



Review

Rationale and support for a One Health program for canine vaccination as the most cost-effective means of controlling zoonotic rabies in endemic settings



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ABSTRACT

Although dog vaccination has been demonstrated to reduce and eliminate rabies in humans, during meetings there are often calls for further pilot studies. The assembled data proves that a widespread approach is now required. While zoonotic rabies has a minimal presence in developed nations, it is endemic throughout most of Asia and Africa, where it is considered to be a neglected tropical disease. In these areas, rabies causes an estimated annual mortality of at least 55,000 human deaths. Worldwide rabid dogs are the source of the vast majority of human rabies exposures. The World Health Organization (WHO), the Food and Agriculture Organization (FAO) of the United Nations and the World Organization for Animal Health (OIE) advocate a collaborative One Health approach involving human public health and veterinary agencies, with mass canine vaccination programs in endemic areas being the mainstay of strategies to eliminate dog-mediated human rabies. While post-exposure prophylaxis (PEP) is effective in preventing deaths in people exposed to rabies, it is comparatively expensive and has little impact on the canine reservoir that is the primary source of zoonotic rabies. Indiscriminate culling of the dog population is expensive and there is little evidence that it is effective in controlling rabies in non-island locations. Mass canine vaccination programs using a One Health framework that achieves a minimum 70% vaccination coverage during annual campaigns have proven to be cost-effective in controlling zoonotic rabies in endemic, resource-poor regions. Case studies, such as in Tanzania and Bhutan, illustrate how an approach based on mass canine rabies vaccination has effectively reduced both canine and human rabies to minimal levels. The multiple benefits of mass canine rabies vaccination in these cases included eliminating rabies in the domestic dog reservoirs, eliminating human rabies cases, and decreasing the rabies economic burden by reducing expenditures on PEP.

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1. Introduction

In the bid to control rabies in humans many approaches have been tried. Of these, wide-scale vaccination of dogs has proven the most effective and impactful. However, during meetings on rabies eradication during 2015 and 2016 it is often heard by the authors that some stakeholders consider further pilot studies are required before dog vaccination can be adopted as the primary method to improve human health. Here we gather current information to demonstrate that this approach, and the benefit, is now sufficiently understood to justify taking the next step on a larger scale, especially when combined with a One Health approach integrating efforts by both the human and veterinary health sectors.

Rabies is an incurable disease and has the highest case fatality rate of any zoonotic disease [1,2]. An understanding of the epidemiology of this disease is essential in the planning and implementation of the most cost-effective control measures, however the epidemiology of zoonotic rabies is distinctly different depending on the geopolitical locale where it exists. In the industrialized nations of North America, Europe, Japan, Australia, New Zealand, Malaysia, and the Arabian peninsula, human rabies cases are rare. In contrast, in developing regions of Asia and Africa, and to a limited extent in Latin America (i.e., Haiti, Honduras, Paraguay), human rabies cases occur widely, particularly in poor, rural communities, where rabies is considered a neglected tropical disease by the WHO [3]. It is in these resource-poor regions, representing more than 80% of the world's population, where canine rabies is endemic and human rabies imposes an economic burden which these countries can ill afford [4].

An effective public health policy for eliminating human rabies exposure is based on universal canine vaccination. This approach has been well established since the mid-20th century and has been successfully implemented in locations where a low risk of human exposure now prevails [5,6]. More recently, various examples exist of a successful "One Health" collaborative strategy that focuses on elimination of canine rabies as the most expedient and cost effective way of preventing human exposure and infection [1]. One Health initiatives recognize that the health of people is connected to the health of animals and the environment and forge partnerships between physicians, veterinarians and other health-related scientists. This framework, strongly advocated by the World Health Organization (WHO), the Food and Agriculture Organization (FAO) of the United Nations, the World Organization for Animal Health (OIE) and other non-government organizations including the American Veterinary Medical Association, has several essential components supporting a canine vaccination program as its central feature, as described in the 2015 WHO review [3]. The pivotal role of vaccination is based on the fact that canine and human rabies are 100% vaccine-preventable diseases [3]. This report also describes how mass canine vaccination programs played a central role in reducing canine and human rabies to negligible levels in two endemic regions of Africa and Asia. A Tanzania case study describes how canine rabies declined by 70% and 97%, respectively, after two successive vaccination campaigns, resulting in significant reductions in the demand for post-exposure prophylaxis (PEP) as the primary means of disease prevention in cases of human

exposure [7,8]. A Bhutan case study describes how mass dog vaccination can eliminate canine rabies and be cost-effective even in a resource-poor country [9]. Statistical models showed that a mass vaccination program in that country from 2001 to 08 was estimated to eliminate canine rabies foci within 2–3 years and lower the combined cost of PEP plus canine vaccination to less than the cost of PEP alone within 3 years.

2. Epidemiology of human rabies exposure

Rabies mortality exceeds that of any other zoonotic disease [4,10]. The latest estimates of human rabies mortality range from 55,000 to 59,000 deaths per year worldwide, 99% of them in Africa and Asia where rabies is endemic [1,3,4,11,12]. Due to the lack of laboratory confirmation, sporadic epidemiologic surveillance, and unreported clinical cases in developing countries, current mortality estimates are considered to be the best estimates that we have but almost certainly under-represent the true incidence of human rabies deaths [4,11,12].

More than 99% of all human cases worldwide result from the bite of a domestic dog [13]. Although the regional incidence of dog bites is difficult to determine with certainty, WHO estimates based on survey data indicate that animal bites in Asia totaled 3,529,000 per year and were associated with 31,539 human rabies deaths, 85% of them in India. In Africa, estimated animal bites totaled 802,100 per year, resulting in 23,823 human rabies deaths [12,14]. Without PEP, WHO investigators predicted that worldwide human rabies deaths would exceed 327,160 annually. Using less conservative statistical models, other investigators estimated bite incidence in Africa ($n = 847,326$) to be somewhat greater than the WHO estimates, and exposures in Asia to be considerably higher ($>14,000,000$) [11]. The Centers for Disease Control (CDC) reported 33 cases of human rabies cases in the US in the decade from 2003 to 13, ten of which originated in other countries and one from Puerto Rico, providing a stark contrast with the far greater incidence in Asia and Africa [15]. Similarly, human autochthonous rabies cases in Europe average <9 per year and most European countries have been designated rabies-free [16]. During 2010–12, 111 human rabies cases transmitted by dogs were reported in ten Latin American countries [17]. In contrast, no countries on the Asian mainland have been declared rabies-free by the WHO and there is evidence that canine rabies has spread to new regions of Asia in the past decade [18]. Statements from the OIE and CDC indicate that they expect that rabies will never be entirely eradicated due to its wildlife reservoir, particularly its global presence in bats [4,19,20].

3. Canine vaccination as an immunologic barrier against human exposure

The WHO has accepted that generalized canine rabies vaccination is the only feasible method of limiting human rabies exposure and is also the most cost effective means of doing so [3]. Sole reliance on costly PEP, consisting of multiple vaccine and rabies immunoglobulin doses, and pre-exposure prophylaxis (PreP) in rabies-endemic areas is not effective in eliminating zoonotic rabies

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