Rabies vaccines
WHO position paper


In accordance with its mandate to provide guidance to Member States on health policy matters, WHO is issuing a series of regularly updated position papers on vaccines and vaccine combinations against diseases that have an international public health impact. These papers, which are concerned primarily with the use of vaccines in large-scale immunization programmes, summarize essential background information on the respective diseases and vaccines, and conclude with the current WHO position concerning their use in the global context. The papers have been reviewed by a number of experts within and outside WHO and since April 2006 they are reviewed and endorsed by WHO's Strategic Advisory Group of Experts (SAGE) on vaccines and immunization. The position papers are designed for use mainly by national public health officials and immunization programme managers. However, they may also be of interest to international funding agencies, the vaccine manufacturing industry, the medical community, scientific media, and the public.

Summary and conclusions
Rabies is a viral zoonosis and many carnivores and bat species are hosts of the rabies virus in nature. Globally, in terms of human disease the dog represent the most important reservoir and transmitter of the virus. Infection of humans usually follows bites by rabid animals and is almost invariably fatal once signs of disease occur. More than 3.3 billion people live in regions where there is a risk of rabies. Approximately 55 000 people die from rabies each year, the vast majority of these deaths occurring in Asia and Africa. Children are at particular risk. Every year, more than 10 million people, mostly in Asia, receive post-exposure vaccination against this disease.

Where rabies is a public health issue, prevention of the disease in humans depends on a combination of interventions including control of rabies in both wild and domestic animals, particularly dogs, pre-exposure immunization of humans at risk of contracting the disease and on delivery of post-exposure prophylaxis to potentially exposed patients. The emphasis of this paper is on human rabies vaccines and their use in post-exposure prophylaxis and pre-exposure immunization.

For many years, safe and highly efficacious rabies vaccines produced in various cell cultures including embryonated egg cells have been commercially available. These vaccines, which in this paper are jointly referred to as cell culture-based vaccines (CCVs) or modern rabies vaccines, are mostly intended for intramuscular injection. However, modern rabies vaccines may be in short supply and/or unaffordable in many countries with a high incidence of rabies. In some of these enzootic areas, the safety and effectiveness of dose-sparing intradermal (ID) administration of selected
CCVs have been well established in recent years. ID administration is also shown to be a cost-saving alternative to the traditional intramuscular immunization regimens.

In a few countries, mainly in Asia, populations at high risk of rabies may still depend on rabies vaccines derived from animal brains for post-exposure prophylaxis. These so called nerve-tissue vaccines (NTVs) are usually provided for free in governmental rabies centres. As compared to modern CCVs, NTVs are more reactogenic and may cause severe, even fatal, encephalitis and polyneuritis. Also, NTVs are less potent and require a higher number of doses.

Following exposure to a rabid or suspected rabid animal, a safe and efficacious CCV should be administered promptly. It is strongly recommended that in all enzootic regions the production and use of NTVs for human use be discontinued and replaced by modern CCVs as soon as possible.

In case of severe (category III) exposure, active immunization should be combined with the administration of specific rabies immune globulin (RIG). Measures to increase the supply and accessibility of high-quality rabies vaccines and RIG among the poor segments of affected populations are strongly encouraged.

Pre-exposure immunization is recommended for all individuals at increased risk of contracting rabies, either by nature of their residence or occupation, or when traveling. In enzootic areas children are at particular risk of exposure to rabies virus. WHO encourages carefully designed studies on the feasibility and impact of incorporating modern rabies vaccines in the routine immunization programmes of infants and children in communities where rabies is a major health problem.

Where rabies poses a significant health problem and modern rabies vaccines are unaffordable and/or in short supply, use of the dose-saving intradermal route for both pre-exposure and post-exposure prophylaxis should be considered. Only rabies vaccines which have been shown to be safe and efficacious for intradermal (ID) administration in post exposure situation should be used*. Staff should be appropriately trained to ensure correct storage, reconstitution and injection of the vaccine for successful ID immunization.

The burden of rabies in humans could be significantly reduced and even eliminated through coordinated efforts as highly efficacious animal and human vaccines are available but significantly underutilized and awareness of preventative measures are lacking in highly endemic regions.

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Background
Public health impact of rabies

In more than 100 countries and territories, rabies is enzootic in both wild and domestic animals. Rabies in dogs poses a potential threat to more than 3.3 billion people, the majority of whom living in Asia and Africa (Knobel DL et al). A variety of wild carnivores and bat species may also transmit rabies to humans, but the total number of reported bat-associated cases in Africa, Australia, Europe, North and Latin-America remains very small compared to the estimated annual number of human deaths due to dog transmitted rabies.

Once clinical symptoms have occurred, rabies is almost invariably fatal. However, deaths from rabies are likely to be grossly underreported in several enzootic countries, particularly in the youngest age groups, and the estimated 55 000 (90% CI: 24.500 – 90.800) deaths per year may be an underestimate (Knobel DL et al). Asia and Africa account for the vast majority of rabies fatalities. In India alone, 20 000 deaths are estimated to occur annually, i.e. 2 per 100 000 population; in Africa the corresponding figures are estimated at 24 000 (4 per 100 000). Although all age groups are susceptible, rabies is most common in people aged below 15 years, with 30%-50% of post-exposure prophylaxis given to children aged 5-14 years, the majority being male. The most severe injuries such as multiple head and/or neck bites have the shortest incubation period and tend to occur in the youngest children.

About 98% of human rabies occurs in regions with large numbers of dogs, many of which are strays. Human rabies has become a very rare disease in the majority of industrialized countries and in most of Latin America where rabies in dogs is close to being eliminated through reduction of strays and vaccination of domestic dogs.

Approximately 10 million people receive post-exposure prophylaxis annually, the majority living in China and India. In countries such as Thailand mass vaccination of dogs and widespread post-exposure prophylaxis has significantly contributed to a reduction of human deaths from rabies. Post-exposure rabies prophylaxis is estimated to prevent 330 304 (90% CI: 141.844 – 563.515) deaths in Asia and Africa (APCRI report 2003).

Deaths caused by rabies are responsible for 1.74 (90% CI: 0.25-4.57) million DALYs lost each year (Knobel DL et al). The annual global expenditure for rabies prevention is by conservative assessment well over US$ 1 billion. This expenditure as well as the frequency of post exposure prophylaxis are expected to rise dramatically as all countries replace nerve tissue-vaccines by modern, safe and highly potent rabies vaccines developed in cell cultures or embryonated duck eggs.

The pathogen and disease

Rabies virus belongs to the genus Lyssavirus within the family Rhabdoviridae. Lyssavirus includes 11 genotypes, of which type 1 represents the classic rabies virus. The RNA of this bullet-shaped virus encodes 5 proteins including the G glycoprotein which carries the main antigenic sites and the nucleocapsid (N) protein which encapsulates the viral genome and the RNA polymerase.
Rabies is a zoonosis and human infection occurs usually as a result of a transdermal bite or scratch by an infected animal. Transmission may also occur when infectious material, usually saliva, comes into direct contact with the victim's mucosa or with fresh skin lesions, or on very rare occasions through inhalation of virus-containing aerosol or via corneal and/or organ transplants from undiagnosed cases of rabies.

The uptake of virus into peripheral nerves is important for the infective process to progress. Both direct entry of virus into nerves at the site of inoculation and indirect entry after viral replication in non-nervous tissue (i.e., muscle cells) have been demonstrated. Within peripheral nerves the virus follows the retrograde axoplasmic flow to the central nervous system where it multiplies and disseminates rapidly, and then moves via anterograde flow to secretory tissues such as the salivary glands. The rabies virus is widely disseminated throughout the body at the time of clinical onset. The incubation period is usually 1 to 3 months, but depending upon factors such as size of viral inoculum, degree of innervation at the site of viral entry, and proximity of the bite to the central nervous system, the period of incubation may vary from a few days to possibly several years.

No tests are currently available to diagnose rabies infection in humans before the onset of clinical disease and hence, diagnosis is based on symptoms and signs, supported by epizootologic information. The initial symptoms of rabies are often mild fever and pain or paraesthesia at the wound site. As the virus spreads in the central nervous system, progressive encephalitis develops, characterized by hydrophobia or aerophobia, hyperactivity and fluctuating consciousness, generalized convulsions and finally cardiorespiratory arrest (Jackson AC 2007). The disease is almost always fatal within a few days. Paralytic rabies runs a less dramatic course, but the final outcome is the same. Flaccid paralysis ascending with pain and fasciculation in the affected muscles and mild sensory disturbances will precede death from bulbar and respiratory paralysis. Even in the absence of intensive care, such patients may survive for about a month.

Antiviral agents, interferon and massive doses of rabies immune globulin have been used to treat human cases, but almost invariably without preventing death. Although recently, one case of bat-transmitted rabies survived following drug-induced coma and antiviral treatment, the same intensive treatment protocol failed to save the lives of several subsequent bat-rabies infected patients.

Immune response
In natural infection, rabies virus is largely unavailable to the immune system resulting in a delayed antibody response to both its G and N proteins and a reduced number of natural killer cells.

Following vaccination with modern CCVs, a prompt antibody response is elicited. Pre-immunized individuals will have a more rapid antibody response as compared to non-immunized individuals due to the presence of memory cells. As a result, the use
of rabies immunoglobulin as part of the post-exposure prophylaxis can in some cases be omitted (see below).

Immunity is believed to depend mainly upon virus neutralizing antibody (VNA) response to the G protein. Also, cell-mediated immunity has long been recognized as an important part of the defense against rabies.

With rabies vaccines no randomized, controlled human trials and cohort studies involving untreated comparison groups are possible. Therefore, information on vaccine efficacy is based on field experience of post-exposure prophylaxis in humans exposed to laboratory confirmed rabid dogs. Also, the efficacy of a given vaccine when administered at the same time as rabies immunoglobulin can be assessed following severe (category III) exposure to confirmed rabies virus. An indirect assessment of vaccine efficacy can be made through immunogenicity studies comparing the VNA titres induced by the test vaccine with those induced in the same study by a reference vaccine of known protective efficacy. Furthermore, animal models serving as human surrogates have been used to demonstrate the utility of CCVs after experimental infection, as a proof of concept.

Although a “protective” VNA-concentration has not been established, concentrations of at least 0.5 IU/mL are widely accepted as adequate. In healthy individuals, adequate concentrations are regularly achieved by day 14 of a standard post-exposure immunization series with a CCV, with or without simultaneous administration of human rabies immunoglobulin. In individuals aged over 50 years the serological response to rabies vaccination may be less efficient than in younger people. However, all seem to seroconvert after the 5 doses that are recommended for post-exposure prophylaxis.

Rabies vaccines

**Nerve tissue based vaccines**

More than 100 years ago, Louis Pasteur and his colleagues developed the first crude rabies vaccine based on attenuated virus in desiccated nerve tissue. Nerve tissue vaccines (NTVs) were intended for post-exposure prophylaxis. Although continuously improved over the years, inactivated NTVs produced in the brains of sheep or goats (Semple) or suckling mice (Fuenzalida) are associated with neurological adverse reactions. Thus, in about 0.3-0.8 persons per 1000 vaccinees sensitization to contaminating neuroproteins present in the vaccine causes severe allergic encephalomyelitis. Also, these vaccines are inferior to modern CCVs in terms of potency and immunogenicity. A complete post-exposure prophylaxis regimen using NTVs involves a prolonged and painful immunization course of 7-10, even up to 23 injections.

In recent years, India and Nepal have successfully phased out production and use of NTV. However, due to their low cost and local availability, NTVs are still used in small number of countries, mainly in South-East Asia
The new generation of rabies vaccines:
The new generation of rabies vaccines is made of virus that has been inactivated following propagation in cell cultures or in embryonated egg cells, for example in human diploid fibroblasts, fetal rhesus cells, primary Syrian hamster kidney cells, Vero cells (African green monkey kidney cells), chick embryo cells, duck embryo cells or in embryonated duck eggs (ref WHO/ Zoonotic Infections). These vaccines are all intended for pre-exposure immunization as well as for post-exposure prophylaxis. Some of these vaccines are manufactured to cover primarily national needs, others are produced for the international markets.

Internationally available cell culture-based rabies vaccines
The human diploid cell vaccine was introduced in 1967. The more recently developed, and less expensive, purified chick embryo cell vaccine and purified Vero cell vaccine have characteristics comparable to the human diploid cell vaccines. The human diploid cell vaccine is based on the Pitman-Moore strain of the rabies virus. Purified chick embryo cell rabies vaccine is prepared from inactivated rabies virus of the Flury strain, whereas the purified Vero cell rabies vaccine contains the Wistar (PMWI 38-1503-3M) strain (Rupprecht: What is the Wistar strain?) of the virus. The internationally available CCVs have been given to millions of people worldwide.

Following growth in their respective cells cultures the viral harvest is concentrated by zonal centrifugation /ultracentrifugation, inactivated by beta-propiolactone, and lyophilized. The shelf life of these vaccines is at least 3 years provided storage at +4°C - +8° C and protection from sunlight. Under these conditions the vaccines retain a potency at least 2.5 IU per intramuscular dose (0.5 mL or 1 mL). Following reconstitution with the accompanying sterile diluent, the vaccines should be used immediately, or within a maximum of 6 hours when kept at +4°C - +8°C. The respective package inserts should be consulted for specific information and instructions regarding the individual vaccine.

These CCVs have been uniformly successful in studies both of pre-exposure immunogenicity and post-exposure protection of animals and humans against rabies. Given pre-emptively, they induce an antibody response in more than 99% of vaccinees. Furthermore, early post-exposure use of these vaccines combined with proper wound treatment and rabies immunoglobulin is considered nearly 100% effective in preventing death, even with high-risk exposure. However, despite their high potency, approximately one “failure” in one million post-exposure treatments does occur. Careful analyses show that such failures are almost always associated with severe lesions on or near the head, inadequate wound treatment, and/or inappropriate administration of the rabies immunoglobulin (RIG) and/or vaccine (for wound care and RIG, see below).
NVA was still found in more than 96% of the vaccinees who 10 years earlier had received a pre-exposure series of cell culture vaccine followed by a single booster dose one year later (Strady et al 1998).

**Rabies vaccines for intradermal administration**

Although injection of cell culture and embryonated egg vaccines by the intramuscular route results in higher antibody concentrations, extensive evaluations have shown that similar schedules based on ID injection of 0.10 ml of the vaccine induce equally high protection against rabies. Cost-effective ID regimens using selected CCVs have been successfully introduced for post-exposure prophylaxis in many developing countries, such as the Philippines, Sri-Lanka, Thailand, and India. ID regimens offer a safer and more effective alternative to the use of NTVs and a more economic alternative compared with the intramuscular use of CCVs.

For administration by the intradermal route CCVs should meet the same WHO requirements for production and control as required for intramuscular rabies vaccines, including a test potency of at least 2.5 IU per single intramuscular dose. In addition, the immunogenicity and safety of the vaccine in question should be demonstrated in appropriate clinical trials using WHO post-exposure prophylaxis regimens. In countries approving this route of administration, the packet leaflets of such vaccines should state explicitly that they are authorized for intradermal use.

**Adverse events**

Modern CCVs are considered to be safe and well tolerated, although reported reaction rates to primary immunization have varied with the monitoring system. Following intramuscular immunization with the human diploid cell vaccine, mild and self-limited local reactions such as pain at the site of injection, redness, and swelling occur in 21% - 74%. Mild systemic reactions such as fever, headache, dizziness, and gastrointestinal symptoms occur in 5%-40%, and systemic hypersensitivity following booster injections in 6% of the vaccines, but is less common following primary immunization. When further purification steps are added systemic hypersensitivity reactions become very rare. With chick embryo- and Vero-cell based vaccines the rates of local reactions are 16% and 11%, respectively, whereas purified chick embryo cell vaccine caused systemic reactions in 15% of vaccinees. In no case have the systemic reactions to rabies CCVs been life-threatening. (Refs.: Dreesen 1997, CDC 1999)

Apart for local pain, intradermal application of rabies vaccines does not cause significant adverse events.

**Contraindications and precautions**

Because rabies is a lethal disease, no contraindications to post-exposure prophylaxis following high-risk exposure exist. However, where NTVs are still used, these vaccines should be replaced by modern CCVs as soon as possible. For pre-exposure immunization previous severe reaction to any of the vaccine components is a
contraindication. Infancy and pregnancy is no contraindication to vaccination against rabies.

Several studies of patients with HIV/AIDS have reported that those with very low CD4 counts will mount a significantly lower or undetectable VNA response to rabies. In HIV-infected persons as well as in others in whom immunological memory is no longer assured, proper and thorough wound treatment and antisepsis accompanied by local infiltration of rabies immunoglobulin are of utmost importance. Persons taking chloroquine for treatment or malaria prophylaxis can have a reduced response to rabies vaccines. These patients should receive the vaccine by the intramuscular route. (Briggs DJ et al). Immunocompromised patients with category II exposures should receive rabies immunoglobulin in addition to a full post-exposure vaccination series. In these situations, the VNA response should be determined 2-4 weeks following vaccination to assess the possible need for an additional dose of the vaccine.

Current recommendations for rabies vaccination

Pre-exposure vaccination
Pre-exposure vaccination using any of the modern rabies vaccines is recommended for anyone at increased risk of exposure to rabies virus. Traditionally, this recommendation includes laboratory staff, veterinarians, animal handlers, wildlife officers with frequent exposure to potentially infected animals, as well as visitors to areas with high risk of rabies. However, according to age-stratified studies of incidence, those at greatest risk are children living in rabies-enzootic regions of the developing world.

For travelers to rabies enzootic countries, see recommendations for pre-exposure immunization in the 2007 issue of WHO International Travel and Health.

_Intramuscular administration:_
The schedule requires intramuscular doses of 1 ml or 0.5 ml, depending on the specific vaccine product, given on days 0, 7 and 21 (or day 28, if more convenient). For adults, the vaccine should always be administered in the deltoid area of the arm; for children < 2 years of age, the anterolateral area of the thigh is recommended. Rabies vaccine should not be administered in the gluteal area because the induction of an adequate immune response is unreliable.

_Intradermal administration:_
Intradermal administration of 0.1 ml volumes on days 0, 7 and 21 or 28, is an acceptable alternative to the standard intramuscular route. However, intradermal administration is technically more demanding and requires appropriate staff training and close supervision by a qualified person.

_Booster injections:_
Periodic booster injections are recommended only for persons whose occupation puts them at continuous or frequent risk of rabies exposure. In such cases, a booster dose should be given at intervals dictated by regular testing for antirabies antibodies (at least 0.5 IU/ml indicate protection).

Post-exposure prophylaxis
The indication for post-exposure prophylaxis with or without rabies immune globulin depends on the type of contact with the suspected rabid animal:

Category I – touching or feeding animals, licks on the skin;
Category II – nibbling of uncovered skin, minor scratches or abrasions without bleeding, licks on broken skin;
Category III – single or multiple transdermal bites or scratches, contamination of mucous membrane with saliva from licks.

For category I no prophylaxis is required, whereas for category II immediate vaccination, and for category III immediate vaccination and administration of rabies immune globulin are recommended. For categories II and III, thorough (for ~15 minutes) washing and flushing with soap/detergent and copious amounts of water of all bite wounds and scratches should be done immediately, or as early as possible.

Post-exposure prophylaxis can be discontinued if the suspect animal is proved by appropriate laboratory examination to be free of rabies, or in the case of domestic dogs or cats, the animal remains healthy throughout a 10-day observation period.

Factors that should be taken into consideration when deciding whether or not to initiate post-exposure prophylaxis include the likelihood of the concerned animal being rabid, category of exposure (I-III), clinical features of the animal, as well as its availability for observation and laboratory testing. In most situations in developing countries the vaccination status of the offending animal should not be taken into consideration to withhold prophylaxis.

Intramuscular administration:
The post-exposure vaccination schedule is based on intramuscular doses of 1 ml or 0.5 ml, depending on the manufacturer. The recommended regimen consists of either a five-dose or a four-dose schedule.
1) The 5-dose regimen prescribes one dose injected into the deltoid muscle (or antero-lateral thigh in children < 2 years of age), on each of the days 0, 3, 7, 14 and 28.
2) The 4-dose regimen prescribes 2 doses on day 0 (one in each of the two deltoid/thigh sites) followed by one dose on each of the days 7 and 21.

Intradermal administration:
Either the 8-site or the 2-site regimen should be used, as recommended by the respective vaccine manufacturer.

1) The 8-site intradermal regimen prescribes on day 0, intradermal injections of 0.1 ml given at 8 sites (one in each upper arm, one in each lateral thigh, one on each side of the suprascapular region, and one on each side of the lower quadrant region of the abdomen); on day 7, one injection in each upper arm and each lateral thigh; and on each of the days 30 and 90, one injection in one upper arm (Warrel MJ et al 1985).

2) The 2-site intradermal regimen (Chutivongse S et al 1990, Quiambao BP et al 2005) prescribes one intradermal injection of 0.1 ml at 2 sites on days 0, 3, 7, and 28.

For rabies-exposed patients who have previously undergone complete pre-exposure vaccination or post-exposure prophylaxis with a CCV, 2 intramuscular or intradermal doses of such a vaccine administered on days 0 and 3 are sufficient. Rabies immune globulin treatment is not necessary in such cases. The same rules apply to persons vaccinated against rabies who have demonstrated neutralizing antibody titres of at least 0.5 IU/ml. Vaccination cards carefully recording previous immunizations are invaluable for correct decision making.

Rabies immunoglobulins (RIG) for passive immunization
RIG should be administered in all category III exposures and in category II exposures involving immunodeficient individuals. Due to its relatively slow clearance, human rabies immunoglobulins (HRIG) is the preferred product, particularly in cases of multiple severe exposures. However, HRIG is in short supply and available mainly in industrialized countries. Where HRIG is not available or affordable, purified equine immunoglobulin (ERIG), or F(ab’)2 products of ERIG should be used. Most of the new ERIG preparations are potent, highly purified, safe and considerably less expensive than HRIG. However, they are of heterologous origin and carry a small risk of hypersensitivity reactions (Suwansrinon et al 2006). Therefore, a skin test is mandatory prior to administration of ERIG and F(Ab’)2 products, according to guidelines by the manufacturer.

RIG for passive immunization should not be injected later than 7 days after the initiation of post-exposure vaccination. The dose for HRIG is 20 IU/kg body weight, and for ERIG and F(ab’)2 products 40 IU/kg body weight. All of the RIG, or as much as anatomically possible (cave compartment syndrome!) should be administered into or around the wound site(s). Any remaining RIG should be injected i.m. at a site distant from the site of vaccine administration.

General WHO position on new vaccines
Vaccines for large-scale public health interventions should meet the current WHO quality requirements:

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1 Document WHO/VSQ/GEN/96.02 available from the IVB documentation centre, World Health
- be safe and have a significant impact against the actual disease in all target populations; - if intended for infants or young children, be easily adapted to the schedules and timing of national childhood immunization programmes; and not interfere significantly with the immune response to other vaccines given simultaneously;
- be formulated to meet common technical limitations, e.g. in terms of refrigeration and storage capacity; and be appropriately priced for different markets.

WHO position on rabies vaccines

Post-exposure rabies prophylaxis is recommended for all category II and III contacts with potentially infected animals. The combined active-passive immunization represents an optimal strategy that unfortunately is not yet available in all enzootic areas of the world, due to lack of resources. Measures to increase the supply and accessibility of modern high-quality rabies vaccines and immune globulin among the poor segments of affected populations are strongly encouraged.

Despite development towards less expensive CCVs and less vaccine-consuming administration schedules, a few countries are still producing and using NTVs. These vaccines induce more severe adverse reactions and are less immunogenic than modern rabies vaccines. It is therefore imperative that production and use of nerve tissue-based rabies vaccines be discontinued as soon as possible and replaced by cell-culture based products (TRS 031, WHO 2005).

Pre-exposure immunization is recommended for all individuals living in or traveling to highly rabies-enzootic areas, and for those exposed to rabies by nature of their occupation. Surveillance data should identify the regions where rabies is a major problem. Decisions should be made about whether to start pre-exposure vaccination of the population segments at highest risk on the basis of careful assessment of the public health impact and of cost-effectiveness analyses.

WHO encourages further studies on the feasibility, cost-effectiveness and long-term impact of incorporating modern rabies vaccines in the early immunization programmes of infants and children in communities where rabies is a major problem. Studies from Thailand and several other countries in South-East Asia have demonstrated the feasibility, safety and immunogenicity of giving CCVs to infants, either intramuscularly or intradermally.

To increase accessibility to post-exposure prophylaxis for the most vulnerable enzootic communities in developing countries intradermal multisite regimens using a fraction of the intramuscular inoculation volume have been developed. In several
countries the introduction of this route for post-exposure prophylaxis has permitted the discontinuation of the local production of NTVs.

Although rabies vaccines are usually administered under qualified medical supervision, field experience from routine infant immunization programmes with other intradermally injected vaccines highlights the potential difficulties in assuring proper delivery. This emphasizes the need for appropriate staff training to ensure correct storage, reconstitution and injection of these vaccines.

The burden of rabies in humans could be significantly reduced and even eliminated through coordinated efforts as highly efficacious animal and human vaccines are available but significantly underutilized and awareness of preventative measures are lacking in highly endemic regions.

Improving post-exposure prophylaxis delivery alone does not offer a long-term solution to prevent human deaths, especially childhood fatalities. The essential tools required to eliminate canine rabies were developed many years ago, but have not been used recently in a stepwise strategic manner to eliminate rabies in developing countries. As shown in many places where it has been attempted a well designed dog rabies control program based on dog immunization and dog population management leads to reduced virus transmission that immediately results in better health through a quick reduction of the number of human deaths and/or lower cost for countries.

Countries are encouraged to have routines in place that ensures coordination between all public sectors involved in rabies control. Coordinated efforts should cover human as well as animal rabies and may include surveillance and reporting, diagnostic procedures, information campaigns, as well as vaccination of individuals and groups at particular risk of exposure to rabies virus.

References


