Journal of Applied Veterinary Sciences, 10 (1): (2025) proof
ISSN: Online: 2090-3308, Print: 1687-4072
Journal homepage : https://javs.journals.ekb.eg

Canine Rabies Outbreak and its Public Health Implications in Ksour Municipality, Northeastern Algeria: A Case Study

Sid Nassim[1,2,3*], Belalmi Nor El Houda[1,2], Shamekh Ali[4,5] and Bannazadeh Baghi Hossein[4,5,6]
[1]Laboratory of Health and Environment. University Mohamed El Bachir El Ibrahimi of Bordj Bou Arreridj, Bordj Bou Arreridj, Algeria
[2]Faculty of Nature and Life Sciences and Earth and the Universe, University Mohamed El Bachir El Ibrahimi of Bordj Bou Arreridj, Bordj Bou Arreridj, Algeria
[3]Directorate of Agricultural Services, Bordj Bou Arreridj, Algeria
[4]Infectious and Tropical Diseases Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[5]Department of Virology, Faculty of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran
[6]Immunology Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
***Corresponding Author:** Sid Nassim, **E-Mail:** nassim.sid@univ-bba.dz

ABSTRACT

Rabies is a fatal zoonotic disease typically transmitted through animal bites. It affects all mammals, domestic and wild, as well as humans. The primary cause of the disease is the multiplication of a neurotropic rhabdovirus in the central nervous system, which almost always leads to fatal encephalomyelitis. This study aimed to describe a canine rabies outbreak in Ksour Municipality, province of Bordj Bou Arreridj (Algeria), and its impact on public health. The epidemiological investigation revealed that a stray local dog breed had bitten multiple people and domestic animals. Seven people, 5-76 years old, were bitten. However, children under 15 years old accounted for 28.57% of the cases. Males were the most commonly bitten (85.71%). All victims sustained severe category III injuries, predominantly located on the upper extremities (85.71%). Seven domestic animals were bitten, including six dogs and one donkey. The direct fluorescent antibody test (DFAT) and the mouse inoculation test (MIT) were both positive when applied and tested. The injured people received post-exposure prophylaxis (PEP) with rabies immunoglobulin and vaccination. Rabies remains endemic in the study area, with stray dogs acting as the primary transmission vectors through bites. A multidisciplinary approach involving collaboration among the national veterinary authority, human health services, political authorities, and local communities has been proven effective in rabies control.

Original Article:

Received
Accepted
Published in

Keywords: Algeria, Bite injuries, Epidemiology, Post-exposure prophylaxis, Stray dogs.

***J. Appl. Vet. Sci., 10(1)*: Proof**

INTRODUCTION

Rabies is a severe viral zoonotic disease caused by a *Lyssavirus* (of the *Rhabdoviridae* family) that affects the central nervous system of all warm-blooded animals and humans (**Lankester *et al*., 2014**). The causative agent is usually transmitted via the saliva of an infected animal through bites (**Hikufe *et al*., 2019; Jackson, 2016**). Clinically, rabies manifests in two distinct forms: the widely recognized furious form and the paralytic form. The disease is virtually always fatal once symptoms develop, as the virus causes progressive encephalomyelitis (**Chen *et al*., 2018; Pal *et al*., 2024**).

Domestic dogs represent the main reservoir of the rabies virus, responsible for its transmission to humans in up to 99% of the reported cases in rabies-endemic regions (**Rupprecht *et al*., 2018a**). Globally, this translates to roughly 15 million people requiring post-exposure prophylaxis (PEP) annually (**Pal *et al*., 2024; WHO, 2018**). The economic toll of rabies is substantial, with global losses approximating 8.6 billion USD, predominantly attributed to premature mortality (reduced productivity) and the costs associated with post-exposure treatment (PET) **(Hampson *et al*., 2015; Rupprecht *et al*., 2018b)**.

Rabies is a widespread tropical disease, affecting over 150 countries and territories globally **(Baghi *et al*., 2016)**. Despite causing an estimated 60,000 deaths a year, primarily in developing nations of Asia and Africa, it remains a neglected disease. In these

regions, unvaccinated dogs and cats in rural areas are the main culprits for transmitting rabies **(Bannazadeh Baghi *et al*., 2018; Aklilu *et al*., 2021)**. To combat this challenge, a powerful alliance has formed. The World Health Organization (WHO), the World Organization for Animal Health (OIE), the Food and Agriculture Organization of the United Nations (FAO), and the Global Alliance for Rabies Control (GARC) have launched a global strategic plan called "Zero by 30." This ambitious initiative aims to eliminate human deaths from dog-mediated rabies by 2030 **(WHO, 2018)**.

In Algeria, the national veterinary authority implemented a prevention and control program in 1996, focusing on reducing free-roaming dogs and mandatory rabies vaccination of domestic carnivores. Despite these efforts, rabies continues to be a significant burden on public and veterinary health, as evidenced by the annual detection of 131 confirmed dog rabies cases, an estimated 20 human deaths, and 120,000 exposure incidents **(Kardjadj, 2016; Yahiaoui *et al*., 2018)**. Benelmouffok reported that rabies prevalence is higher in northern Algeria, with no reported cases (animals or humans) in the Sahara region of southern Algeria **(Benelmouffok, 2004)**. Bordj Bou Arreridj province (northeast Algeria) reported 64 animal rabies cases between 2018 and 2023, averaging five cases annually. Notably, Ksour municipality was the source of 20.68% of all reported rabies cases in this province during this period. An estimated 850 dogs, 650 goats, 400 cattle, and 12,700 sheep reside within Ksour municipality. However, rabies vaccination rates among the dog population remain low, with only 10% immunized in October 2022 **(DSA, 2024)**.

This study describes a large-scale exposure event involving humans and animals attacked by a suspected stray dog exhibiting aggressive behavior. We further analyzed the multidisciplinary response implemented to manage this public health concern.

MATERIALS AND METHODS

Ethics approval

This investigation was ethically approved by the Provincial Veterinary Authority of Bordj Bou Arreridj (Approval No. 1277/IVW/2023). The study strictly adhered to all applicable international, national, and institutional guidelines for the care and use of animals and complied with Algerian legislation concerning veterinary activities and animal health.

Study area

The study was conducted in Ksour municipality, Bordj Bou Arreridj province, located in northeastern Algeria **(Fig. 1)**. Ksour has an estimated population of 13,836 and sits at an altitude of 943 meters above sea level (35°59′28″ N, 4°35′52″ E). Agricultural activity is the main economic activity in this rural area, where the inhabitants live in villages.

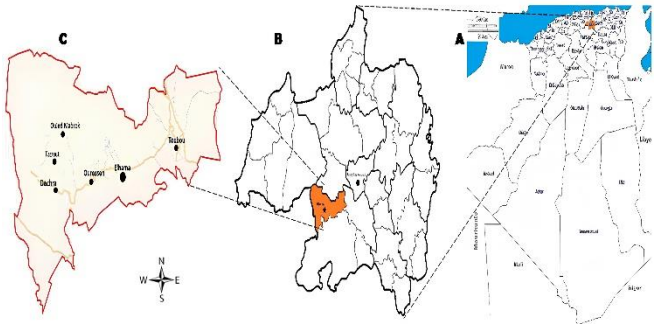

Fig. 1: Maps indicating the People's Democratic Republic of Algeria (A) and the Bordj Bou Arreridj Province (Northeast Algeria) (B) with the study site Ksour Municipality (C).

Ksour is comprises of six villages: Toubou, Elhamma, Ouaressen, Dachra, Tazrout, and Ouled Mabrouk. These villages benefit from a network of public healthcare facilities. This network includes one polyclinic offering a wider range of medical services and three smaller facilities providing basic medical care. Notably, basic healthcare services are free for all Algerian citizens.

Rabies surveillance management system

The rabies surveillance and control management system in Ksour Municipality functions through multi-sectoral cooperation. Various departments collaborate, all coordinated by the Municipal Committee for Health, Hygiene, and Environmental Protection. At the forefront is the Municipal Health Office, which registers the dogs vaccinated against rabies, issues licenses, and plays a crucial role in raising public awareness about rabies infection, for example, through educational campaigns. The municipal veterinarian plays a critical role in identifying and containing potential outbreaks. They conduct thorough investigations to detect rabies in animals, follow up on suspected cases requiring quarantine, and identify rabies cases. The agricultural office takes the lead in planning and executing animal vaccination campaigns, ensuring widespread protection for the animal population. Local public security contributes by keeping stray and unlicensed dog populations under control. This crucial step helps minimize the risk of rabies transmission. Finally, health centers stand ready to provide immediate medical intervention in case of human exposures. They offer post-exposure prophylaxis (PEP), vaccines, and immunoglobulins to safeguard the health of the community.

A multidisciplinary communication and collaboration strategy between veterinary services, public health agencies, environmental departments, and the agricultural sector is crucial for combating a wide range of diseases, from zoonotic illnesses, such as rabies, to emerging threats.

Rabies outbreak data and case management

Following established rabies control protocols, the Municipal Committee for Health, Hygiene, and Environmental Protection, in collaboration with the municipal veterinarian, swiftly responded to a stray dog bite incident reported on February 24, 2023. Immediate efforts were focused on identifying affected individuals and gathering details about the culprit dog and the attack sites. All identified victims were promptly referred to the local public health polyclinic.

At the polyclinic, medical professionals assessed patients, documenting bite location and severity. Exposures were categorized as follows **(WHO, 2024)**:

Category I: Minimal or no exposure, such as touching, feeding, or licking intact skin.

Category II: Minor scratches or abrasions without bleeding.

Category III: Single or multiple bites, scratches on broken skin, licks on mucous membranes, or saliva contamination of mucous membranes.

Seven individuals received rabies vaccinations and immunoglobulin treatments. The vaccine regimen consisted of four intramuscular injections of 0.5 mL RAGIVAC (Institute Pasteur Algeria) in the deltoid region. The initial two doses were administered on the day of exposure, followed by booster doses on days 7 and 21. HRIG (Equirab, Bharat Serums and Vaccines Limited, India) was infiltrated deep into and around the wounds on the day of the attack, based on a dosage of 40 IU/kg body weight, following the National Guideline for Post-Exposure Prophylaxis issued by the Algerian Ministry of Health. Additionally, the clinic recorded their personal information and vaccination schedule to ensure proper follow-up and completion of the rabies prophylaxis program.

Veterinary legislation for prevention and control of animal rabies

Following the Algerian Veterinary Law and Decree No. 95/66, which specifies the list of notifiable animal diseases and their applicable general measures, and the Inter-Ministerial Decree of 17 July 1995, which specifies the health measures applicable to animal rabies, in all cases of suspected animal disease, the owner must immediately notify the nearest official veterinarian and the president of the municipal people's assembly. The official veterinarian must forward this information to both the state veterinary inspector and the national veterinary authority.

Rabies is a notifiable disease in Algeria under Decree No. 95/66. If an animal is found dead or killed and is suspected or confirmed to be affected by rabies, the carcass or head must be sent to an authorized laboratory for diagnosis. The laboratory must inform the competent inspector of the diagnostic results. In cases of confirmed rabies with human exposure (zoonosis), the state veterinary inspector must inform the competent health organization.

Detection method

Rabies diagnosis in Algeria adheres to protocols set by the National Institute of Veterinary Medicine, under the Ministry of Agriculture and Rural Development. While clinical signs, such as unexplained aggression, are initial indicators, definitive diagnosis necessitates post-mortem laboratory analysis.

In this case, brain, hippocampus, and brainstem tissue samples were collected from the stray dog and subsequently sent to the regional veterinary laboratory. Laboratory confirmation typically relies on antigen detection through the direct fluorescent antibody test (DFAT), with the mouse inoculation test (MIT) serving as a confirmatory method.

For DFAT, brain, hippocampal, and cerebellar tissue from the suspected rabid animal is prepared on a glass slide, fixed in acetone, and incubated with a fluorescently labelled antibody (conjugate). After washing with PBS and mounting with buffered glycerol, the slide is examined under a fluorescence microscope. The mouse inoculation test (MIT) inoculum is prepared from clarified brain tissue, including the brainstem, suspended in a buffered solution containing antibiotics. Mice are anesthetized before intracerebral inoculation and monitored for 28 days. Deceased mice undergo rabies testing using the DFA test (**Rupprecht *et al.*, 2018c**).

RESULTS

On the afternoon of February 24th, 2023, the municipal veterinarian received a community report of a stray dog attack. In response, the Ksour Committee for Health, Hygiene, and Environmental Protection launched a joint prevention and control operation involving local public health agencies, veterinary services, law enforcement, and other relevant departments.

Upon arrival at the scene, authorities discovered the carcass of a rabid, white stray dog. Epidemiological

investigation revealed that the dog's attacks spanned over three villages: Dachra, Tazrout, and Ouled Elmabrouk. The first human attack occurred on February 24th, 2023, at 1:30 PM, with six additional people subsequently injured **(Fig. 2)**.

Fig. 2: Locations and the exact time of stray dog attacks in Ksour Municipality (marked by stars).

The dog terrorized the area for approximately five hours before being killed by the public. The municipal veterinarian removed the animal's head and transported it to the regional veterinary laboratory for rabies virus confirmation. The DFAT revealed rabies virus (RABV) antigen within the brain tissue, characterized by intracytoplasmic inclusions exhibiting a bright, apple-green fluorescence. A subsequent mouse inoculation test (MIT) confirmed the diagnosis after a 21-day observation period.

A total of seven individuals were exposed to rabies through dog bites, including six males and one female, aged 5 to 76 years **(Table 1)**. The higher proportion of adult male victims (71.43%) can be attributed to increased exposure to dogs due to outdoor activities.

Table 1: Dog bite victims' information. The type of injury was noted according to the WHO classification system.

Cases	Age (years)	Gender	Anatomical bitten site	Wounds number	Type of injury
1	5	M	thigh and hand	2	III
2	8	F	Neck	1	III
3	18	M	Arm	1	III
4	40	M	Hand	1	III
5	47	M	Hand	1	III
6	64	M	Arms	2	III
7	76	M	hands, arms, knee	4	III

F: female; M: male

Children comprised 28.57% of the victims. All victims sustained severe category III injuries, primarily to the upper extremities (85.71%), likely as a result of defensive actions against the attacking dog. Wounds were either single (57.14%) or multiple (42.86%), affecting the arms, hands, neck, knee, and thigh **(Fig. 3)**.

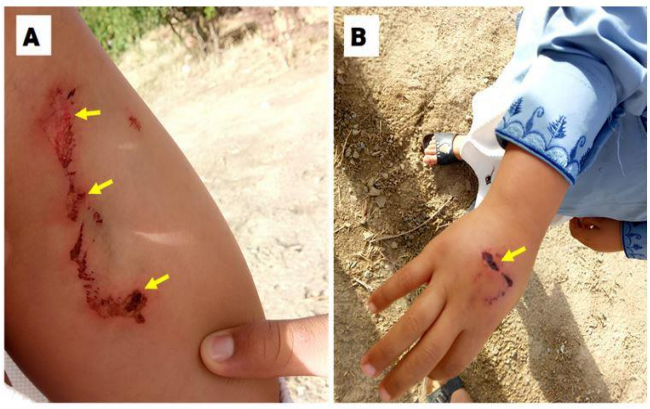

Fig. 3: Rabid stray dog bite injuries to the thigh (A) and hand (B) of a 5-year-old child.

All victims received immediate rabies vaccination and human rabies immunoglobulin (HRIG) at the local health polyclinic. Free-of-charge, 24/7 care was provided to the individuals exposed to rabies. No rabies symptoms were observed among the exposed individuals during six months of follow-up. The dog's rampage also resulted in injuries to six dogs and one donkey. None of these animals had been vaccinated against rabies. In a joint effort, the agricultural department provided the vaccine, and the municipal veterinarian conducted a vaccination campaign for domestic dogs and cats within a 2-kilometer radius of the attacks. The Municipal Health Office took steps to raise public awareness by posting advertisements and distributing leaflets that explained the risks of rabies and provided guidance on responding to animal bites.

Following the Inter-ministerial Decree of July 17, 1995, to prevent the further spread of rabies, the six unvaccinated dogs and one unvaccinated donkey exposed to the rabid animal were humanely euthanized. Disposal of rabid animal carcasses is carried out in a

designated communal area. As per Decree No. 95/66, carcasses are buried at a depth of approximately two meters between layers of quicklime.

DISCUSSION

Rabies is a viral disease transmitted by various mammals, including domestic animals like dogs and cats, as well as wild animals such as wolves, foxes, jackals, bats, raccoons, and skunks **(Ruan, 2017; Bannazadeh Baghi et *al*., 2021)**. Based on the primary host species, rabies is categorized into three cycles: urban, sylvatic (wildlife), and vampire. Notably, the sylvatic cycle often transitions to the urban cycle due to frequent contact between rabid wild carnivores and stray dogs **(Barecha et *al*., 2017; Bannazadeh Baghi et *al*., 2018)**.

This disease is often overlooked as a public health priority, especially in African countries. Mass canine vaccination is the most effective method for rabies control. However, human mortality rates remain high due to socioeconomic challenges, inadequate dog immunization coverage, and delays or interruptions in post-exposure vaccination after bites **(Gao *et al*., 2014; Rasizadeh and Bannazadeh Baghi, 2023)**.

Determinants of successful rabies response

The prompt intervention of the Municipal Committee for Health, Hygiene, and Environmental Protection, facilitated by interdepartmental collaboration, ensured the appropriate management of this public health emergency. The municipal veterinarian was pivotal in conducting an epidemiological investigation, accurately diagnosing the disease, and identifying the full extent of animal and human cases. Serving as the primary point of contact for the public regarding animal diseases, the veterinarian played a critical role in containing the outbreak.

A multisectoral One Health approach was employed for rabies surveillance and control. This strategy focuses on canine vaccination, managing stray dog populations, eliminating infection reservoirs, treating exposed individuals, and public health education. Since 2008, when the last case of human rabies was reported, Ksour municipality has remained rabies-free, demonstrating the success of this surveillance strategy. Extensive public education campaigns on rabies prevention, conducted by the municipal health office in collaboration with civil society, schools, and media, have been instrumental in this achievement. Regular dog vaccination programs and community engagement have significantly contributed to public awareness about rabies transmission and prevention, including the importance of post-exposure prophylaxis.

Challenges of free-roaming dogs

Free-roaming dogs present a multifaceted challenge, including zoonotic disease transmission, human bites, economic losses due to livestock predation, and societal disruptions caused by traffic accidents and nuisance behaviors **(Massei and Miller, 2013)**.

Algeria currently lacks comprehensive data on the size of its semi-roaming and free-roaming dog population, and there is no established official vaccination program specifically targeting these animals. A thorough understanding of the demographic characteristics of these dog populations is crucial for assessing the potential transmission and maintenance of zoonotic pathogens, such as knowledge would inform effective logistical planning, including determining optimal vaccine quantities and campaign frequency **(Yahiaoui *et al*., 2018; Kardjadj and Ben-Mahdi, 2019)**.

Thousands of free-roaming domestic and stray dogs inhabit the territory of Ksour municipality. The actual number is likely significantly higher than the current estimates. Despite posing a serious public health risk, the municipality lacks dedicated animal shelters. Recent efforts by the Municipal Health Office to reduce the stray dog population, focusing on promoting responsible dog ownership and vaccination programs, have had limited success. Factors such as readily available food sources, including those from widespread garbage dumps and the illegal disposal of animal carcasses, particularly poultry, have contributed to the increase in Ksour municipality's stray dog population. The animal birth control (ABC) program, encompassing intensive sterilization and vaccination of stray dogs, has been shown to be effective in reducing stray dog populations across several countries **(Shamsaddini *et al*., 2022)**.

Ksour municipality has also implemented measures to register, manage, and improve vaccination rates among pet dogs, while a comprehensive strategy to address the overall stray dog problem is still under development.

Crucial role of rabies post-exposure prophylaxis

Rabies is a fatal but preventable zoonotic disease. Timely vaccination and immunoglobulin treatment after exposure are crucial for survival. The worldwide approach to rabies prevention and control predominantly involves comprehensive vaccination programs. These strategies emphasize mass immunization of domestic animals, especially dogs, and post-exposure prophylaxis for humans. The provision of high-quality human and animal rabies vaccines, coupled with increased public awareness of rabies prevention, is the first critical step towards eliminating rabies **(Wei *et al*., 2023)**.

To comply with WHO and OIE guidelines, individuals and animals must develop neutralizing antibodies after rabies vaccination. A minimum protective serum titer of 0.5 IU/mL is required; otherwise, an additional vaccine dose is necessary. The Rapid Fluorescent Focus Inhibition Test (RFFIT), recommended by WHO, is used to measure these antibodies **(Gao *et al*., 2014)**.

CONCLUSIONS

This study highlights the severe public health risks associated with a single rabid stray dog and confirms that prompt and coordinated action by veterinary services, public health officials, and local authorities is crucial for managing such situations. The One Health approach is effective in both controlling rabies and preventing postexposure rabies emergencies.

Acknowledgment

The authors would like to express their sincere gratitude to the Provincial Veterinary Inspection of Bordj Bou Arreridj, especially Dr Bakhouche Aziza, the staff of Ksour Municipality, and the Regional Veterinary Laboratory of Tizi Ouzou for their invaluable contributions to this study.

Conflict of interest

The authors declare no conflicts of interest.

REFERENCES

AKLILU, M., TADELE, W., ALEMU, A., ABDELA, S., GETAHUN, G., HAILEMARIAM, A., TADESSE, Y, KITILA, G., BIRHANU, E., FLI, I., GETACHEW, A., and MULUGETA, Y., 2021. Situation of Rabies in Ethiopia: A Five-Year Retrospective Study of Human Rabies in Addis Ababa and the Surrounding Regions. Journal of tropical medicine, 2021:6662073. https://doi.org/10.1155/2021/6662073

BAGHI, H.B., BAZMANI, A., and AGHAZADEH, M., 2016. The fight against rabies: the Middle East needs to step up its game. Lancet, 388(10054):1880. https://doi.org/10.1016/S0140-6736(16)31729-9

BANNAZADEH BAGHI, H., ALINEZHAD, F., KUZMIN, I., and RUPPRECHT, C.E., 2018. A perspective on rabies in the Middle East—Beyond Neglect. Veterinary sciences, 5(3):67. https://doi.org/10.3390/vetsci5030067

BANNAZADEH BAGHI, H., and RUPPRECHT, C.E., 2021. Notes on three periods of rabies focus in the Middle East: From progress during the cradle of civilization to neglected current history. Zoonoses and Public Health, 68(7): 697-703. https://doi.org/10.1111/zph.12781

BARECHA, C.B., GIRZAW, F. KANDI, V., and PAL, M., 2017. Epidemiology and public health significance of rabies. Perspectives in Medical Research, 5(1): 55-67. https://pimr.org.in/Barecha-new.PDF

BENELMOUFFOK, A., 2004. Épidémiologie de la rage en Algérie. Bulletin de l'Académie vétérinaire de France, 157(2): 61-66. https://doi.org/10.4267/2042/47703

CHEN, L.H., GAUTRET P., and VISSER, L.G., 2018. Rabies Preexposure Prophylaxis: Application of Updated World Health Organization Position to Travelers. Clinical Infectious Diseases, 67(12):1948-1950. https://doi.org/10.1093/cid/ciy422

DIRECTORATE OF AGRICULTURAL SERVICES (DSA), 2024. Collection of statistical data for the province of Bordj Bou Arreridj for the year 2023.

GAO, L.D., ZHANG, H., CAI, L., CHEN, B.Z., JIANG, Y.L., LIU, Y.Z., LV, X.J., YU, P.C., HU, S.X., LIU, F.Q., LI, H., LI, G.Y., SHEN, X.X., TAO, X.Y., ZHANG, S.Y., LIU, J.H., TANG, Q., and LI, J.H., 2014. Epidemic of rabies and effect of its vaccine against a dog that consecutively attacked ten people in one day. Biomedical and Environmental Sciences, 27(1):60-4. https://doi.org/10.3967/bes2014.017

HAMPSON, K., COUDEVILLE, L., LEMBO, T., SAMBO, M., KIEFFER, A., ATTLAN, M., BARRAT, J., BLANTON, J.D., BRIGGS, D.J., CLEAVELAND, S., COSTA, P., FREULING, C.M., HIBY, E., KNOPF, L., LEANES, F., MESLIN, F.X., METLIN, A., MIRANDA, M.E., MÜLLER, T., NEL LH., RECUENCO, S., RUPPRECHT, C.E., SCHUMACHER, C., TAYLOR, L., VIGILATO, M.A., ZINSSTAG, J., and DUSHOFF, J., 2015. Global Alliance for Rabies Control Partners for Rabies Prevention. Estimating the global burden of endemic canine rabies. PLOS Neglected Tropical Diseases, 9(4):e0003709. 10.1371/journal.pntd.0003709

HIKUFE, E.H., FREULING, C.M., ATHINGO, R., SHILONGO, A., NDEVAETELA, E.E., HELAO, M., SHIINDI, M., HASSEL, R., BISHI, A., KHAISEB, S., KABAJANI, J., VAN DER WESTHUIZEN, J., TORRES, G., BRITTON, A., LETSHWENYO, M., SCHWABENBAUER, K., METTENLEITER, T.C., DENZIN, N., AMLER, S., CONRATHS, F.J., MÜLLER, T., and MASEKE, A., 2019. Ecology and epidemiology of rabies in humans, domestic animals and wildlife in Namibia, 2011-2017. PLOS Neglected Tropical Diseases, 13(4):e0007355. https://doi.org/10.1371/journal.pntd.0007355

JACKSON, A.C., 2016. Human Rabies: a 2016 Update. Current infectious disease reports, 18(11):38. https://doi.org/10.1007/s11908-016-0540-y

KARDJADJ, M., 2016. Epidemiology of human and animal rabies in Algeria. Journal of Dairy, Veterinary & Animal Research, 4(1):244-247. https://doi.org/10.15406/jdvar.2016.04.00109

KARDJADJ, M., and BEN-MAHDI, M.H., 2019. Epidemiology of dog-mediated zoonotic diseases in Algeria: a One Health control approach. New Microbes and New Infections, 28:17-20. https://doi.org/10.1016/j.nmni.2019.01.001

LANKESTER, F., HAMPSON, K., LEMBO, T., PALMER, G., TAYLOR, L., and CLEAVELAND, S., 2014. Infectious Disease. Implementing Pasteur's vision for rabies elimination. Science, 345(6204):1562-4. https://doi.org/10.1126/science.1256306

MASSEI, G., and MILLER, L.A., 2013. Nonsurgical fertility control for managing free-roaming dog

populations: a review of products and criteria for field applications. Theriogenology, 80(8):829-38. https://doi.org/10.1016/j.theriogenology.2013.07.016

PAL, M., REBUMA, T., REGASSA, M., GUTEMA, C., and MAZZEO, A., 2024. Endemic Rabies in Ethiopia in the One Health Era. American Journal of Public Health, 12(2): 22-32. https://doi.org/10.12691/ajphr-12-2-2

RASIZADEH, R., and BANNAZADEH BAGHI, H., 2023. Increase in rabies cases during COVID-19 pandemic: Is there a connection ?. The Journal of Infection in Developing Countries, 17(3):335-336. https://doi.org/10.3855/jidc.17537

RUAN, S., 2017. Spatiotemporal epidemic models for rabies among animals. Infectious disease modelling, 2(3):277-287. https://doi.org/10.1016/j.idm.2017.06.001

RUPPRECHT, C.E., BANNAZADEH BAGHI, H., DEL RIO VILAS, V.J., GIBSON, A.D., LOHR, F, MESLIN, F.X., SEETAHAL, J.F.R., SHERVELL, K., and GAMBLE, L., 2018a. Historical, current and expected future occurrence of rabies in enzootic regions. Revue Scientifique et Technique, 37(2):729-739. https://doi.org/10.20506/rst.37.2.2836

RUPPRECHT, C.E., BANNAZADEH BAGHI, H., DEL RIO VILAS, V.J., GIBSON, A.D., LOHR, F., MESLIN, F.X., SEETAHAL, J.F.R., SHERVELL, K., and GAMBLE, L., 2018b. Global rabies management: perspectives on regional strategies for prevention and control. Revue Scientifique et Technique, 37(2):711-727. https://doi.org/10.20506/rst.37.2.2835

RUPPRECHT, C.E., FOOKS, A.R., and ABELA-RIDDER, B., 2018c. Laboratory techniques in rabies, 5th ed. Volume 1. World Health Organization. https://iris.who.int/bitstream/handle/10665/310836/9789241515153-eng.pdf

SHAMSADDINI, S., AHMADI GOHARI, M., KAMYABI, H., NASIBI, S., DERAKHSHANI, A., MOHAMMADI, M.A., MOUSAVI, S.M., BANESHI, M.R., HIBY, E., and HARANDI, M.F., 2022. Dynamic modeling of female neutering interventions for free-roaming dog population management in an urban setting of southeastern Iran. Scientific reports, 12(1):4781. https://doi.org/10.1038/s41598-022-08697-w

WEI, Y., LI, D., YANG, Z., CHEN, K., PAN, X., XU, J., and CHEN, S., 2023. One Health responses to prevent the occurrence of rabies due to attacks by a rabid stray dog. Veterinary Medicine and Science, 9(2):618-624. https://doi.org/10.1002/vms3.986

WORLD HEALTH ORGANIZATION, **2024**. Rabies. https://www.who.int/news-room/fact-sheets/detail/rabies. Accessed 20 June 2024.

WORLD HEALTH ORGANIZATION, 2018. Zero by 30: the global strategic plan to end human deaths from dog-mediated rabies by 2030. https://iris.who.int/bitstream/handle/10665/272756/9789241513838-eng.pdf

YAHIAOUI, F., KARDJADJ, M., LAIDOUDI, Y., MEDKOUR, H., and BEN-MAHDI, M.H., 2018. The epidemiology of dog rabies in Algeria: Retrospective national study of dog rabies cases, determination of vaccination coverage and immune response evaluation of three commercial used vaccines. Preventive veterinary medicine, 158:65-70. https://doi.org/10.1016/j.prevetmed.2018.07.011