Why is there Still Rabies in Nigeria? - A Review of the Current and Future Trends in the Epidemiology, Prevention, Treatment, Control and Possible Elimination of Rabies

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Abstract: This study reports on why is there still rabies in Nigeria? Rabies is one of the most typical zoonosis that has been well known since ancient ages. Rabies is endemic in Nigeria and remains an important public health issue in Nigeria, West Africa. It is the most important typical and zoonotic disease in the country. Public concern and fears are most focused on dogs as the source of rabies. Rabies is an acute infectious viral disease that attacks the nervous system, leaving victims suffering from convulsions, paralysis, excessive salivation and an aversion to water. There have been fewer than five known cases where recovery has occurred. Rabies kills an estimated 35,000 per year, mostly in Africa, Asia and Latin America. Its occurrence in man and domestic animals is well known but the importance of wild animals in its spread has not been determined. To date, no effective medical therapy has been established for overt rabies. Preventive vaccination against rabies virus is a highly effective method for preventing rabies in humans and animals. The rabies Post-Exposure Prophylaxis (PEP), which is a serial vaccination against rabies starting as soon as possible after the patient was bitten by a suspected rabid animal, is the only way to prevent death. In Nigeria where dog bites continue to be the main mode of transmission of the disease to man, it remains a serious public health hazard. Despite proper vaccination some animals do not reach the threshold. Contributing factors include human factors through increased human activities, attitudes, and error; socioeconomic factors through major ecologic, environmental and anthropogenic changes of the biosphere, changes in agricultural practices, poverty, hunting with dogs, and increasing demands for meat; animal factors (through animal importation, host population increase, migration of dogs, migration of stray animals, frequency of consumption of animal brain); and vaccines and vaccination factors (low vaccination coverage by increasing nonimmune population and factor contributing to vaccine failures) and other vaccine related problem. Therefore, the need for detailed epidemiological studies in Nigeria together with surveillance, control, the vaccination of human and animals, and accurate data collection and adequate reporting is emphasized.

Keywords: Continued endemicity, domestic animals, preventive vaccination, public health issue, rabies, rabies virus, wild animal, zoonotic disease, Nigeria

INTRODUCTION

Rabies originated about 3000BC from the word rabha meaning violence. Rabies is one of the most typical zoonosis that has been well known since ancient ages and has been known for more than 4300 years (Takayama, 2005, 2008). Rabies remains a zoonotic viral disease that affects human, domestic and wild animals. Rabies kills an estimated 35,000 per year, mostly in Africa, Asia and Latin America (Beard, 2001). It remains an important
public health issue in Nigeria, West Africa. It is the most important zoonotic disease in the country. Public concern and fears are most focused on dogs as the source of rabies (Suzuki et al., 2008a, b). Rabies is a serious, acute, highly contagious, and fatal disease marked by a long and variable incubation period (Awoyomi et al., 2007).

It is an infectious viral disease of Central Nervous System (CNS) leaving victims suffering from convulsions, paralysis, excessive salivation and an aversion to water and leading to death of affected animal in most cases (Beard, 2001). Two types of rabies exist, this include sylvatic and urban. In the sylvatic cycle, this infection is maintained as an enzootic disease in several species, such as foxes, raccoons, and bats (Salmón-Mulanovich et al., 2009). The disease is acute progressive encephalitis characterized by changes in behavior like agitation excitation and drooling of saliva. At first there might not be any symptoms. But weeks, or even years after a bite, rabies can cause pain, fatigue, headaches, fever, and irritability. These are followed by seizures, hallucinations, and paralysis. There have been fewer than five known cases where recovery has occurred (Beard, 2001).

Rabies is mainly a disease of all warm-blooded animals. Its occurrence in man and domestic animals is well known but the importance of wild animals in its spread has not been determined (Umoh and Belino, 2008). Usually humans contract rabies through a rabid animal bite. However, human-to-human transmission of rabies virus occurred through organ transplantations. Furthermore, the virus is usually transmitted through the bite of an infected animal; corneal transplantation from an infected donor and viral inhalation however, may also result in infection (Takayama, 2005).

It is caused by rabies virus (RABV), a bullet–shaped, enveloped RNA virus 180-75 nm with projections and helical nucleocapsid, one of the better known encephalitis viruses of the family Rhabdoviridae and genus Lyssavirus (genotype 1). The genus Lyssavirus is differentiated into 7 genetically divergent genotypes: classical Rabies virus (genotype 1), Lagos bat virus (LBV; genotype 2), Mokola virus (MOKV; genotype 3), Duvenhage virus (genotype 4), European bat lyssavirus (genotypes 5 and 6), and Australian bat lyssavirus (genotype 7). All but MOKV have been isolated from bats. LBV and MOKV are each distributed in Africa and are members of phylogroup 2 within the genus Lyssavirus (Hayman et al., 2008). Because LBV isolates (Markotter et al., 2006a) from African bats are increasing. Recently, Hayman et al. (2008) determined the prevalence of virus neutralizing antibodies against LBV in bat populations in West Africa.

Host identity is rarely a problem in domestic animals, but wildlife species show potential uncertainty, such as demonstrated in the case reported by Markotter et al. (2006b). One important aspect of disease epidemiology is accurate information about the host species involved, which enables informed decisions to be made with regard to the epidemiologic patterns and potential threats to public and veterinary health (Markotter et al., 2006b). In Nigeria rabies infections both in animals and humans are grossly under reported (Fagbami et al., 1981). Though, the epidemiology, virology, transmission, pathology, clinical manifestations, diagnosis, and treatment of rabies infection have been described extensively by many authors. Yet the incidence of rabies is increasingly on the high side. This study therefore, reports on why is there still rabies in Nigeria?

**RESULTS AND DISCUSSION**

**Epidemiology of rabies in Nigeria:** A thorough description of rabies epidemiology depends on a comprehensive surveillance program and application of accurate molecular methods to discriminate among different variants and the emergence of new foci (Favoretto et al., 2006). Analysis of RABVs circulating in any region with the highest rabies incidence will help in establishing the true epidemiology of rabies (WHO, 2005). RABV is the prototype member of the family Rhabdoviridae and the genus Lyssavirus (Tao et al., 2009). It encodes 5 structural proteins: nucleoprotein, phosphoprotein, matrix protein, glycoprotein, and RNA-dependent RNA polymerase. The nucleoprotein (N) gene has been extensively used for genetic typing and evolutionary studies because of its relatively conserved variation among reservoir-associated variants and geographic lineages (Tao et al., 2009).

Rabies has a long history of occurrence throughout Africa, spanning hundreds of years. At least four distinct Lyssavirus species persist throughout the continent, among carnivores, bats and other mammals. Besides a prominent toll on humans and domestic animals, the disease has an underappreciated role in conservation biology, especially for such highly endangered fauna as African wild dogs. Both Duvenhage and Lagos bat viruses are adapted to bats, but their epidemiology, together with Mokola virus, is poorly understood (Nel and Rupprecht, 2007). The fluorescent antibody test used as a diagnostic test for rabies can only indicate the presence of lyssavirus antigens and cannot distinguish between lyssavirus genotypes. To identify a lyssavirus precisely, antigenic typing or genetic characterization is necessary, but these techniques are beyond the capability of most laboratories responsible for rabies diagnostics in Africa (Markotter et al., 2006b).

**1950s era:** History of rabies in Nigeria dated back to the 1950s. Lagos Bat Virus (LBV) was also isolated from frugivorous bats (*Eidolon helvum*) in Nigeria in 1956 (Kemp et al., 1972; MMWR, 1983).
1960s era: Mokola virus (MOKV) was first isolated from shrews (Crocidura spp.) in Nigeria in 1968 (Kemp et al., 1972; MMWR, 1983). Also, in 1968, Kemp et al. (1972) reported on the isolation of Kotonkan, a new rhabdovirus, which related to Mokola virus of the rabies serogroup. According Kemp et al. (1968), four rabies-related serotypes have been isolated, of which three may be new serotypes, and further investigation of these were recommended. These include: Kotonkan virus (IbAr 23380) represented by a single isolate from Culicoides spp. collected at the University of Ibadan Agricultural Farm, Nigeria, in December 1967. Kotonkan virus (IbAr 23380) is a chloroform-sensitive agent related to Mokola virus of the rabies serogroup by complement fixation and fluorescent antibody tests but not by neutralization test (Kemp et al., 1968).

1970s era: Subsequent cases of MOKV were reported in humans in Nigeria in 1969 and 1971 (Kemp et al., 1972; Ogunkoya et al., 1990). However, in Nigeria, where MOKV was isolated for the first time, two human cases with one death were reported. Two cases of (1 fatal) of human Mokola (Lyssavirus subtype 3) were reportedly claimed to have been isolated from Ibadan (Mokola Forest) (Table 1). Le Gonidec et al. (1978) emphasized the possibility of transmission of this virus by the bite of an arthropod.

Kemp et al. (1972) reported serological evidence of infection of dogs and man in Nigeria by lyssaviruses (family Rhabdoviridae). Kemp et al. (1973) carried out experimental infection and transmission studies on Mokola virus with the shrew (a natural host for MOKV).

1980s era: In Tomori (1980) reported cases of wild life rabies in Nigeria in an experimental infection and transmission studies with the shrew (Crocidura sp.). In 1981, a case of rabies in Hungary was reported in a child who had lived in Nigeria (Guseo et al., 1981). Also, Fagbami et al. (1981) in their study on hospital of human rabies and antirabies prophylaxis in Nigeria from 1969-1978 reported that rabies infections both in animals and humans are grossly under reported in Nigeria.

Okoh (1982) reported cases of canine rabies in vaccinated dogs in Nigeria from 1970-1980. According to him, from 1970 through 1980, 14 cases of rabies in vaccinated dogs were reported in various parts of Nigeria (Okoh, 1982). Most cases of human rabies were acquired from dogs. Its occurrence in man and domestic animals is well known but the importance of wild animals in its spread has not been determined. In 1983, a rabies case was reported in the United States following a dog-bite in Nigeria (MMWR, 1983). Okolo (1989) reported vaccine-induced rabies infection in rural dogs in Anambra State, Nigeria.

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Source: Umoh and Belino (2008). Information in this review is based on annual reports of the Nigerian veterinary departments, WHO statistics and surveys conducted.

1990s era: In 1990, serological evidence of infection of dogs and man in Nigeria by lyssaviruses (family Rhabdoviridae) was reported by Ogunkoya et al. (1990). In 1997, the last previous death from rabies in Britain was also traced and linked to an infection Nigeria, where an 18-year-old London man contracted the disease during a visit to Nigeria (WHO, 1997; Beard, 2001).

2000s era: In 2000, the retrospective dog rabies vaccination at Ibadan was evaluated by Adeyemi (2000 reviewed in Awoyomi et al. (2007) showed that there is still low response of dog owners to routine control of dog rabies by immunization. In 2001 June 1, Beard (2001) reported in the Independent Newspaper, The London, that rabies claimed its second victim in a month in Britain after the 51-year-old woman was bitten by a dog during a trip to Nigeria to see relatives died from the disease on Wednesday night in Lewisham hospital, south London, where staff were seeking to reassure those who had come into contact with her that the chances of catching rabies were "infinitesimal". She was flown back to Britain and admitted to hospital on Monday where doctors detected vomiting (Beard, 2001).
knew rabies could be prevented by vaccination, while 38.7% believed that the infection could be treated with herbs. Of the 387 victims of dog bite, 240 (62%) never sought prophylactic postexposure treatment. Of the 10 people who received postexposure treatment, only one received the appropriate treatment consisting of washing, disinfection of wounds, tetanus toxoid and complete antirabies immunization.

Awoyomi et al. (2007), in their study, pointed out the socioeconomic factors associated with non-vaccination of dogs against rabies in Ibadan, Nigeria. In 2008, to investigate the presence of Lagos Bat Virus (LBV)-specific antibodies in megachiroptera from West Africa, Hayman et al. (2008) conducted fluorescent antibody virus neutralization tests. Bats host a range of lyssaviruses, depending on their species and locality. Umoh and Belino (2008) gave a historical review of rabies in Nigeria and reported further on the new rabies-related viruses isolated in Nigeria. According to Umoh and Belino (2008), surveys of available serum specimens collected in Nigeria disclosed neutralizing substance for kotonkan virus in man, cattle, rodents and insectivores in the north, and in cattle, sheep and horses the south. In their study, results of additional neutralization tests with sera of newly imported cattle suffering a bovine ephemeral fever-like illness, suggest a possible connection between such outbreaks and kotonkan virus (Kemp et al., 1968).

In March 29, 2009 ProMED-mail post, Woolf (2009) reported on cases of rabies through dog or cat butchering in Nigeria. A ProMED-mail post, a program of the International Society for Infectious Diseases.

Notable outbreaks of rabies in Nigeria: Notable outbreaks of rabies in Nigeria are shown in Table 1. Most cases of human rabies in Nigeria were acquired from dogs. Surveillance strategies for rabies viruses and other rabies-related viruses in Nigeria must be improved to better understand the epidemiology of this virus and to make informed decisions on future vaccine strategies because evidence is insufficient that current rabies vaccines provide protection against these rabies-related viruses (Markotter et al., 2006b).

Current trends in control, elimination and possible eradication of rabies in Nigeria: Although rabies in domestic and wild animals represents a significant threat to public health and can cause economic losses among livestock, there are very few studies that examine the economics of rabies in animals. The literature that does exist can be characterized as poorly documented estimates of costs, with insufficient information to allow replication of the analyses. Most papers have numerous ‘violations’ of the standard recommended procedures for assessing burden of disease and the cost and benefits of interventions. The economics of using oral vaccines to prevent rabies invading uninfected areas has yet to be examined (Meltzer and Rupprecht, 1998a).

Asserting that rabies kills 100 children per day, worldwide, the Alliance for Rabies Control acknowledged that “rabies is also a concern for animal welfare, as fear of the disease results in hostile and antagonistic attitudes towards dogs and often inhumane approaches to dealing with suspected rabid dogs by communities and emphasized the need to expand dog vaccination against rabies in Asia and Africa” (Clifton, 2007).

Animal rabies control consists of the vaccination of dogs and cats, the elimination of stray animals, health education for the public, etc. In some countries, mass vaccination of dogs is not implemented, and the effective coverage rate is not exactly known. The elimination of stray dogs and other animals by shooting and poisoning is still implemented in certain countries; however, this has a minimal effect on rabies transmission (Seimenis, 2008). Preventive vaccination against rabies virus is a highly effective method for preventing rabies in humans and animals (Jakel et al., 2008). For travel purposes, vaccination of domestic carnivores is obligatory. In addition, some countries require testing for neutralizing antibodies against rabies. The minimal threshold level accepted by WHO/OIE is 0.5 IU/ml. Despite proper vaccination some animals do not reach the threshold (Jakel et al., 2008).

“In Asia and Africa,” the Alliance for Rabies Control points out, “the domestic dog is the main reservoir for rabies. As rabies is generally maintained only in a single reservoir population in any given area, control of disease in this population will result in its disappearance from all other species. This has been demonstrated with the elimination of rabies following oral vaccination of foxes in Western Europe, where red foxes are the reservoir host (Clifton, 2007).

Despite the availability of effective human and animal vaccines against rabies, and other measures for its control, rabies continues to account for at least 55,000 human deaths each year, mainly in the developing countries of Africa (Knobel et al., 2005). In these countries, most human rabies infections result from exposure to infected dogs, by bites, scratches, and mucosal exposures (Cohen et al., 2007). Rabies vaccination of animals and postexposure prophylaxis (PEP) for humans is prohibitively expensive for most African governments, and it has long been contended that the effects of rabies are underestimated in Africa (Cohen et al., 2007). Hilary Koprowski of Thomas Jefferson University, according to Rupprecht and Tumpey (2007), gave an overview of the historical aspects of rabies and the current need for integrated technology to eliminate canine rabies in the developing world such as Nigeria.
In Nigeria where dog bites continue to be the main mode of transmission of the disease to man, it remains a serious public health hazard (Awoyomi et al., 2007). Since dog has been established as the predominant vector of rabies in Nigeria, the most logical and cost–effective approach to rabies control is elimination of stray and owner less dogs combined with a programme of single mass immunization in the shortest possible time, at least 80% of the entire dog population (Awoyomi et al., 2007).

Although industrialized countries have been able to contain recent outbreaks of zoonotic diseases, many resource-limited and transitioning countries like Nigeria have not been able to react adequately. The key for controlling zoonoses such as rabies, echinococcosis, and brucellosis is to focus on the animal reservoir (Zinsstag et al., 2007). In this respect, ministries of health question whether the public health sector really benefits from interventions for livestock (Zinsstag et al., 2007). Effective, practicable and acceptable control strategy can only be put in place after the socio-economic facts associated with dog owners in each community in Nigeria have been studied.

Factors contributing to the continued endemicity of rabies in Nigeria: The number of reported human rabies cases, particularly in Africa, greatly underestimates the true effects of the disease (Cohen et al., 2007). Contributing factors include failure to seek treatment at healthcare facilities, failure to make a laboratory diagnosis, and failure to report the disease (Coleman et al., 2004; Knobel et al., 2005; Cohen et al., 2007). Dog rabies control relies principally on the mass immunization of dogs in order to achieve population immunity levels sufficient to inhibit rabies transmission (Perry and Wandeler, 1993). In Nigeria and Africa generally, such high levels of population immunity are rarely achieved due to a number of reasons. Oral immunization has been shown to be an effective means of inducing high levels of immunity in fox populations in several European countries, and this technique has been mooted as a means of overcoming the logistical problems of delivering injectable rabies vaccines to dogs (Perry and Wandeler, 1993). Although highly effective if administered correctly, PEP is much more costly than vaccination of domestic dogs (Rupprecht and Gibbons, 2004; Cohen et al., 2007). Whether a virus disease can be eradicated or not depends on many factors (Tamashiro et al., 2007). The main factors that contribute to the increase in the number of cases of rabies and factors affecting elimination of rabies in Nigeria include:

**Human factors:** Meslin et al. (2000) described the direct and indirect implications for public health of emerging zoonoses. Direct implications are defined as the consequences for human health in terms of morbidity and mortality. Indirect implications are defined as the effect of the influence of emerging zoonotic disease such as rabies on two groups of people, namely: health professionals and the general public. Professional assessment of the importance of these diseases influences public health practices and structures, the identification of themes for research and allocation of resources at both national and international levels (Meslin et al., 2000). The perception of the general public regarding the risks involved considerably influences policy-making in the health field. However, other human factors affecting elimination of rabies are:

**Increasing travel:** Rabies is a fatal disease, and increased travel to rabies endemic areas, communities or villages is one of the important factors influences the continual endemicity of rabies in Nigeria. Moreover, visitors to these communities and villages are sometimes unaware of the rabies risk posed by dog bites and thus may not seek appropriate medical attention for such bites. However, travelers going to endemic areas need to take precautions (Shaw et al., 2009).

**Lack of risk communication:** Lack of risk communication is one of the factors affecting rabies elimination especially in Nigeria. Although, the boycott of immunization is no longer in effect as in the case of polio, low participation during vaccination may persist reflecting a failure to implement risk communication (Agbeyegbe, 2007). The silence of the government over the alleged report by JNI and widely in the media that the government acknowledged the use of contaminated vaccines (as in the case of poliovaccines) but claimed that the contaminated batch had been completely used could be interpreted as indicative of the accurateness of the report. To address such situations, risk communication is increasingly becoming important in public health (Rudd et al., 2003). Risk communication offers a two-way communication process that presents the expert opinions based on scientific facts to the public, and acknowledges the fears and concerns of the public, seeking to rectify knowledge gaps that foster misrepresentation of risk (Leiss, 2004; Aakko, 2004; Agbeyegbe, 2007).

**Lack of knowledge and information:** This is one other factor affecting rabies elimination especially in Nigeria and has contributed to the continued endemicity of rabies in Nigeria. Many countries, especially those with resource constraints and those in sub-Saharan Africa, lack information on the distribution of zoonotic diseases such as rabies and rabies-related viruses (Zinsstag et al., 2007). Risks for zoonoses are considered negligible compared with those for diseases of higher consequence because the societal consequences of zoonoses are not recognized by
the individual sectors. However, transmission of rabies to humans can already be greatly reduced by health information and behavior. Interventions in human and livestock should always be accompanied by mass information, education, and communication programs.

**Lack of adequate public awareness:** Lack of public education campaigns is another factor affecting rabies elimination in Nigeria. Though, public awareness of the human health risks of zoonotic infections has grown in recent years (Heeney, 2006), reliable data on rabies are scarce in many areas of the country, making it difficult to assess its full impact on human and animal health (Awoyomi et al., 2007). Physicians in Nigeria can consult colleagues, libraries, or data banks for help with puzzling cases. At present, the networks do not address the underlying causes of new and reemerging infectious diseases. And they probably can do little to get to the heart of the real issues: educating the public, immunizing the children, improving sanitation, cleaning up the water, housing the homeless, feeding the starving (Okonko et al., 2008).

**Lack of good laboratory and proper surveillance:** This is another factor affecting rabies elimination in Nigeria. Isolation of LBV from terrestrial wildlife in study reported by Markotter et al. (2006a) serves as further confirmation of our lack of understanding of the incidence and host range of lyssaviruses in Africa. Poor surveillance of rabies-related viruses and poor diagnostic capability in most of area in Nigeria are large contributors to our lack of information and the obscurity of the African lyssaviruses. The lack of surveillance data on emerging zoonoses as rabies means that the burden of human, livestock and wildlife disease is underestimated and opportunities for control interventions thereby limited. Despite the availability of techniques to improve the global rabies situation, limitations in surveillance and epidemiologic investigations impede the institution of such measures (Knobel et al., 2005; Nadin-Davis et al., 2007). However, in Nigeria, laboratories continue to be sadly behind the times in terms of equipment and skills for diagnosing the emerging pathogens as can be readily observed in Nigeria (Okonko et al., 2008).

**Lack of appropriate control methods:** Lack of appropriate control methods is one of the factors affecting rabies elimination especially in Nigeria. Lethal methods of dog population control are even more expensive, and attempting to control rabies by reducing dog populations has not worked for any extended period (Meltzer and Rupprecht, 1998b).

**Lack of motivation:** Lack of motivation is another factor affecting rabies elimination in Nigeria. Several studies have documented the costs associated with wildlife-rabies epizootics (Shwiff et al., 2007; Sterner et al., 2009). According to the Alliance for Rabies Control, “the tools for effective rabies control are available. What is lacking are the motivation, commitment and resources to tackle the disease effectively (Clifton, 2007).”

**Lack of solid commitment and resourced initiatives:** Lack of solid commitment and resourced initiatives on the part of the government of Nigeria is one other factor affecting rabies elimination and this has contributed to the continued endemicity of rabies in the country. In Nigeria, little public domain information is available, but solid commitment and resourced initiatives are still lacking. However, in many areas in Nigeria, little is known about the real cost of mass vaccination of dogs, and quantitative data are urgently needed to evaluate the cost-effectiveness of different rabies control strategies in Nigeria.

**Inappropriate management:** Inappropriate management of rabies is another factor affecting rabies elimination in Nigeria. The clinical signs and symptoms of the initial rabies case-patients in Africa may have been altered due to use of traditional medicines. As reviewed by Cohen et al. (2007), the use of traditional medicines is common in rural settings in Africa (Nigeria inclusive) and may result in toxicities, including abdominal and psychiatric symptoms and abnormal liver function test results (Luyckx et al., 2004). These medicines could have contributed to the atypical manifestations in some cases. In addition, clinicians may have attributed some of the neurologic symptoms to herbal intoxication (Cohen et al., 2007). “In areas where there is a high prevalence of rabies, such as Africa, the need for vaccination has often been overlooked, despite the fact this would cost less than other health care programs, including administering post-exposure rabies immunization to save dog bite victims (Clifton, 2007) reflecting inappropriate management.

**Human attitudes and errors toward vaccination:** This is one other factors affecting rabies elimination especially in Nigeria. In rural areas of Nigeria, nearly every family owns several dogs, most of which are free roaming, without special diets, and these dogs go unvaccinated against rabies (to save costs). Free-roaming and unvaccinated dog populations may increase the likelihood of transprovincial or transregional as well as transcommunity spread of RABVs.

**Poor attitude of vaccination record keeping:** Poor attitude to keeping of vaccination records is also another factor affecting rabies elimination especially in Nigeria. There is a poor attitude of record keeping among Nigerians as it was practically impossible to obtain the vaccination records for any vaccine preventable diseases.
such as measles according to a study by Ogundiji (2008). Vaccinees should be educated in all immunization programs to keep their vaccination cards for future reference. Virology Laboratories also should be equipped with adequate test facilities to monitor post vaccination seroconversion among subjects (Ogundiji, 2008).

Gross under-diagnosis: This is another factor responsible for the continued endemicity of rabies in Nigeria and has affected the elimination of rabies in Nigeria. The incidence of rabies in many parts of Africa is unknown, but rabies is probably underdiagnosed (Mallewa et al., 2007). Cases of rabies may be incorrectly attributed to other causes of pyrexia and confusion common to rural Africa, including cerebral malaria, bacterial infections, and infection with HIV (Bleck and Rupprecht, 2005; Mallewa et al., 2007; Cohen et al., 2007). No investigations into infections of humans were made during most investigations, but lyssavirus infections in humans in Africa are underdiagnosed (Mallewa et al., 2007; Hayman et al., 2008).

Gross under reporting: This is another factor responsible for the continued endemicity of rabies in Nigeria and has affected the rabies elimination especially in Nigeria. Rabies is no doubt underreported and probably misdiagnosed in Nigeria and elsewhere in Africa (Asselbergs, 2007; Fagbo, 2009; Woolf, 2009). Quick, decisive action to detect and control novel pathogens, and thereby contain outbreaks and prevent further transmission, is frequently hampered by inadequate or inaccurate data about a new or re-emerging pathogen (Tapper, 2006). According to Ogundipe et al. (1989), in their study the development and efficiency of the animal health information system in Nigeria as well as the completeness and immediacy of data supply by the system for the period between January 1977 and December 1984 revealed that the system was found to be characterized by: late, inaccurate and gross under reporting. And these constraints in reporting include inadequate personnel, poor diagnostic and reporting facilities (Okonko et al., 2008).

Poor coordination and cooperation: Poor coordination and cooperation among federal government and some states is another factor responsible for the continued endemicity of rabies in Nigeria and has affected the rabies elimination especially in Nigeria. Because animal disease control, e.g. rabies control and ORV, is the responsibility of each federal state, insufficient cooperation in the planning of vaccination campaigns between neighboring federal states has also been an important shortcoming (Müller et al., 2005).

Lack of emergency preparedness planning: This is another factor affecting rabies elimination and has contributed to its continued endemicity in Nigeria. Emergency preparedness planning for animal diseases such as rabies is a relatively new concept that is only now being applied in Africa (Roeder et al., 1999).

Political instability and armed conflicts: Political instability or armed conflicts is another factor affecting rabies elimination and has contributed to its continued endemicity in Nigeria. In several states particularly the Niger Delta and the Northern States, political instability or armed conflicts make vaccination logistically difficult and unpredictable (Okonko et al., 2009). In addition to this internal politics in the 2003 polio and measles immunization boycott in Northern States in Nigeria, were ramifications from the internal political arena. Anti-western sentiments have increased among Northern Muslims fundamentalist following the September 11, 2001 attacks and America’s war on terrorism. Given the distrust and growing antagonism towards America, the involvement of the West in a program that benefits Muslims was viewed with suspicion (Agbeyegbe, 2007; Okonko et al., 2009).

Conflict-Threat of armed militias and forced Migration: Other challenges facing vaccination teams included the threat of armed militias that roam the area in search of opportunities to seize control over the local oil resources in the Niger Delta (Njoku, 2006). According to Okonko et al. (2008), with the overwhelming increase in high-intensity of local conflicts among political, ethnic, and religious rivals, government-based disease-surveillance systems have little or no chance of success. This has therefore affected rabies elimination and has also contributed to its continued endemicity in Nigeria.

Cultural and religious beliefs: This is another factor affecting rabies elimination and has contributed to its continued endemicity in Nigeria. Cultural and religious beliefs contribute to the underreporting of human rabies that may arise from the consumption of infected apparently healthy dogs and cats. The rabies-related lyssaviruses (Lagos bat and Mokola viruses) still remain under-diagnosed in the human populace (Fagbo, 2009; Woolf, 2009). Most of the anti-immunization campaigns in Nigeria have been predominantly Muslim north of Nigeria, and a number of Muslim clerics have been quoted in the Nigerian media as claiming that vaccines are dangerous and cause sterility or illness (Adeija, 2007). Cultural and religious objections under vaccinations efforts, resulting in persistently low immunity in the population and consequently, a high incidence of emerging vaccine-derived viruses and reemergence of wild viruses (Okonko et al., 2009). Whereas the undercurrents between Muslims and Christians in Nigeria as well as Western donors may have been sufficient to begin the controversy on the vaccines as was seen in the
Deception: Deception is another factor affecting rabies elimination and contributes to its continued endemicity in Nigeria. According to Clifton (2007), policymakers in the developing world often seek for their cities the superficially animal-free appearance of a “modern” city that they see in Europe and the U.S., equating this with ridding themselves of rabies. But casual outdoor observation of the country by daylight is deeply deceptive.

Socioeconomic factors:
Poverty: Poverty is one major socioeconomic factor responsible for the continued endemicity of rabies in Nigeria. Rabies in humans can be prevented by appropriate postexposure prophylaxis, which is not; however, always available and affordable in resource-limited or resource-misused countries like Nigeria (Zinsstag et al., 2007). Tissue-culture vaccines are expensive and they are not always used in all parts of the world (Takayama et al., 1997). Industrialized countries have (Klempner and Shapiro, 2004), but many resource-limited and transitioning countries have not been able to respond adequately and rapidly to recent zoonosis outbreaks and contained them well because they lack human and financial resources, and have not sufficiently adapted public health surveillance. In industrialized countries, an important part of successful zoonosis control has been compensating farmers for culled livestock. However, many Nigeria has not been able to conduct such programs (Zinsstag et al., 2007).

Hunting with dogs: Hunting activities is another socioeconomic factor responsible for the continued endemicity of rabies in Nigeria. The combination of urban demand for bushmeat and greater access to primate habitats provided by logging roads has increased the amount of hunting in Africa countries; Nigeria inclusive, which has increased the frequency of human exposure to zoonotic diseases and other disease-causing agents such as primate retroviruses (Chomel et al., 2007).

Increasing demands for meat: Increasing demands for meat in Nigeria is one other socioeconomic factor affecting rabies elimination and has contributed to its continued endemicity in Nigeria. Another risk factor related to the emergence of zoonotic diseases (such as rabies) from wildlife has been the considerable increase in consumption of bushmeat in this part of the world (Karesh et al., 2005; Chomel et al., 2007). In Nigeria, dog eating is very common in states such as Plateau, Akwa Ibom, Cross River, Kaduna, Kebbi and Ondo. In fact, dog suya (barbequed dog meat) is sold publicly in the dog eating areas. In some areas such as Jos, only local and seasoned connoisseurs may easily distinguish restaurants where dog and other conventional meats are sold. Cat eating, though not as common as dog eating, can also be encountered, even in cosmopolitan places such as Lagos. While human consumption of bats is also common, there seems to have been little or no local effort (as per the limited information available) to evaluate the risk of rabies transmission (Durosinsloun, 2009; Fagbo, 2009; Woolf, 2009).

Lack of good road network: Lack of good road network is another important factor affecting elimination of rabies in Nigeria and this also contributes to its continued endemicity in Nigeria. Of the targeted 29 million children, 4 million reside in impoverished and hard-to-reach settlements across the Niger Delta Region (Njoku, 2006).

Animal factors: Host population increase: Host population is one major animal factor affecting rabies elimination and this has also
Roseveare exposures have been derived from rabid wildlife reported potential rabies exposures are associated with long-distance spread of rabies. While the majority of these are caused by domestic dogs (Cohen et al., 2007). The pet dog and cat populations rose proportionate to the human population. The pet dog population had increased by just about exactly as much as the street dog population declined (Clifton, 2007).

Migration of dogs: Migration of dogs is one other major animal factor affecting rabies elimination and this has also contributed to its continued endemicity in Nigeria. This has been previously pointed out that in several studies that, “outbreak of rabies in humans followed an outbreak in domestic dogs”. Increasing numbers of human rabies cases in Africa, Nigeria inclusive, have been attributed to the mobility of human and animal populations (Cohen et al., 2007). Other human-related activities, such as persons migrating with their dogs may also contribute to long-distance spread of rabies. While the majority of reported potential rabies exposures are associated with dog and cat incidents in most places, most rabies exposures have been derived from rabid wildlife (Roseveare et al., 2009).

Migration of stray animals: This is another factor responsible for the continued endemicity of rabies in Nigeria. According to Roseveare et al. (2009), stray cats were most frequently rabid among domestic animals. In Nigeria, we have so many stray dogs and cats all over the cities and there is no mass vaccination programme for such animals. This underscores the need for improvement of wildlife rabies control and the reduction of interactions of domestic animals, including cats, with wildlife in Nigeria.

Frequency of consumption of animal brain: Frequency of consumption of animal brain is another factor that might have been responsible for the continued endemicity of rabies in Nigeria. Oral transmission of rabies could be produced in laboratory animals like mice, guinea pigs and hamsters using Challenge Virus Strain (CVS) and 2 strains of street virus (Madhusudana and Tripathi, 1990). Study of virus pathway following ingestion suggested predominant neural spread to brain and centrifugal spread to non-neural organs like heart and kidneys. However, it was found that virus dose required for oral infection was relatively very high in a study by Madhusudana and Tripathi (1990). The role of such a transmission in nature needs to be further evaluated, keeping in view the high dose of virus required for oral infectivity and the frequency of consumption of brain by carnivorous animals.

Vaccines and vaccination factors (by increasing nonimmune population), including factors contributing to low coverage: This is another major factor affecting rabies elimination and contributes to its continued endemicity in Nigeria. Vaccines are the basis of the medical and veterinary medical future, the belief being that, if a vaccine can be made to every disease, then all disease can be prevented. This presupposes that 1) disease attacks from outside and has nothing whatsoever to do with the person or animal themselves; 2) that vaccines actually always protect one hundred per cent; and 3) that vaccines themselves are only beneficial and cannot cause harm. None of these are true. There is a growing list of research into and information on the problems that can be caused by vaccines. There has been much debate on the subject of annual pet vaccination, chiefly in response to concerns voiced by pet owners. The veterinary profession is largely unaware of the range of side effects vaccines can stimulate, and consequently they go unreported. Despite the availability of effective human and animal vaccines against rabies, and other measures for its control, rabies continues to account for at least 55,000 human deaths each year, mainly in the developing countries of Africa and Asia (Knobel et al., 2005). In these countries, most human rabies infections result from exposure to infected dogs, by bites, scratches, and mucosal exposures (Cohen et al., 2007). Rabies vaccination of animals and postexposure prophylaxis (PEP) for humans is prohibitively expensive for most African governments, and it has long been contended that the effects of rabies are underestimated in Africa (Cohen et al., 2007). A radical rethink of the vaccination programme is necessary - immunization programmes need not be abandoned, but reassessed.

Low vaccination coverage: This is a major vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. The single most important factor affecting eradication of rabies is the failure to immunize domestic dogs, which transmit rabies to humans (Fu, 2008). Descriptive epidemiologic analysis has also shown that low vaccination coverage has contributed to rabies epidemics (Lv et al., 2004; Wang, 2006; Li et al., 2005). Mass vaccination of the domestic dog provides the most cost-effective and efficient strategy for controlling canine rabies and hence transmission from dogs to humans (Clifton, 2007).

Vaccine failure: Vaccine failure is another major vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. Okoh (1982) reported 10 cases of apparent vaccine failure in Nigeria involving modified live (low egg passage chick embryo) vaccine in use during the study period. In their study, 4 of these...
cases of infection may actually have been induced by the vaccine. In 1989, Six cases of apparent vaccination failures in rural dogs given modified live virus, chicken embryo origin, low egg passage, Flury-type vaccine, was reported (Okolo, 1989). However, the most likely cause of the vaccine failures lies in the vaccine ingredients used. According to Wu et al. (2009), any failure of vaccination and PEP should be investigated thoroughly and independently to trace potential errors in the protocol. A national vaccine adverse-event reporting system should be established to track suspected problems for safety and efficacy. Surveillance should be heightened to monitor efficacy of vaccines in current use in the country through seroconversion testing after vaccination may not be necessary in either humans or animals.

Unavailability of WHO recommended RIG: This is is another vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. After severe exposure to suspected rabid animal WHO recommends a complete vaccine series using a potent effective vaccine that meets WHO criteria, and administration of Rabies Immunoglobulin (RIG). RIG is not available globally (Yanagisawa et al., 2008) and is not marketed in Nigeria.

Use of low potency vaccines: Use of low potency vaccines is another vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. When post-exposure prophylaxis are most health sector do not take time to know the sort of rabies vaccine being injected. It is important to know the sort of rabies vaccine injected abroad, because brain-tissue vaccines are less effective in inducing antibody than tissue-culture vaccines (Takayama et al., 1997).

Safety problem: The currently available modified-live rabies virus vaccines have either safety problems or do not induce sufficient protective immunity in particular wildlife species. This is also is another major vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. Therefore, there is a need for the development of new live virus vaccines that are very safe and highly effective in particular wildlife species (Dietzschold and Schnell, 2002).

Failure to show an adequate antibody titre: Cases of failure of vaccinated animals to show an adequate antibody titre is another vaccine and vaccination factors affecting rabies elimination and this also contributes to the continued endemicity of rabies in Nigeria. In line with study carried out in other countries, Nigeria faces with problem of some vaccinated animals fail to show an antibody titre adequate to meet the requirements of the 0.5 IU/ml minimal threshold level accepted by WHO/OIE (Jakel et al., 2008).

Lack of ideal cross-reactivity with modern biologicals: Lack of ideal cross-reactivity with modern biologicals is one other vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. Significantly, less than ideal cross-reactivity with modern biologicals used for veterinary and public health interventions is a major cause for concern among these emerging viral agents [Duvenhage and Lagos bat viruses] (Nel and Rupprecht, 2007).

High cost of postexposure prophylaxis: Although rabies is preventable, the high cost of postexposure prophylaxis, compounded by the lack of education and awareness about rabies, limits use of postexposure prophylaxis in many developing countries such as Nigeria (Nadin-Davis et al., 2007). This also might have contributed to the continued endemicity of rabies in Nigeria.

Lack of delivery systems and resources: Lack of delivery systems and resources in some parts of Nigeria especially in the rural areas is one other major factor affecting rabies elimination and this also contributes to its continued endemicity in Nigeria. Outbreak of rabies in humans followed an outbreak in domestic dogs. Increasing numbers of human rabies cases in Africa have also been attributed to deteriorating infrastructure and resources for rabies control. Although, the tools for effective rabies control are available, lacking are the delivery systems, public education campaigns and resources to apply these technologies in the developing world (Clifton, 2007).

Challenge in testing of vaccine efficacy: This is another vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. The ultimate test of vaccine efficacy is challenge with a dose and strain of rabies virus known to be lethal to unvaccinated animals. However, establishing the necessary challenge conditions, followed by carrying out the challenge experiments themselves, would necessitate killing at least 20-30 captive wild dogs. The consensus of vets and biologists involved in research on rabies in wild dogs and other carnivores is that challenges would be both unnecessary and unethical - for this reason, applications for government licenses to carry out such experiments would probably be unobtainable (Ginsberg and Woodroffe, 1997).

Existence of healthy carriers: This is another factor affecting rabies elimination and which could have also contributed to the continued endemicity of rabies in Nigeria. Most authors have suggested that trends in spread of rabies may be caused by a carrier state in healthy dogs that remains undetected (Zhang et al., 2008). The paper by Ajayi et al. (2006) also indicates a disturbing...
possibility of transmission of rabies by apparently healthy (free of overt rabies signs) stray dogs. If their observations are confirmed, this, in their words, "signifies a new dimension in the epidemiology of the disease in this environment where the high-risk practices are prevalent (Durosinnloun, 2009; Fagbo, 2009; Woolf, 2009)." What's more intriguing epidemiologically and culturally is that the research by Ajayi et al. (2006) was carried out in Maiduguri; the overwhelming Muslim population in the city provides zero economic incentives for dog meat restaurants (Durosinnloun, 2009; Fagbo, 2009; Woolf, 2009). However, the dogs were slaughtered in restaurants associated with 2 military barracks in the city (Durosinnloun, 2009; Fagbo, 2009; Woolf, 2009).

**Long incubation period:** During most of the long incubation period of rabies, the virus likely remains close the site of viral entry. Centripetal spread to the central nervous system and spread within the central nervous system occur by fast axonal transport. Neuronal dysfunction, rather than neuronal death, is responsible for the clinical features and fatal outcome in natural rabies (Jackson, 2003) thus, might have also contributed to the continued endemicity of rabies in Nigeria.

**Inconsistent vaccination and wrong vaccination regime:** This is one of the vaccine and vaccination factors affecting rabies elimination and this has also contributed to its continued endemicity in Nigeria. The local increase in the number of rabies cases and the resulting spread of rabies in recent years has also been attributed to inconsistent vaccination, e.g., missing complementary distribution of baits per hand in non-flying zones (Müller et al., 2005).

**Inferior vaccine quality:** Inferior vaccine quality is also another vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. Any potent rabies vaccine will protect against rabies. The inferior quality of the domestically manufactured dog vaccine has been documented (Hu et al., 2008). According to Wu et al. (2009), vaccine quality control and mass production, rather than matching, are urgently needed and most important for addressing the current rabies problem.

**Vaccine shortage:** Vaccine shortage is also another vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. Vaccine shortages can result from higher-than-expected demand, interruptions in production/supply, or a lack of resources to purchase vaccines (Hinman et al., 2006). In developing countries like Nigeria, the major cause of vaccine shortages is lack of resources or political will and commitment to purchase them.

**Limited number of related vaccine strains:** Limited number of related vaccine strains is another vaccine and vaccination factor responsible for the continued endemicity of rabies in Nigeria. Attenuated tissue culture-adapted and natural street rabies virus (RV) strains differ greatly in their neuroinvasiveness (Faber et al., 2004). A study by Tomori (1980) on wild caught shrews infected with rabies virus strains by the intramuscular, subcutaneous and oral routes suggested a mechanical role in the transmission of rabies. In his study, virus was isolated only from shrews infected with street or wild strains of rabies, but not with vaccine or fixed rabies strains.

**Role of rabies related viruses:** The public health significance of the rabies-related viruses was emphasized in Nigeria where the Mokola virus was isolated from shrews, Lagos bat virus from fruit bats and Kotonkan were found in insects and are only distantly related to rabies virus. This factor might have been responsible for the continued endemicity of rabies in Nigeria.

**Other vaccine related problem:** Other vaccine related problems that affects rabies elimination and have also contributed to its continued endemicity in Nigeria is the failure to provide subsidized post-exposure vaccination in some part of the country. Subsidized post-exposure vaccination is the standard response to rabies. Post-exposure vaccination saves thousands of lives annually, despite many failures when dog bite victims fail to seek treatment soon enough, do not complete the full course of injections, or receive fake, expired, or obsolescent vaccines, a problem particularly prevalent in this parts of the world, where post-exposure vaccines are not manufactured nor made by local suppliers, and using vaccines elsewhere long abandoned.

**Future corrective actions:** The following corrective actions are recommended concerning mainly the weak points that have been identified in developing countries such as Nigeria and the preventing measures:

**Communication:** To provide to the Virology and Veterinary Services all means of communication as it has been noticed that some of them had no internet facilities, the GSM, telephone or fax or any other mean of communication. The radio sets once they used are all out of order and necessitate repair and maintenance.

**Reporting:** This point is tightly linked with the precedent one. It is highly recommended that the field operators (virologist, biologist, zoologist, parasitologist, veterinarians and animal health technologists/ superintendents) should report periodically the zoo-sanitary events they notice and every time they feel that something abnormal is happening. Special instructions should be directed to the State Health and Veterinary Services on that matter. According to the Federal Services, the health officers, and veterinarians report
monthly to the State Directorate and the Federal Offices report quarterly to the Federal Services in Abuja; the field technologists report if necessary and the dog owners never report. The dog owners and hunters should be approached by the field veterinary staff in order to obtain their commitment in the diseases control, so they can inform them in case of abnormality.

**Information:** According to the Veterinary Services in Nigeria, the information has been spread to the veterinary staff, and to the administrative responsible but none of the public or the other agents of the Ministry of Agriculture and Natural Resources or the animal owners had been informed. It is recommended to perform a public information campaign through the media, in English and local languages, taking care of the content of the messages directed to the Public, avoiding misunderstanding and possible panic. Papers, leaflets or booklets on rabies epidemiology, pathogenesis and control should be prepared and distributed to the veterinary staff, and training sessions on clinical and post mortem recognition should be organized. Less elaborated leaflets and posters should be printed for distribution to the villagers, dog breeders, and hunters and to other concerned people and displayed in public places.

**Awareness:** There must be a greater public health effort to educate clinicians and the public about proper response to bat exposures, particularly undetectable bite exposures (Abazeed and Cinti, 2007). Had public health authorities been contacted to collect and test the captured bat for rabies, there would have been no ambiguity as to the appropriate course of action (Abazeed and Cinti, 2007). The awareness of dog owners and hunters should be raised, holding village level meetings. Civil administrative authorities should also be put in state of alert by periodical epidemiological information. An early warning system should be implemented in every State and at the Federal level. According to the Veterinary Services, all the veterinary staffs are in alert but nothing have been done on the field for the villagers. Also, to reduce risk for emerging zoonoses, the public should be educated about the risks associated with wildlife, bushmeat, and exotic pet trades; and proper surveillance systems should be implemented (Chomel et al., 2007).

**Solid investigation and active surveillance:** As no programme of investigation at the Local Governments and villages levels has been implemented, it is recommended that epidemiological investigation should be carried out by the field veterinary staff and extension personnel, in the villages, asking a single question: "have you noticed any abnormality on dog population"? As suggested by Kuiken et al. (2005), it is time to form "a joint expert working group to design and implement a global animal surveillance system for zoonotic pathogens that gives early warning of pathogen emergence, is closely integrated to public health surveillance and provides opportunities to control such pathogens before they can affect human health, food supply, economics or biodiversity (Chomel et al., 2007)."

**Preventing measures:** Human PEP should be initiated on the basis of diagnosis of biting animals. Reliable national systemic surveillance of rabies-related human deaths and of animal rabies prevalence is urgently needed (Wu et al., 2009). A laboratory diagnosis-based epidemiologic surveillance system can provide substantial information about disease transmission and effective prevention strategies (Wu et al., 2009). Key measures for reducing the dispersion of emerging zoonoses such as rabies include sustainable agricultural development, proper education of tourists about the risks of outdoor activities, and better control of the live animal trade (exotic pets, wet markets, bushmeat). Public health services and clinical practitioners (physicians, veterinarians) need to more actively educate the public about the risks of owning exotic pets and adopting wild animals (Chomel et al., 2007).

**Need for detailed epidemiological studies:** The need for detailed epidemiological studies in Nigeria together with surveillance, control, the vaccination of dogs, and accurate data collection is emphasized. It is therefore necessary to make the following recommendations for effective control of this disease.

- Surveillance should be heightened to monitor efficacy of vaccines in current use in the country and measure effectiveness of control measures.
- There should be public education on Rabies. Sustained awareness, together with political and economic commitment to animal and human rabies control programs, particularly the vaccination of dogs, is essential (Cohen et al., 2007).
- Government policy should include stiff measures and free mass vaccination of dogs and cats should be carried out regularly.
- Clinicians should consider rabies in the differential diagnosis, especially in cases of fatal encephalitis and submit appropriate specimens for rabies diagnosis (Cohen et al., 2007).
- Well equipped diagnostic laboratories and means of identifying vaccinated animals like tagging
- People at risk should have up to date pre-exposure and post-exposure vaccination
- People must avoid unfamiliar wild or domestic animals even if they appear friendly.
- People especially children must be educated to avoid wildlife, including bats and to always keep dogs on a leash for a walk.
What next? In addition to what has been said before, it is recommended that, in the rabid infected families, infected persons and dogs movement should be prohibited and that the dogs should be kept secured. For the states it is recommended to restrict the movement and trade of dogs coming from the rabies endemic states/countries. The immediate emergency action on the subject by the States Veterinary Services is required. The Nigerian Federal and State Veterinary Services are represented in all the states and veterinary staff can be found at least at the level of Local Governments, covering most of the national territory. Well trained and well equipped, they could face the epizootics, report, inform and carry out any control measure. The most important constraint is the lack of funds for compensation.

Knowledge of the association of specific variants with animal hosts has led to increasingly effective control measures that target the hosts responsible for spreading this disease (Slate et al., 2005). Moreover, molecular epidemiologic approaches have enabled study of the spread of certain rabies virus variants and their incursion into new geographic regions. According to Nadin-Davis et al. (2007), adaptation of such methods in developing countries like Nigeria would help provide reliable data on the true extent of rabies in such countries, provide epidemiologic data about the spread of rabies and justify allocation of increased resources.

CONCLUSION

Most human deaths from rabies occur in tropical resource-limited countries (Zinsstag et al., 2007). In Africa and Asia, an estimated 24,000-70,000 persons die of rabies each year (Knobel et al., 2005). The domestic dog is the main source of exposure and vector for human rabies (Zinsstag et al., 2007). Rabies in humans can be prevented by appropriate postexposure prophylaxis and through vaccination of the animal vector, which is not, however, always available and affordable in resource-limited countries (Zinsstag et al., 2007).

However, rabies as a fatal viral zoonosis remains an important public health problem in Nigeria due to uncontrolled enzootic rabies, lack of vaccination and poor information. Questions are raised why rabies has not evolved more rapidly in the New World, given the frequency and ease with which antigenic changes can be induced in the laboratory, and how the virus became so extensively established in New World bats (Shope, 1982). However, the situation reported in Viet Nam, Nigeria, etc. only reaffirms that rabies is more of a neglected tropical disease than thought and which deserves attention (Durosinloun, 2009; Fagbo, 2009; Woolf, 2009). Borrowing a leaf from the examples described by Meslin et al. (2000), current review reports emphasized the importance of intersectorial collaboration for disease containment, and of independence of sectorial interests and transparency when managing certain health risks. Zoonoses must be dealt with at the interface of human and animal health by all available information (Murphy, 2008).

Public health implications of African rabies and rabies-related lyssaviruses should be recognized by laboratory workers, researchers, veterinarians, wildlife personnel, gamekeepers, and pet owners. A better understanding of the epidemiology of these viruses is vital and can only be achieved by improved surveillance and awareness (Sabela et al., 2007).

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