ONE VISION, ONE HEALTH, ZERO RABIES

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ABSTRACT

Rabies is a fatal but preventable viral infection of the central nervous system, responsible for thousands of human deaths each year, mostly from dog-mediated transmission. Children are disproportionately affected, and once symptoms appear, the disease is almost invariably fatal. Rabies virus (RABV) and related Lyssaviruses circulate among dogs, bats, and wildlife, with growing genetic diversity raising long-term concerns for current vaccines. Clinical diagnosis is difficult during incubation, and postmortem confirmation remains the standard, underscoring the critical importance of prevention. Effective management centres on immediate wound cleansing, timely administration of rabies vaccines, and rabies immunoglobulin when indicated. At the population level, rabies elimination hinges on the One Health approach, linking human, animal, and environmental health. Mass dog vaccination reaching at least 70% coverage, integrated bite case management, and prompt post-exposure prophylaxis are proven strategies. Case studies from Goa and Tamil Nadu, India, demonstrate the feasibility of coordinated programs that combine vaccination, surveillance, digital tools, and community education to drive human rabies deaths to zero at cost-effective levels. Despite setbacks during the COVID-19 pandemic, global efforts such as the Zero by 30 initiative emphasize that rabies elimination is a realistic goal. Protecting animals, protecting people, and sustaining communities through One Health action offers a clear path to ending human rabies deaths worldwide.

INTRODUCTION

Rabies is a preventable viral infection of the central nervous system that spreads mainly through the saliva of infected animals, usually via bites. Dogs are the main carriers, responsible for nearly 99% of human infections, with children aged 5–14 years being the most common victims. The virus can infect many mammals, including cats, livestock, and wildlife, and once clinical signs appear, the disease is almost always fatal.

While dog-mediated rabies is the main concern worldwide, other sources exist. In the Americas, blood-feeding bats are now the leading cause of human rabies, and similar risks are emerging in parts of Europe and Australia. Human infections from wild animals such as foxes, raccoons, or skunks are very rare, and rodents are not known to transmit the virus. Extremely uncommon transmission routes include inhalation of contaminated aerosols, consumption of raw animal products, organ transplants, or human-to-human exposure, none of which play a major role in the spread of rabies.

ETIOLOGY

Rabies is caused by the rabies virus (RABV) and related rabies-like viruses, which are zoonotic, neurotropic, bullet-shaped RNA viruses belonging to the genus Lyssavirus in the family Rhabdoviridae. Advances in surveillance and sequencing have revealed that Lyssaviruses are highly diverse, with at least 14 species besides RABV capable of causing rabies disease. The rabies virus likely

originated from bats and spread through multiple host-switching events involving dogs, bats, and other animals. Globally, seven major RABV lineages are recognized, each linked to particular hosts and geographic regions. The most widespread lineage circulates in dogs and wildlife such as foxes, jackals, and skunks across Europe, Africa, Asia, and the Americas, while numerous bat-associated variants in Latin America continue to infect both humans and livestock. Ongoing genetic diversification of RABV and other Lyssaviruses has raised concerns about the long-term effectiveness of current rabies vaccines and human rabies immunoglobulin (HRIG).

CLINICAL FEATURES AND DIAGNOSIS OF RABIES

The incubation period of rabies averages 2–3 months but may vary from one week to a year depending on bite site and viral load. Early illness is nonspecific, marked by fever, pain, or tingling at the wound, before progressing to fatal encephalomyelitis once the central nervous system is invaded.

Two clinical forms occur. Furious rabies (most common) is characterized by agitation, hallucinations, hydrophobia, and aerophobia, leading to death within days from cardio-respiratory failure. Paralytic rabies (≈20% of cases) progresses more slowly with ascending paralysis, coma, and eventual death, and is often misdiagnosed.

No WHO-approved test can detect rabies during incubation. Diagnosis relies on exposure history and key symptoms, with accurate risk assessment guiding post-exposure prophylaxis. Once clinical signs develop, recovery is virtually impossible and palliative care is recommended. Laboratory confirmation is usually postmortem, using detection of virus, antigens, or nucleic acids in brain, skin, or saliva; testing of the biting animal is also essential where feasible.

TREATMENT AND MANAGEMENT

Rabies treatment and management rely mainly on prevention through timely postexposure prophylaxis (PEP), as there is no effective cure once symptoms appear. The cornerstone of PEP is immediate and thorough wound cleansing with soap and water for at least 15 minutes, followed by the application of a virucidal agent such as povidone-iodine. Patients with no prior rabies vaccination require both rabies vaccine and rabies immunoglobulin (RIg). Vaccines, such as human diploid cell vaccine (HDCV) and purified chick embryo cell vaccine (PCECV), are safe in all groups, including pregnant and lactating women, and can be given intramuscularly or intradermally depending on local guidelines. RIg (20 IU/kg for human, 40 IU/kg for equine) should be infiltrated into and around the wound, with the remainder given intramuscularly at a site distant from the vaccine. Previously vaccinated patients need only the rabies vaccine without RIg. For immunocompromised individuals, extended vaccine schedules and serological testing may be required. If exposure is ruled out or the biting animal tests negative, PEP may be discontinued. In confirmed clinical rabies, management is supportive and aimed at minimizing suffering, including hydration and mouth care for hydrophobia, antipyretics for fever, benzodiazepines for agitation or seizures, anticholinergics for excess secretions, and opioids for pain relief. Public health authorities play a vital role in guiding exposure assessments, coordinating observation or testing of animals, and ensuring prophylaxis protocols are correctly followed. Ultimately, rabies treatment emphasizes rapid PEP, as supportive care alone cannot alter the invariably fatal course of symptomatic rabies.

ONE HEALTH: MORE THAN A BUZZWORD

One Health is based on a simple but powerful principle: the health of humans, animals, and the environment are interconnected. For rabies, this connection is strikingly clear. Dogs are responsible for up to 99% of human cases. Vaccinating dogs not only protects them but also creates a protective barrier for communities. Scientific models

show that mass vaccination of at least 70% of dogs in a region can halt rabies transmission to humans. Pair that with timely post-exposure prophylaxis (PEP) for bite victims, and rabies deaths can be driven to zero.

In response to the persistent threat of rabies, four leading organizations—the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the World Organisation for Animal Health (WOAH, formerly OIE), and the Global Alliance for Rabies Control (GARC)—came together in 2018 to launch Zero by 30: The Global Strategic Plan. This initiative sets an ambitious target: to eliminate all human deaths caused by dog-mediated rabies by the year 2030. At its core lies the One Health approach, which recognizes the deep interdependence between people, animals, and the environment, and calls for coordinated action across these sectors to achieve lasting success.

Yet the COVID-19 pandemic revealed both the strengths and vulnerabilities of rabies control efforts. Lockdowns and resource shifts disrupted large-scale dog vaccination drives, strained vaccine, and biologics supply chains, and diverted public health capacities away from neglected tropical disease (NTD) programs. In Bhutan, for instance, border closures and suspended dog vaccination campaigns during the pandemic reduced herd immunity in dogs and tragically led to the country's first human rabies death since 2016. This case illustrated how quickly gains can be lost when health systems are stretched by global crises.

On the brighter side, progress is being made in many places. Nepal is doubling down on efforts toward the Zero by 30 goal with intensified collaborative initiatives under the One Health framework.

LESSONS FROM THE FIELD

Successful rabies control stories from India highlight what is possible through the One Health approach.

Goa: A Blueprint for Success

Goa, a small Indian state, provides one of the most successful modern examples of rabies control through a comprehensive One Health program implemented between 2013 and 2019. The initiative combined large-scale dog vaccination—reaching over 95,000 dogs annually and achieving more than 70% coverage—with innovative digital tools, where smartphones were used to map and monitor dog populations. Alongside this, community education played a vital role, with more than 150,000 schoolchildren trained each year on safe animal handling and appropriate actions after a bite. The impact was remarkable: human rabies deaths were reduced to zero for consecutive years, and canine rabies cases declined by 92%. The program was also recognized by the WHO as "very cost-effective," with an estimated cost of only USD 526 per DALY saved. Goa's experience demonstrates that rabies elimination is not an unattainable goal but a realistic achievement through a well-coordinated One Health strategy.

Tamil Nadu: Small Steps, Big Gains

Tamil Nadu has broken new ground by rolling out the country's first state-wide, multisectoral rabies control program. Guided by the CDC's Program Evaluation Framework, the initiative brought together public health, veterinary, and civic agencies under a common agenda.

The effort combined dog population control, waste management, vaccination drives, public awareness campaigns, and a steady supply of anti-rabies vaccines across government facilities. Dog bite surveillance was cross-checked with vaccine use and animal census data to spot trends at the district level. The Tamil Nadu model shows that rabies elimination is achievable when strong political will is matched with evidence-based policies, clear roles for all stakeholders, coordinated action, and open information sharing—a true example of the One Health approach in action.

STRATEGIES FOR RABIES ELIMINATION

Rabies elimination depends on a set of complementary strategies. Mass dog vaccination is the cornerstone, as dogs are the main reservoir and vaccinating at least 70% of the population interrupts virus transmission. Integrated bite case management links veterinary and human health systems so that when a bite occurs, both the dog and the exposed person are assessed, ensuring efficient use of vaccines and avoiding unnecessary treatments. Post-exposure prophylaxis (PEP) is critical for saving lives; intradermal regimens are especially effective because they require smaller doses, reduce costs, and provide strong immunity within a shorter period. Public education campaigns play a vital role by raising awareness, teaching people to wash bite wounds immediately, and encouraging them to seek treatment without delay. When applied together, these measures create a scientifically sound and cost-effective framework for eliminating rabies

CONCLUSION

Rabies elimination is not a question of if but when — and whether we can muster the political will, resources, and coordination to achieve it.

The fight against rabies captures the essence of One Health: protecting animals protects people, and protecting both sustains communities.

The message is simple yet profound: **All for one, and One Health for all**

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