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Full Length Research Article

RABIES OUTBREAKS IN DOMESTIC ANIMALS AND HUMAN EXPOSURES IN NIGERIA DURING THE COVID-19 PANDEMIC: A PUBLIC HEALTH CHALLENGE

*Tekki Ishaya Sini, Davou Joseph Alex, Weka Rebecca, Sada Aliyu, Nwosuh Chika

National Veterinary Research Institute, PMB 01, Vom, Plateau State, Nigeria

*Corresponding Author Email Address: istekki@nvri.gov.ng

ABSTRACT
This study aims to report outbreaks of rabies in domestic animals and two human dog-bite exposures in Nigeria during the COVID-19 pandemic, from April 2019 to 2021, underscoring the persistent public health challenge and socioeconomic burden posed by the disease. Rabies remains a significant global zoonosis, particularly impacting socio-economically disadvantaged populations in low-income countries. Eight outbreaks of rabies were confirmed in various domestic animals. These include a horse, a sheep, a donkey, a stray dog that bit two minors, a cat that bit four individuals, piglets, a goat, and a cow that was bitten by a stray dog. All the outbreaks were confirmed as rabies positive by the Direct Fluorescent Antibody Test (DFAT) at the National Laboratory. Rabies has continued to circulate in domestic dogs and spills over to other domestic animals in Nigeria. While no human fatalities occurred, the estimated economic losses exceeded ₦2.0 million (approximately US$133,333), reflecting a substantial financial impact on already vulnerable communities concurrently grappling with the socio-economic effects of COVID-19. This study highlights the ongoing circulation of rabies within domestic dog populations and its spill over into other domestic animals in Nigeria. It underscores the urgent need for a coordinated, integrated One Health intervention approach, increased public awareness, and the development of frameworks for assessing social incidence, community risk perceptions, and the disease's economic toll on livelihoods.

Keywords: Rabies, domestic animals, humans, public health, Socio-economic impact, Nigeria

INTRODUCTION

Rabies is an acute, fatal viral zoonosis and a serious public health problem (American Public Health Association, 2008), especially in endemic countries. Globally, between 50,000 and 60,000 human deaths from rabies occur annually (WHO, 2024), while the average economic losses per herd due to rabies were estimated at 49 USD per year in the developing countries of the world (Jibat *et al*., 2016). Although the rabies virus infects all warm-blooded animals in nature, the primary hosts are domestic and wild dogs (CDC, 1987; Bingham, 2005). Bites and scratches of domestic dogs and wild carnivores are the major threat for transmission of the rabies virus to humans and other domestic animals (World Organization for Animal Health, 2013; Moges, 2009; Okell *et al*., 2913). However, non-bite transmission is possible by contamination of the mucous membranes or fresh wounds (Murrel, 1998).

Rabies has a direct or indirect adverse economic impact on the national and subnational economy in many countries (Meltzer & Rupprecht, 1998; Gemechu, 2017). The disease has continued to be a global zoonosis of significant public health and socio-economic impact, causing economic losses of over 1.8 million DALYs (disability adjusted life years) every year in low-income countries. The global socio-economic losses from rabies are estimated at $5.5 billion annually (Gemechu, 2017), and the disease's impact on livestock production is increasing due to an upsurge in human populations and interactions with wildlife (NCBI, 2003).

Nigeria is endowed with an estimated 142 million livestock (cattle, goats, sheep, pigs, horses, and donkeys), and 41.3 million of which were sheep. Livestock provides nutrition and supports livelihoods and social benefits for poor farmers, consumers, traders, and labourers throughout the developing world. However, diseases impact livestock production through direct costs (deaths, morbidity, reduction in productivity) and indirect costs, by means of disease prevention and control (Marsh *et al*., 2024). In Nigeria, however, only sporadic and low incidences of rabies in livestock are generally reported, compared to the number that actually occurred (Okoh, 1981). This paper reports cases of rabies in domestic animals in some parts of Nigeria from December 2019 to April 2021 and highlights its socio-economic and public health impacts.

MATERIALS AND METHODS

Case Reports

Case I (Horse): On February 12, 2019, a whole carcass of a horse (Figure 1A) was brought to the National Veterinary Research Institute, NVRI, Vom, for post-mortem examination. Investigation revealed that the six-year-old female local breed of horse died on the same day in a farm situated in Jos South LGA. According to the farm manager, the horse appeared clinically normal at the close of the day on Friday, February 9, 2019. Over the weekend, it became aggressive, biting and mutilating itself, biting inanimate objects, and another horse in the stable (Figure 1B). It was then isolated for observation and died naturally in isolation.

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Figure 1 (A & B): A) Carcass of horse submitted for diagnosis; B) Stablemate that had been bitten by the horse from Jos South LGA, Plateau State

Case II (Sheep): A carcass of an adult female mixed Yankasa/Balami breed of sheep (Figure 2) was submitted from an established public farm in Jos South LGA, Plateau state, for post-mortem examination and confirmatory rabies diagnosis on July 30, 2019. The case history revealed that the animal had been observed on the morning of its death to exhibit restlessness, unusual aggression, and frothing at the mouth. Further inquiry by the farm manager showed that this sheep belonged to the same flock as an ewe that had died of rabies two weeks earlier after being bitten by a rabid dog the previous month.

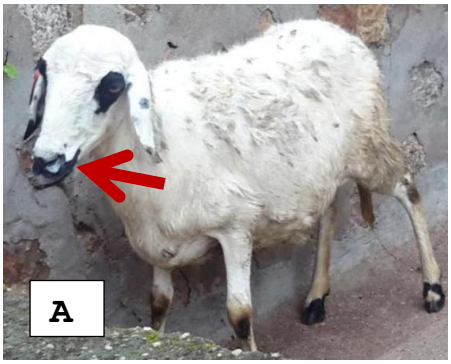

Figure 2 (A & B): A) Rabid ewe exhibiting hyper salivation (arrow shows hypersalivation before euthanasia; (B) the head of the ewe submitted for rabies confirmatory diagnosis, arrow showing wound scar sustained from the dog bite

Case III (Donkey): On August 9, 2019, a client reported that a local breed of male adult donkey (Figure 3A) was bitten by a stray dog on July 22, 2019, in the Alkalawa Area of Dawakin Tofa Local Government Area, Kano state. Eight days later, the donkey became recumbent and began to bite objects and itself, and died on August 5, 2019 (Figure 3B). Rabies was suspected, and the head of the carcass was removed and shipped to NVRI, Vom, for confirmatory diagnosis.

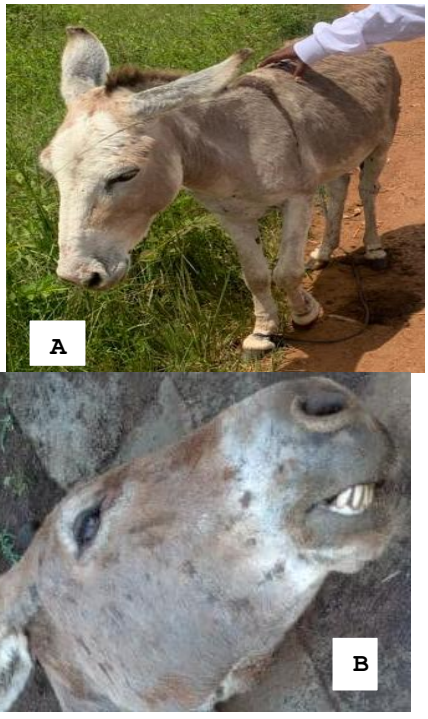

Figure 3 (A & B): A) Image of rabid donkey depicting the live animal; B) severed head submitted for post-mortem examination

Case IV (Dog): On July 30, 2020, a dog head (Figure 4A) from the Nunchwak community in Riyom LGA, Plateau State, was submitted for a rabies test at NVRI, Vom. The stray dog was reported to have bitten an 11-year-old girl and a 6-year-old boy, inflicting serious

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wounds on them (Figure 4B & C). Each of the minors received five (5) shots of human rabies vaccine on day 0, 3, 7, 14, and 28, as well as a shot of Equine Rabies immunoglobulin (ERIG) on day 0. In addition, the immunoglobulin was infiltrated around and within the bite sites.

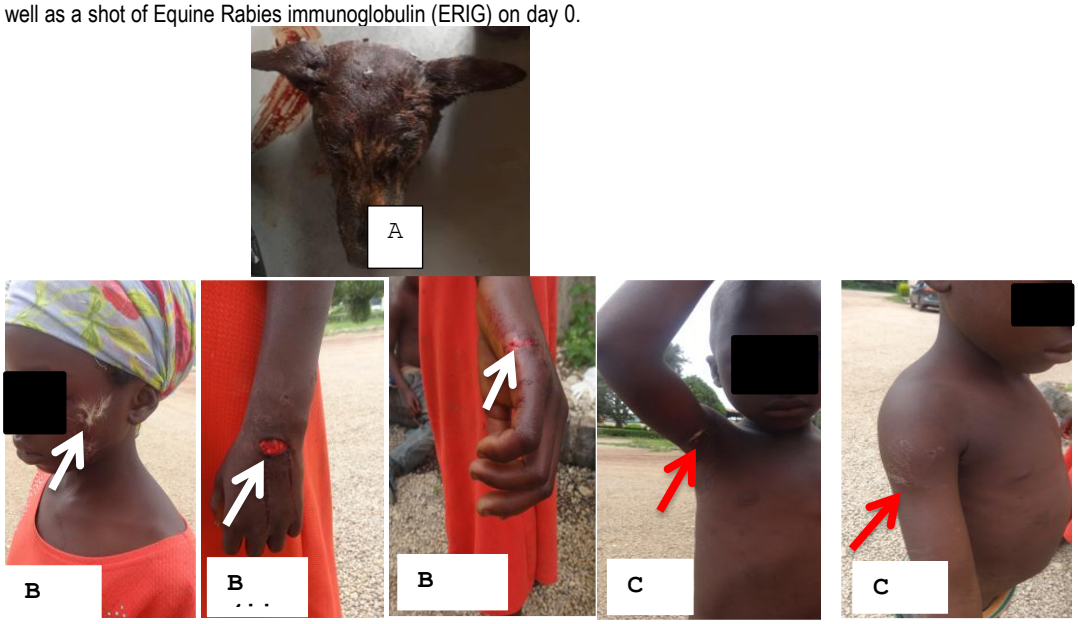

Figure 4 (A, B & C): A) The head of the dog submitted for rabies test from Riyom LGA, Plateau State. B) i–iii: Dog-bite wounds on various body parts of the 11-year-old girl (white Arrows); C) i–ii: Dog-bite wounds on various body parts of the 5-year-old boy (Red Arrows)

Case V (Cat): A Cat head (Figure 5) was submitted to the Rabies laboratory, NVRI, Vom, for rabies confirmatory diagnosis on May 9, 2020. Records indicated that the cat was an adult female of a local breed. It was reported to have strayed in Gambari Lere community in Bogoro LGA, Bauchi State, on September 4, 2020, and bit four (4) people, around 6:00 PM on that fateful day.

Figure 5: Cat head submitted for test from Gambari Lere community in Bogoro LGA, Bauchi State

Case VI (Pig): On December 7, 2020, two piglet heads were submitted from Ikot Abong, Ibiono Ibom LGA, Akwa-Ibom State, to the Rabies laboratory, NVRI, Vom, for confirmatory diagnosis. The case report showed that a stray dog went into a piggery and bit three piglets (Figure 6), and the dog escaped. The piglets died a few weeks later, and the heads were submitted for a rabies test.

Figure 6: carcass of one of the piglets before decapitation and shipment of the head to NVRI, Vom for rabies test from Ikot Abong, Ibiono Ibom LGA, Akwa-Ibom State

Case VII (Goat): On March 16, 2021, a carcass of the head (Figure 7) of an adult female goat (breed not specified), from the Alheri community, in Jos North LGA, Plateau State, was submitted to NVRI, Vom, for a rabies test. The animal owner reported that the doe had kidded (three kids within the week), but two (2) died due

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to an unknown cause. The doe became aggressive, biting itself, resulting in self-mutilation, especially its udder, and attacking anyone who came near it. It was then quarantined in a veterinary facility, and it died the next day.

Figure 7: The head of the goat shipped to NVRI, Vom, for rabies test from Jos North LGA, Plateau State

Case VIII (Cattle): On April 17, 2021, an incident of suspected rabies was reported to a Veterinary Clinic in Kano metropolitan city. Case history revealed that a dog, from a nearby community, strayed into a herd of 100 white Fulani breed of cattle in Buwawa, Gude settlement, Kabo LGA, Kano State, Nigeria, on February 7, 2021. The dog bit three animals in the herd and died. The bitten animals were salvaged, but barely two months after the invasion of the herd by the dog, one cow exhibited nervous signs such as salivation, extreme aggression, and incoordination. The animal was slaughtered, and the head (Figure 8) was shipped to NVRI, Vom, for rabies testing.

Figure 8: The head of the rabid cow shipped to NVRI, Vom, for rabies test, Kabo LGA, Kano State

Laboratory Diagnosis

Laboratory diagnosis was performed on the smears of brain tissues harvested from all the samples submitted in each of eight cases, using the DFAT as described by Dean *et al.* (Dean & Abelseth, 1973). A freshly prepared working dilution of rabies fluorescein isothiocyanate conjugate (FITC) Anti-Rabies Monoclonal Globulin (FDI FUJIREBIO Diagnostic, Inc.) was applied to stain each brain sample smear according to the manufacturer's instructions, and results were recorded. Smears of control and control test samples were examined using an inverted fluorescent microscope (**ZEISS AXIO VERT. A1; I.D No. 195-043500**) for the presence of brightly coloured apple-green or greenish-yellow appearance of virus particles against a dark background. Smears that showed fluorescence were considered positive, while those that showed no apple-green fluorescence were considered negative.

RESULTS AND DISCUSSION

The cases in these reports show that the rabies virus has continued to circulate in domestic dogs and spills over to other domestic animals such as cattle, sheep, goat, pigs, horses, and donkeys, which are dead ends of the infection. As observed in the cases, domestic dogs are the main source of rabies in humans and domesticated animals (WHO, 2025). Unfortunately, there is no treatment for rabies in animals, and treatment for exposed humans must be undertaken before clinical symptoms appear. Rabies deaths are, however, preventable with prompt post-exposure prophylaxis (PEP) by stopping the virus from reaching the central nervous system (WHO, 2013). PEP consists of thorough wound washing, administration of a course of human rabies vaccine, and, when indicated, rabies immunoglobulins (RIG) (WHO, 2024). By means of this practice, all the people who were victims of dog bites and who handled the infected horse in this report were given rabies post-exposure prophylaxis (without rabies RIG, because of its unavailability at that moment), and they all survived. To provide a safety barrier between wild animals and humans, public health officials stress the importance of vaccinating domestic pets and livestock against rabies (Bowen, 2009). In Nigeria, there is a locally produced vaccine licensed for use in dogs. Imported exotic vaccines are commercially available for dogs and cats, but there are currently no vaccines approved for use in cattle, sheep, goats, swine, or the Equidae.

It is possible that the sheep in case II was bitten on the same day as the ewe, which was said to have been bitten by a stray dog a month before. This implies that the incubation period of the virus, which manifested a month after the death of the sheep, which was said to have died of rabies earlier, was much longer than in the sheep in this case. According to Bowen (Bowen, 2009), the average incubation period for rabies in sheep is about 10 days. However, the incubation period can range from a few days to several weeks. Once clinical signs appear, sheep typically die within a few days. Cases of rabies in sheep appear more similar to rabies in cattle, with an average incubation period of ten days. A rabid sheep exhibits muzzle and head tremors, aggressiveness, hyperexcitability, hyperesthesia, salivation, vocalization, and recumbency (Bowen, 2009). In the current case, however, only some of the signs (tremors, hyperexcitability, and hypersalivation)

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were observed. Reports of rabies in goats are rare, but the furious form of rabies appears to be more common. Previous reports documented that symptoms in goats include aggressive behavior, excessive bleating, and salivation following an incubation period of one to five days (Cole, 2007). Rabies in horses typically manifests as a severe neurological disease with symptoms including incoordination, weakness, and paralysis. They may also exhibit behavioral changes such as aggression, hyperexcitability, and self-mutilation, as reported in the current study. Other symptoms include fever, colic, lameness, and difficulty swallowing (Wilkins & Del Piero, 2006; Fernanda, 2010).

While rabies in pigs is rare, initial clinical manifestations may include aggression, loss of coordination, hypersalivation, backward movement, chewing of inanimate objects, and a feeling of lethargy. Late stages of the disease include depression, convulsions, and recumbency. Inception usually takes place suddenly and is characterized by facial muscles twitching, fits and seizures, rapid chewing movement in the mouth, drooling, and posterior paralysis (Cole, 2007). Although most people think rabies is a disease of dogs, these case reports show that the virus can affect any mammal, including cats. In the USA, more cats are affected than dogs by rabies, and most states have legislation for enforcing vaccination to control the disease in animals and humans (Fernanda, 2010). The report of Claussen (2025), showed that rabies can be transmitted from an infected cat to the owner through direct contact with the saliva through bite or contamination of the mucous membrane and broken skin (WHO, 2024). The warning signs of rabies include changes in temperament, as cats who are usually calm and friendly may become restless. Claussen 2025) also revealed that an unreserved cat may become less friendly and may go into isolation. Other signs include drooling and loss of muscle coordination leading to paralysis, coma, and death.

The symptoms of rabies in donkeys are similar to the signs in other animals. These comprise behavioral changes, paralysis, and aggression. Additionally, rabid donkeys may display anxiety, depression, chewing on foreign objects, and colic, sporadically (Alhassan *et al*., 2020). The moment rabies manifests clinically in the donkey, death becomes inevitable within a few days (Carrieri *et al*., 2006; Alhassan *et al*., 2020). Globally, rabies in donkeys is occasionally reported; however, the disease is a significant cause of death in the Equidae species in numerous countries and regions (Green, 1993; Alhassan *et al*., 2020). Like in other domesticated animals, the transmission of rabies from an infected donkey or horse to humans and other mammals is uncommon (Green, 1993). Nevertheless, the risk of exposure to a rabid animal is without doubt of grave socio-economic and public health consequences, especially in Africa and Asian, where the infection is associated with a lack of proper control measures (Gautret *et al*., 2015; Alhassan *et al*., 2020). There was no case of human rabies in this report, because the two minors who were bitten by a rabid dog received PEP in record time. However, a recent report showed that the signs and symptoms of rabies in humans occur after an incubation period of 3 weeks to 3 months or more (WHO, 2024). Often, broad-based early signs such as flu and sore throat, spasms of the muscles in the throat resulting in painful drinking, and paresthesia at the site of the bite. Other signs include difficulty in breathing, hydrophobia, photophobia, aerophobia, Confusion, nervousness, and anxiety. This is followed by paralysis and, eventually, death within 3 days to 3 weeks of the onset of clinical manifestations (WHO, 2013). In dogs, behavioral Changes occur from one to 8 weeks. These signs include irritability, excitation, and unprovoked biting. Some rabid dogs would snap at, bite, or attack moving objects, and signs progress to altered voice, depraved appetite, strange facial expression, and hypersalivation. These are followed, terminally, by difficulty in swallowing, paralysis, and inevitable death, usually within days (WHO, 2013).

The escape of the offending stray dog, which invaded the piggery in case number V, could result in to spread of the virus to more dogs and further spill overs to humans and other domestic animals. Spill over to cats, which are not known to be maintenance reservoirs for the virus, is also common, but cats serve as important incidental hosts in the transmission circle and the chain of transmission to humans and other domestic animals. As explained by Chao *et al.* (2020), eliminating rabies is challenging in many developing countries, especially in rural areas. As annual human cases of rabies have increased in the last decade, the incidence of the disease in livestock has also increased (Alhassan *et al*., 2020). Consequently, the cases reported in this study could be an understatement of the true situation, as many others possibly occurred unnoticed and unreported.

Lack of surveillance and reliable data on the number of rabies cases is a major constraint in assessing the economic impact of the disease on the local economies in exposed/infected livestock, working animals, and humans who die as a result of rabies. As high incidences of rabies in domesticated animals in Nigeria are demonstrated during the COVID-19 pandemic, caution should be exercised when examining domestic animals with neurological signs. Animal health workers and animal owners need to recall that such animals may be rabid, and the appropriate personal protective equipment should be worn to examine animals with neurological signs, especially (Bowen, 2009). Based on the prevailing market value of the domestic animals in Nigeria and the estimated cost of PEP to the eight people exposed to the infection in these reports, the economic losses incurred in these cases were over ₦2.0M (US$133, 333) at the exchange rate of one thousand five hundred naira (₦1,500) per US dollar as at the period of the study. This is in agreement with the report of Gemechu (Gemechu, 2017), that the importance of animal diseases as a constraint to the development of the livestock industry in West African countries is well recognized. A specific estimate of animal disease impact at the West African level is not available. However, a survey conducted by Grace et al (Chao *et al.,* 2020) at the continental level revealed that 35 priority diseases recorded by state Veterinary Services among African countries cost nearly 9 billion USD per year, which is equivalent to 6 percent of the value of the livestock sub-sector. Several infectious (viral, bacterial, and parasitic) diseases are responsible for huge socio-economic losses by reducing livestock production and productivity. The various zoonotic diseases in West Africa are constant threats to the public health situation in the subregion. Consequently, the socio-economic impact of rabies in Nigeria is quite huge and devastating, especially among the rural dwellers whose livelihoods depend on the income from their animals and/or their products. The losses incurred in these reports had doubtless added to the hardship caused by the impact of the COVID-19 pandemic during the period under review. After exposure in case number IV, the individuals either sought medical treatment and were given post-exposure prophylaxis, incurring direct and indirect costs. Further costs could have been incurred in

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situations where post-exposure prophylaxis was not administered and the victim either recovers or dies from rabies. The necessity to pay for transport and expensive post-exposure prophylaxis for a rabies-exposed family can result in an unintentional sale of production animals and properties, including psychological trauma, resulting from rabies-associated death in the family. Additionally, livestock mortality from rabies impacts on food security and safety, draught animals (transport and ploughing) by-products (Manure), societal cost (including bride price) and canine mortality impact on herding and hunting affecting security or food source for dog consumers direct impact on humans include loss of source of income, labour and funeral expenses within the family and cost of treatment, hospitalization and number of days lost within the course of treatment

The domestic dog was reported to be the offending animal in each of the cases in these reports. This conforms with the assertion that domestic dogs are the main reservoir hosts and source of transmission of the rabies virus to man and other domestic animals in most developing countries of Africa and Asia (Jibat *et al*., 2016; WHO, 2013). In a defined maintenance circle, they are capable of maintaining virus transmission if it is not broken by vaccination or other means. Cats, on the other hand, are not known to be a maintenance reservoir for unique rabies virus variants, but they serve as important incidental hosts in the transmission circle and the chain of transmission to humans and other domestic animals, when affected by spillover from dogs (Atuman *et al*., 2014).

Conclusion and Recommendations

To curb the socio-economic and public health menace of rabies in developing countries, therefore, intensification of disease surveillance at the field and abattoir level, farmer sensitization, and awareness campaign is required to assist in capturing the disease situation for taking timely action and reporting. Disease reporting also needs the support of an effective veterinary diagnostic laboratory system to confirm what the surveillance component detects on the ground. However, the low level of reporting animal diseases in many countries is noteworthy. In fact, because of the endemic nature of many diseases and lack of sampling or diagnostic facilities, field veterinary services are often obliged to report diseases based on clinical diagnosis (Ouagal *et al*., 2008).

There is a dire need for a coordinated, integrated one-health intervention strategy and collaboration of animal health, human health, and wildlife authorities. To surmount the current public health and economic impact of rabies in Nigeria, an urgent and constituted response is required from the Government, and stakeholders are recommended. As recommended by public health experts (Bowen, 2009), the need to vaccinate domestic pets and livestock against rabies to provide a safety barrier between wild animals and humans cannot be overemphasized.

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