

Rabies is a major zoonotic disease common to humans and other mammals but very neglected in Africa

(Punguyire et al., 2017). It is a highly lethal infectious disease caused by a virus that is most often inoculated by the bite of rabid dogs (Bénet and Haddad, 2004; Singh et al., 2017). Moreover, it is one of the most feared zoonoses in the World because it causes encephalomyelitis which leads inevitably to death after the appearance of symptoms (Hampson et al., 2015; Lu et al., 2018; Masiira et al., 2018). The majority of human cases worldwide are due to the bite of rabid dogs (Barrios et al., 2019; Pantha et al., 2020). It is responsible for 59,000 human deaths each year worldwide, accounting for about 44% of cases in Africa and an estimated economic loss of \$8.6 billion per year (Hampson et al., 2015; Keita et al., 2020). According to the WHO, rabies is present on all continents and more than 95% of fatal human cases occur in Asia and Africa. In France, there have been 33 deaths from dog bites in the past 20 years and in most cases, the person bitten knows the dog and attacks occur at home (Lang and Klassen, 2005; De Keuster et al., 2006).

By their number and severity, dog bites are a major public health problem and only vaccination of mostly biting dogs could limit zoonotic transmission of rabies (Kaare et al., 2009; Nodari et al., 2017; Zinsstag et al., 2017). Two-thirds of the bites involve children under 15 years of age (Mège et al., 2004; Tetchi et al., 2020; Weyer et al., 2020) with two age groups, 1 to 4 and 10 to 13 years, which are most affected and most exposed to dog bites (Bordas et al., 2002; Chevallier and Sznajder, 2006; Sondo et al., 2015). They are very vulnerable to bites with lesions more specifically on the head and neck (Bordas et al., 2002; Ostanello et al., 2005), which can lead to physical, aesthetic and psychological sequelae (Kahn et al., 2003). They are also more susceptible and susceptible to dog bite-borne zoonoses because they have a less mature immune system (Afakye et al., 2016). These bites often result in thousands of emergency room calls each year (Lang and Klassen, 2005), requiring numerous hospitalizations (Bordas et al., 2002; Tan et al., 2004; Afakye et al., 2016). Thus, biting dogs pose a health hazard to populations (Adomako et al., 2018; Yizengaw et al., 2018).

In Africa, rabies has been found everywhere it has been found (Jemberu et al., 2013; Nel, 2013; Salomão et al., 2017). Thus, a synthesis of the literature with a meta-analysis of 1966-2019 data on the incidence and seroprevalence of rabies virus in humans, dogs and other animal species in 21 African countries estimated a seroprevalence of 33.8% in humans and 19.8% in animals (Wobessi et al., 2021). The prevalence was generally higher in biting dogs (Wobessi et al., 2021). In Mali, the prevalence of this condition was estimated at

90.9% in biting dogs (Traoré et al., 2020). In Kenya, 93% of bites were attributed to dogs, 78% of which were stray dogs (Ngugi et al., 2018). The disease is therefore endemic to the African continent (Reta et al., 2014; Tetchi et al., 2020). However, vaccination coverage in dogs remains very low and most dogs are stray (Hergert et al., 2016). In Burkina Faso, the dog is traditionally raised by all households either to keep the house or the herd, or to hunt, either for sacrifices at traditional funerals against the conspiracy of misfortune or for human consumption as a source of protein (Savadogo et al., 2021). But, most of the dogs are stray and go out rambling and come home only at night (Minougou et al., 2021). Very few owners take care of their dogs with rabies vaccines (Savadogo et al., 2021; Minougou et al., 2021). However, rabies does exist in Burkina Faso with a high prevalence in stray dogs (Minougou et al., 2021). Hundreds of cases of animal bites were recorded each year and 90% of bites were attributed to dogs, of which 93.3% were stray dogs (Minougou et al., 2021). Rabies was confirmed in 78.2% of dog biters in Burkina Faso between 2008 and 2012 (Minougou et al., 2021). These dogs therefore constitute a major risk of zoonotic transmission of rabies and a permanent danger to the health of populations. The objective of this study is to investigate rabies virus in biting dogs received in 2020 at the veterinary clinic of the National School of Livestock and Animal Health and behaviour at risk of zoonotic transmission of rabies in Ouagadougou, Burkina Faso.

## MATERIALS AND METHODS

### Study area

The study was carried out between 1 January and 31 December 2020 at the veterinary clinic of the National School of Livestock and Animal Health of Burkina Faso. This urban clinic is located in Ouagadougou, the capital of Burkina Faso. It receives all the biting dogs of said city for a 15-day observation. It refers bitten people to the health center commonly known as the city's hygiene service for immediate management. It plays a major role in veterinary public health and is a good example of the "One Health" approach in the country.

### Study population and sampling method

This study covered all bite dogs presented at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso between 1 January and 31 December 2020. The sample was systematically compiled by all the bite dogs presented at the veterinary clinic of the said school for observation during our study period. An epidemiological questionnaire was developed and completed following the information and written consent of each dog owner.

E-mail: tialladfaso@yahoo.fr.

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

**Table 1.** Individual and collective characteristics of bite dogs received at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso, 2020.

Variable		Biting dogs (n = 577)
Age group (years)	[0 - 2]	17.9% (103/577)
	> 2	82.1% (474/577)
Sex	Male	73.1% (422/577)
	Female	26.9% (155/577)
Breed	Local	96.7% (558/577)
	Exotic	3.3% (19/577)
	Stray	92.2% (532/577)
Farming conditions	Care in the home	7.8% (45/577)
	Vaccinated	15.4% (89/577)
<b>Vaccination status</b>	<b>Unvaccinated</b>	<b>84.6% (488/577)</b>

### Diagnostic methods

Bite dogs that died during observation were sampled. Their brains were collected aseptically and brain smears were prepared and subjected to fluorescent antibody testing (FAT). The virus was identified using the immunofluorescence technique as recommended by the World Organisation for Animal Health (OIE). The most commonly used test for the diagnosis of rabies is the FAT, which is recommended by the World Health Organization (WHO) and the OIE (2013). It remains the reference technique for the diagnosis of rabies. This “baseline” test can be used directly on a smear and can also be used to confirm the presence of rabies antigens in brain tissue (OIE, 2013). FAT provides reliable results on fresh samples in a matter of hours in more than 95-99% of cases (OIE, 2013). It is also 98-100% reliable for all virus genotypes, plus it is sensitive, specific and inexpensive (OIE, 2013). For the direct diagnosis of rabies, smears were prepared from composite samples of brain tissue consisting of brain trunks and cerebellum, and attached to 100% high-quality cold acetone for at least 20 min, air-dried and then stained with a specific conjugate drop for 30 min at 37°C and stained with a cocktail of three fluorescein-labelled monoclonal antibodies to the nucleocapsid rabies virus protein (N). Slides were observed under the fluorescent microscope and positive rabies smears gave apple color fluorescence as described above (Tenzin et al., 2020; Minougou et al., 2021).

### Statistical analysis

The data was entered before being imported on the software R. The variables of interest, coded in presence/absence, were positivity to the laboratory diagnostic test. The explanatory variables were individual and collective characteristics. Risk factors in dogs and risk behaviours in humans were identified using a multivariate model. A logistic regression model (proc logistic, SAS 9.3) was used to analyse positivity on the diagnostic test based on explanatory variables considered as risk factor or risk behaviour. The significance threshold was set at 5%.

### Ethical consideration

This study received approval clearance from *Centre Muraz* ethical

committee (number 2016-15/MS/SG/CM/IEC).

## RESULTS

### Individual and collective characteristics of bite dogs

As of December 31, 2020, a total of 577 bite dogs have been registered at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso. To compare young biters to older dogs, two age classes have been defined. This is Class 1 which includes animals aged 0 to 2 years and Class 2 for animals aged over 2 years. The biting dogs were divided by sex and into two breed categories: the local breed and the exotic breed. A dog was considered a stray if its owner leaves him free, he goes out and he comes home whenever he wants. The stray dogs were therefore made up of dogs left to themselves, they went out to ramble and returned home only at night. The individual and collective characteristics of the bite dogs received at the veterinary clinic of the National School of Livestock and Animal Health of Burkina Faso in 2020 are recorded in Table 1.

### Prevalence of rabies in biting dogs

Of the 577 biters observed, 246 dogs died during observation, or 42.6% of biters. Of the 246 bite dogs that died during the observation 232 were confirmed positive for immunofluorescence testing or 94.3% of dead bite dogs. Rabies virus was found in 40.2% (232/577) of bite dogs received in 2020 at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso. Test positivity was significantly associated with age, sex, breed, breeding conditions and vaccination status of the biting dog.

**Table 2.** Prevalence of rabies by age, sex, breed, breeding conditions and vaccination status of dead biters dogs during observation at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso, 2020.

Variable	Dogs tested	Positive	Prevalence	p-value
			(%) and CI : 95%	
<b>Age (years)</b>				
0-2	19	7	36.8±2.1	0.03
>2	227	225	99.1±0.9	
Total	246	232	94.3±2.4	
<b>Sex</b>				
Male	231	228	98.7±2.3	0.02
Female	15	4	26.6±3.2	
Total	246	232	94.3±2.4	
<b>Breed</b>				
Local	238	230	96.6±2.9	0.01
Exotic	8	2	25.0±3.1	
Total	246	232	94.3±2.4	
<b>Farming conditions</b>				
Stray	240	231	96.3±3.1	0.01
Care in the home	6	1	16.7±1.2	
Total	246	232	94.3±2.4	
<b>Vaccination status</b>				
Vaccinated	14	2	14.3±2.2	0.01
Unvaccinated	232	230	99.1±0.5	
Total	246	232	94.3±2.4	

CI: Confidence Interval.

**Table 3.** Risk factors identified in bite dogs received at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso, 2020.

Variable	OR	CI: 95%	P
Age	2.2	1.1- 4.5	0.03
Sex	1.7	1.1-2.5	0.02
Breed	1.6	1.1-2.4	0.02
Rambling dogs	1.3	1.2-1.9	0.01
<b>Unvaccination of dogs</b>	<b>1.2</b>	<b>1.3-1.7</b>	<b>0.01</b>

OR: Odds Ratio; CI: Confidence Interval.

Table 2 shows the different prevalence of rabies by age, the sex, breed, breeding conditions and vaccination status of dead biters dogs during observation at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso in 2020.

#### Identified risk factors in animals

The risk factors identified in the study animals were

recorded in Table 3. Test positivity was significantly associated with age, sex, breed, dog divagation and unvaccination of dogs. These explanatory variables were considered to be identified risk factors in bite dogs.

#### Identified risk behaviours in humans

The most frequently observed risk behaviours among bite

**Table 4.** Risk Behaviours Observed in Bite Dog Owners Received at the Veterinary Clinic of the National School of Livestock and Animal Health of Ouagadougou in Burkina Faso, 2020.

Variable	OR	CI: 95%	P
Let children have fun with the stray and/or unvaccinated dog	1.8	1.2-2.8	0.04
Let the stray and/or unvaccinated dog lick the wounds of children	1.9	1.1-4.6	0.01
Getting licked wounds by stray and/or unvaccinated dogs	2.1	1.7-4.4	0.03
Do not wash the wound thoroughly with soap and water after dog bite	1.9	1.1-3.9	0.02
<b>Eating Undercooked Dog Meat</b>	<b>1.8</b>	<b>1.2-4.1</b>	<b>0.01</b>

OR: Odds Ratio; CI: Confidence Interval.

dog owners received in 2020 at the veterinary clinic of the National School of Livestock and Animal Health in Ouagadougou, Burkina Faso were: let the children have fun with the stray dog and/or unvaccinated; let the stray dog and/or unvaccinated lick the children's wounds; let the stray dog lick the wounds and/or unvaccinated; do not wash the wound thoroughly with soap and water after dog bite and consume undercooked dog meat. The results are presented in Table 4.

## DISCUSSION

Of the bite dogs that were observed for 15 days, 42.6% of them died during their observation. This situation made us think that they were all rabid during the bites and that they would certainly have died of rage because any biting dog is suspect of rage and once declared rabies leads inevitably to death no later than 15 days after the appearance of symptoms (Hampson et al., 2015; Lu et al., 2018; Masiira et al., 2018). But after checking, rabies virus was found in 94.3% of dead dog biters. The other 5.7% would certainly have died from different diseases of rabies such as Carré's disease especially as the dogs concerned were particularly young with an age between 0 and 2 years. Considering all dog biters, the prevalence of rabies was estimated at 40.2%. This prevalence is significantly lower than that obtained (78.2%) by Minougou et al. (2021) in biting dogs in Burkina Faso between 2008 and 2012. But considering only dead biting dogs, our prevalence of 94.3% is higher than the 78.2% of Minougou et al. (2021) who considered only shot biting dogs. It is also above 90.9% obtained by Traoré et al. (2020) in Mali. These differences could therefore be explained by the fact that the dogs in our study were not only biters but they were dead during observation hence a high real prevalence of rabies while the dogs of Minougou et al. (2021) were biter dogs most often killed prior to observation. In this case, some dogs were wrongly killed while they were not suffering from rabies while they were biting. Burkina Faso is participating in the Collaborative Programme for the Elimination of Rabies by 2030 with two main measures: the vaccination campaign and passive surveillance.

Positivity on the test was significantly associated with age, sex, breed, rambling and unvaccinated of dogs and these variables were considered risk factors for biting dogs in our study. The majority of these dogs being stray dogs and most often unvaccinated the probability that they will be bitten by a rabid dog and clinically manifest rabies is very high. Moreover, contrary to what Minougou et al. (2021) found that most rabid dogs were less than four months old, in our study dogs over 2 years old and especially males were the most affected. This could be explained by the fact that during the Oestrus in females, the latter release pheromones that generally attract adult males over 2 years of age. Several males can be found around a single dog causing very fierce fights between males with bites and wounds anything that would certainly promote the transmission of rabies virus to adult male dogs over 2 years old. According to Hergert et al. (2016), in Africa the majority of dogs are stray with very low vaccination coverage, which promotes the spread of rabies and makes the continent endemic to this disease. For Ngugi et al. (2018), in Kenya 78% of bite dogs are stray dogs, often without owners, thus constituting a reservoir for the rabies virus. The local breed dogs were the most affected unlike the exotic breed dogs. In fact, in Burkina Faso, locally bred dogs have the least fortunate owners who do not take care of them. They are most often left to their own devices. They go out and ramble and come home only after dark. In addition, they are very rarely vaccinated against rabies. All this promotes contact with rabies virus and the manifestation of the disease by these dogs. On the other hand, exotic dogs are usually held by the wealthiest members of society who keep them at home. They take good care of themselves. In addition, they are vaccinated and do not leave the house to be in contact with stray and/or rabid dogs which would certainly explain the low rate of rabies virus contamination in exotic dogs. Some dogs, although vaccinated, were tested positive. This is similar to the comment made by Minougou et al. (2021). This could be explained by the specificity of the individual often leading to vaccine failures in some individuals as highlighted by Nodari et al. (2017). It is also necessary to mention the denaturation of the vaccine by heat. The protein is denatured starting at 40°C. However, in Burkina Faso,

especially during the month of April, the temperature can easily exceed 45°C in the shade. We are also witnessing repeated long-term cuts in the electric current, leading to a break in the cold chain for a long period of time. Often the vaccine is transported long distances without a cold chain. Under these conditions, the vaccine is denatured and can no longer protect. It is therefore advisable to measure the level of rabies virus antibodies sometime after each vaccination to be sure that the dog is actually protected by the vaccine.

The most frequently observed risk behaviours among bite dog owners have been to let children have fun with the stray and/or unvaccinated dog; to let the stray and/or unvaccinated dog lick children's wounds; get the sores licked by the stray and/or unvaccinated dog; do not wash the sore thoroughly with soap and water after dog bite and eat the undercooked dog meat. Indeed, some of these risk behaviours had already been highlighted by Afakye et al. (2016) in Ghana, Madjadinan et al. (2020) in Chad and Tetchi et al. (2020) in Côte d'Ivoire. The dangers associated with bites are not sufficiently known and are a real public health problem. Dog saliva can contain many pathogens including rabies virus. According to Bénet and Haddad (2004), these different pathogens can be inoculated during the bite or can be transmitted by licking a skin lesion. Therefore, getting the wounds licked by the stray and/or unvaccinated dog is a major risk of transmission of the rabies virus to humans. In Burkina Faso, the average person thinks that when you are bitten by a dog it is enough to remove the hair of the biting dog and stick it on the wound. According to them, this would allow to be protected against rabies in case the biting dog is rabid. Post-exposure prophylaxis is not controlled by the majority of bite dog owners. In addition, dog meat is widely consumed in the suburbs of Ouagadougou. These behaviours can have a negative impact on public health.

## Conclusion

The objective of this study was to search for rabies virus in biting dogs received in 2020 at the veterinary clinic of the National School of Livestock and Animal Health and behaviour at risk of zoonotic transmission of rabies in Ouagadougou, Burkina Faso. Rabies virus was found in 94.3% of bitten dogs that died during observation. Positivity on the test was significantly associated with age, sex, breed, rambling and non-vaccination of dogs and these variables were considered risk factors for biting dogs in our study. On the other hand, risk behaviours have been identified among bite dog owners, including licking wounds by stray and/or unvaccinated dogs. However, the majority of bite dogs are stray and unvaccinated. Many do not know that the wound should be washed thoroughly with soap and water after a bite. In view of this situation, adequate measures such as raising children's and the general public's awareness of the danger of being in contact with a stray and unvaccinated

dog and the consumption of undercooked dog meat are necessary. Vaccines must be kept in accordance with the manufacturer's recommendations without breaking the cold chain. Dog owners must vaccinate their dogs against rabies. Municipalities must be heavily involved in the fight against rabies by limiting the rambling of animals and put out of order stray dogs.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

## ACKNOWLEDGEMENTS

The author thanks the whole team of the Laboratory and the Veterinary Clinic of the National School of Livestock and Animal Health for their collaboration, participation and contribution to this study. Thanks to the financial support of the National School of Livestock and Animal Health of Burkina Faso.

## REFERENCES

- Adomako BY, Baiden F, Sackey S, Ameme DK, Wurapa F, Nyarko KM, Kenu E, Afari E (2018). Dog bites and rabies in the Eastern Region of Ghana in 2013-2015 : A call for a one-health approach. *Journal of Tropical Medicine* <https://doi.org/10.1155/2018/6139013>.
- Afakye K, Kenu E, Nyarko KM, Johnson SAM, Wongnaah F, Bonsu GK (2016). Household exposure and animal-bite surveillance following human rabies detection in Southern Ghana. *Pan African Medicine Journal* 25(1):12.
- Barrios CL, Vidal M, Parra A, Valladares C, González C, Pavletic C (2019). Epidemiological characterization of bites : A retrospective study of dog bites to humans in Chile during 2009. *Journal of Veterinary Behavior* 33:31-37.
- Bénet JJ, Haddad N (2004). Des zoonoses transmises à l'homme par morsure. *Le Nouveau Praticien Vétérinaire* 193:21-25.
- Bordas V, Meyer-Broseta S, Bénet JJ, Vazquez MP (2002). Etude descriptive des morsures canines chez les enfants : analyse de 237 cas enregistrés aux urgences de l'hôpital Trousseau (Paris). *Epidémiologie et Santé Animale* 42(115):e21.
- Chevallier B, Sznajder M (2006). Les morsures de chien chez l'enfant, de l'épidémiologie à la prise en charge. Session : Enfants et animal (Groupe de Pédiatrie Générale). *Archives De Pédiatrie* 13(6):579-587.
- De Keuster T, Lamoureux J, Kahn A (2006). Epidemiology of dog bites : a Belgian experience of canine behaviour and public health concerns. *Veterinary Journal* 173(3):482-487.
- Hampson K, Coudeville L, Lembo T, Sambo M, Kieffer A, Atllan M, Barrat J, Blanton JD, Briggs DJ, Cleaveland S, Costa P, Freuling CM, Hiby E, Knopf L, Leanes F, Meslin FX, Metlin A, Miranda ME, Müller T, Nel LH, Recuenco S, Rupprecht CE, Schumacher C, Taylor L, Vigilato MAN, Zinsstag J, Dushoff J (2015). Estimating the global burden of endemic canine rabies. *PLoS Neglected Tropical Diseases* 9(4):e0003709.
- Hergert M, Le Roux K, Nel LH (2016). Risk factors associated with nonvaccination rabies status of dogs in KwaZulu- Natal, South Africa. *Veterinary Medicine: Research and Reports* 7:75-83.
- Jemberu WT, Molla W, Almwaw G, Alemu S (2013). Incidence of rabies in humans and domestic animals and people's awareness in North Gondar Zone, Ethiopia (CE Rupprecht, Ed.). *PLOS Neglected Tropical Diseases* 7:e2216.
- Kaare M, Lembo T, Hampson K, Ernest E, Estes A, Mentzel C,

- Cleaveland S (2009). Rabies control in rural Africa: evaluating strategies for effective domestic dog vaccination. *Vaccine* 27(1):152-160.
- Keita Z, Gerber F, Lechenne M, Thiero O, Hattendorf J, Zinsstag J, Traoré A, Traoré AK (2020). Burden of rabies in Mali. *Acta Tropica* 210:105389.
- Lang ME, Klassen T (2005). Dog bites in Canadian children : a five-year review of severity and emergency department management. *Canadian Journal Epidemiology and Medicine* 7(5):309-314.
- Lu XX, Zhu WY, Wu GZ (2018). Rabies virus transmission via solid organs or tissue allotransplantation. *Infectious Diseases of Poverty* 7(1):82.
- Madjadinan A, Hattendorf J, Mindekem R, Mbaipago N, Moyengar R, Gerber F, Oussiguéré A, Naissengar K, Zinsstag J, Lechenne M (2020). Identification of risk factors for rabies exposure and access to post-exposure prophylaxis in Chad. *Acta Tropical* 209:105484.
- Masiira B, Makumbi I, Matovu JKB, Ario AR, Nabukenya I, Kihembo C, Kaharuzza F, Musenero M, Mbonye A (2018). Long term trends and spatial distribution of animal bite injuries and deaths due to human rabies infection in Uganda, 2001-2015. *PloS One* 13(8):e0198568.
- Mège C, Beaumont-Graff E, Béata C, Diaz C, Habran T, Marillois N (2004). Pathologie comportementale du chien. Paris : Masson-AFVAC. pp. 21-26.
- Minougou G, Dahourou LD, Savadogo M, Tialla D, Combari AHB, Kanyala E, Ouattara L, Kaboré SA, Ouédraogo V, Tabouret Y, Kéré I (2021). Surveillance of Animal Rabies in Burkina Faso: A Retrospective Laboratory Data from 2008 to 2012. *International Journal of Veterinary Science* 10(3):172-176.
- Nel LH (2013). Discrepancies in data reporting for Rabies, Africa. *Emerging Infectious Diseases* 19(4):529-533.
- Ngugi JN, Maza AK, Omolo OJ, Obonyo M (2018). Epidemiology and surveillance of human animal-bite injuries and rabies post-exposure prophylaxis, in selected counties in Kenya, 2011-2016. *BMC Public Health* 18(1):996.
- Nodari ER, Alonso S, Mancin M, Nardi MD, Hudson-Cooke S, Veggiato C, Cattoli G, Benedictis PD (2017). Rabies vaccination : Higher failure rates in imported dogs than in those vaccinated in Italy. *Zoonoses and Public Health* 64(2):146-155.
- OIE (2013). *Terrestrial Manual 2013* : Chapter 2.1.13.-Rabies. OIE, Paris, France, 28 pages. <http://www.oie.int/en/our-scientific-expertise/reference-laboratories/list-of-laboratories/>
- Ostanello F, Gherardi A, Caprioli A, La PL, Passini A, Prosperi S (2005). Incidence of injuries caused by dogs and cats treated in emergency department in a major Italian city. *Emergency medicine Journal* 22(4):260-262.
- Pantha S, Subedi D, Poudel U, Subedi S, Kaphle K, Dhakal S (2020). Review of rabies in Nepal. *One Health* 10:100155.
- Punguyire DT, Osei-Tutu A, Aleser EV, Letsa T (2017). Level and pattern of human rabies and dog bites in Techiman Municipality in the Middle Belt of Ghana : a six year retrospective records review. *Pan African Medicine Journal* 28:281.
- Reta T, Teshale S, Deresa A, Ali A, Mengistu F, Sifer D, Freuling CM (2014). Rabies in animals and humans in and around Addis Ababa, the capital city of Ethiopia : A retrospective and questionnaire based study. *Journal of Veterinary Medicine and Animal Health* 6(6):178-186.
- Salomão C, Nacima A, Cuamba L, Gujral L, Amiel O, Baltazar C, Cliff J, Gudo ES (2017). Epidemiology, clinical features and risk factors for human rabies and animal bites during an outbreak of rabies in Maputo and Matola cities, Mozambique, 2014 : Implications for public health interventions for rabies control. *PLOS Neglected Tropical Diseases* 11:e0005787.
- Savadogo M, Tialla D, Ouattara B, Dahourou LD, Ossebi W, Ilboudo SG, Combari AHB, Tarnagda Z, Alamedji RB (2021). Factors associated with owned-dogs' vaccination against rabies: A household survey in Bobo Dioulasso, Burkina Faso. *Veterinary Medicine and Science* pp. 1-11.
- Singh R, Singh KP, Cherian S, Saminathan M, Kapoor S, Manjunatha RGB, Panda S, Dhama K (2017). Rabies – epidemiology, pathogenesis, public health concerns and advances in diagnosis and control : a comprehensive review. *Veterinary Quarterly* 37(1):212-251.
- Sondo KA, Yonaba/Okengo C, Diop SA, Kaboré BE, Diallo I, Kyelem N, Basshono J, Thombiano R, Kam L (2015). Rabies in children: report of 24 cases at the Yalgado Ouédraogo University Hospital Center of Ouagadougou in Burkina Faso. *Journal of Tropical Diseases and Public Health* 3(168):1-5.
- Tan RL, Powell KE, Lindemer KM, Clay MM, Davidson SC (2004). Sensitivities of three county health department surveillance systems for child-related dog bites : 261 cases (2000). *Journal of American Veterinary Medical Association* 225(11):1680-1683.
- Tenzin T, Lhamo K, Rai PB, Tshering D, Jamtsho P, Namgyal J, Wangdi T, Letho S, Rai T, Jamtsho S, Dorji C, Rinchen S, Lungten L, Wangmo K, Lungten L, Wangchuk P, Gempo T, Jigme K, Phuntshok K, Tenzinla T, Gurung RB, Dukpa K (2020). Evaluation of a rapid immunochromatographic test kit to the gold standard fluorescent antibody test for diagnosis of rabies in animals in Bhutan. *BMC Veterinary Research* 16(1):183.
- Tetchi MS, Coulibaly M, Kallo V, Traoré GS, Issaka T, Benié BVJ, Gerber F, Saric J, Lechenne M, Zinsstag J, Bonfoh B (2020). Risk factors for rabies in Côte d'Ivoire. *Acta Tropical* 212:105711.
- Traoré A, Keita Z, Léchenne M, Mauti S, Hattendorf J, Zinsstag J (2020). Rabies surveillance-response in Mali in the past 18 years and requirements for the future. *Acta Tropical* 210:105526.
- Weyer J, Dermaux-Msimang V, Grobbelaar A, Le Roux C, Moolla N, Paweska J, Blumberg L (2020). Epidemiology of human rabies in South Africa, 2008-2018. *South Africa Medicine Journal* 110(9):877-881.
- Wobessi JNS, Kenmoe S, Mahamat G, Belobo JTE, Emoh CPD, Efietngab AN, Bebey SRK, Ngongang DT, Tchatchouang S, Nzukui ND, Modiyinji AF, Simo REG, Ka'e AC, Tazokong HR, Ngandji AB, Mbaga DS, Kengne-Nde C, Sadeuh-Mba SA, Njouom R (2021). Incidence and seroprevalence of rabies virus in humans, dogs and other animal species in Africa, a systematic review and meta-analysis. *One Health* 13(2021):100285.
- Yizengaw E, Getahun T, Mulu W, Ashagrie M, Abdela I, Geta M (2018). Incidence of human rabies virus exposure in northwestern Amhara, Ethiopia. *BMC infectious diseases* 18(1):1-7.