

Review



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Progress towards eliminating canine rabies: policies and perspectives from Latin America and the Caribbean

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Human rabies transmitted by dogs is considered a neglected disease that can be eliminated in Latin America and the Caribbean (LAC) by 2015. The aim of this paper is to discuss canine rabies policies and projections for LAC regarding current strategies for achieving this target and to critically review the political, economic and geographical factors related to the successful elimination of this deadly disease in the context of the difficulties and challenges of the region. The strong political and technical commitment to control rabies in LAC in the 1980s, started with the regional programme coordinated by the Pan American Health Organization. National and subnational programmes involve a range of strategies including mass canine vaccination with more than 51 million doses of canine vaccine produced annually, pre- and post-exposure prophylaxis, improvements in disease diagnosis and intensive surveillance. Rabies incidence in LAC has dramatically declined over the last few decades, with laboratory confirmed dog rabies cases decreasing from approximately 25 000 in 1980 to less than 300 in 2010. Dog-transmitted human rabies cases also decreased from 350 to less than 10 during the same period. Several countries have been declared free of human cases of dog-transmitted rabies, and from the 35 countries in the Americas, there is now only notification of human rabies transmitted by dogs in seven countries (Bolivia, Peru, Honduras, Haiti, Dominican Republic, Guatemala and some states in north and northeast Brazil). Here, we emphasize the importance of the political commitment in the final progression towards disease elimination. The availability of strategies for rabies control, the experience of most countries in the region and the historical ties of solidarity between countries with the support of the scientific community are evidence to affirm that the elimination of dog-transmitted rabies can be achieved in the short term. The final efforts to confront the remaining obstacles, like achieving and sustaining high vaccination coverage in communities that are most impoverished or in remote locations, are faced by countries that struggle to allocate sufficient financial and human resources for rabies control. Continent-wide cooperation is therefore required in the final efforts to secure the free status of remaining countries in the Americas, which is key to the regional elimination of human rabies transmitted by dogs.

1. Introduction

Rabies is a zoonotic disease caused by *Lyssavirus* infection and is characterized by progressive acute encephalitis that is often fatal [1]. Because of its high burden of disease, human rabies is a major public health concern and is considered a neglected disease worldwide by the World Health Organization (WHO). Over US \$1 billion is spent on rabies prevention annually, and 15 million people receive post-exposure prophylaxis each year [2]. Deaths caused by rabies are estimated to be 55 000 per year worldwide, mostly in Asia and Africa [3].

Lyssavirus circulates in mammalian vectors from the Carnivora and Chiroptera orders, including bats, foxes, jackals, coyotes, skunks, raccoons, mongooses and monkeys [4]. There are multiple antigenic variants (AgV) of the genotype 1 rabies virus in Latin America and the Caribbean (LAC). These include AgV1 and AgV2 (associated with canines), as well as AgV3 and AgV4 (associated with haematophagous and non-haematophagous bats). Other variants are limited to specific countries, such as AgV11 in Mexico, AgV8 in Mexico and Colombia, and AgV3 in Venezuela [5].

Canine rabies is caused by the AgV1 and AgV2 variants; it is directly transmitted between dogs and was most likely introduced to the New World during its colonization. Many epizootic outbreaks in dogs were reported between the early eighteenth and mid-twentieth century until a mass canine vaccination campaign in Memphis, TN was introduced in 1948 [6]. A high prevalence of canine rabies increases the risk of dog-transmitted human rabies. Currently, more than 99 per cent of all human rabies cases in LAC are caused by bites or scratches by infected dogs [5,7], mostly affecting children living in poor rural communities [8]. Canine rabies can be eliminated through mass vaccination of the domestic dog reservoir, thereby eliminating the vast majority of deaths owing to rabies in the region [9].

The availability of effective and safe vaccines, improvements in the healthcare infrastructure and the implementation of new strategies emphasizing primary healthcare have made it possible to control and eliminate diseases in LAC such as smallpox, polio and measles [10–12]. In 1983, supported by the Pan American Health Organization (PAHO), the regional WHO office, LAC pledged to eliminate dog-transmitted rabies in humans by 2005 [7,9]. Additionally, the PAHO's Directing Council passed a resolution called 'Elimination of Neglected Diseases and other Poverty-related Infections' that identified 12 target diseases. This resolution reinforced the commitment of these countries and the organization to combating the diseases affecting neglected populations through the implementation of integrated plans and comprehensive approaches. These diseases, including dog-transmitted human rabies, were selected based on the technical feasibilities for elimination and regional evidence for achievable elimination [11]. Thus far, these efforts have resulted in a sharp reduction in human rabies cases as well as increased reductions in the prevalence of canine rabies [7,8,13,14].

Here, we aim to share the experiences of Latin American and Caribbean countries in their efforts to eliminate human rabies transmitted by dogs and to detail challenges arising in the last mile of rabies elimination.

2. The canine rabies situation in Latin America and the Caribbean

The regional programme for rabies control introduced in LAC in 1983 was based on mass canine vaccination, pre- and

post-exposure prophylaxis, improving disease diagnosis, intensive surveillance and educational campaigns with community involvement. The programme has been considered a success due to the almost 90 per cent decrease in both human and canine rabies incidence as well as the complete elimination of canine rabies in many countries [7,9,13–15]. Several countries have not reported cases for many years (Belize, Colombia, Costa Rica, Chile, Ecuador, Panama, Paraguay and Uruguay) or have not reported cases in large areas of the country for several years (Argentina, Brazil and Mexico). Confirmed rabies cases in dogs decreased from approximately 25 000 in 1980 to less than 300 in 2010, and dog-transmitted human rabies deaths decreased from 350 to less than 10 during the same time period.

The period of greatest decline occurred between 1982 and 2003 with a 91 and 93 per cent reduction in human and canine rabies, respectively. Incidence continued to decrease after 2003, a low incidence of transmission continued in some geographical areas [7,8,13]. Rabies is still endemic in Haiti, Bolivia and their international border areas, and sporadic outbreaks still occur in Cuba, Nicaragua, Venezuela, the border territories of several Central American countries (El Salvador, Honduras, Guatemala and Mexico) and some states in north and northeast Brazil [7,8,13,14].

From 2000 to 2008, the regional information system for epidemiological surveillance of rabies (SIRVERA; [15]) registered an average of 25 dog-transmitted rabies cases, in an average of seven countries per year. Significant reductions in these numbers were observed from 2009 to 2012 where an average of 12 cases per year in 4.5 countries was seen (table 1). This progressive reduction in the annual incidence of rabies and the number of affected regions indicate real progress towards the goal of eliminating canine rabies in LAC. Both regional and national programmes continue to work on eliminating canine rabies in LAC by 2015 using centralized operational strategies aimed at maintaining and expanding the number of territories free of dog-transmitted human rabies [10–14].

According to official data, from the last three years, out of 35 countries in the Americas, only seven countries reported cases of human rabies transmitted by dogs (Bolivia, Brazil, Peru, Honduras, Haiti, Dominican Republic and Guatemala; [15]).

An epidemiological survey conducted by PAHO in 2003 [8] classified LAC into five different epidemiologic areas based on the frequency of canine rabies in relation to surveillance efforts by first-level geopolitical units (state, department or province). Surveillance of samples from 0.2 per cent of the dog population each year was considered ideal, and the following distinctions were established: group 1—areas free of canine rabies for more than 10 years; group 2—areas with no canine rabies cases reported and excellent surveillance (with 0.1% of canine samples tested annually); group 3—areas with no canine rabies cases reported and good surveillance; group 4—silent areas (no surveillance and no canine rabies case reports); and group 5—areas with active circulation of AgV1 and AgV2 viral strains.

Group 1 was represented by several countries in Central America and the Southern Cone countries, a macro-region in South America characterized by the highest human development index. These countries, included Argentina, Chile, Paraguay, Uruguay and southern and southeast Brazil (São Paulo). A few large regions had ideal surveillance (groups 2 and 3), and a few areas located in the Andean subregion

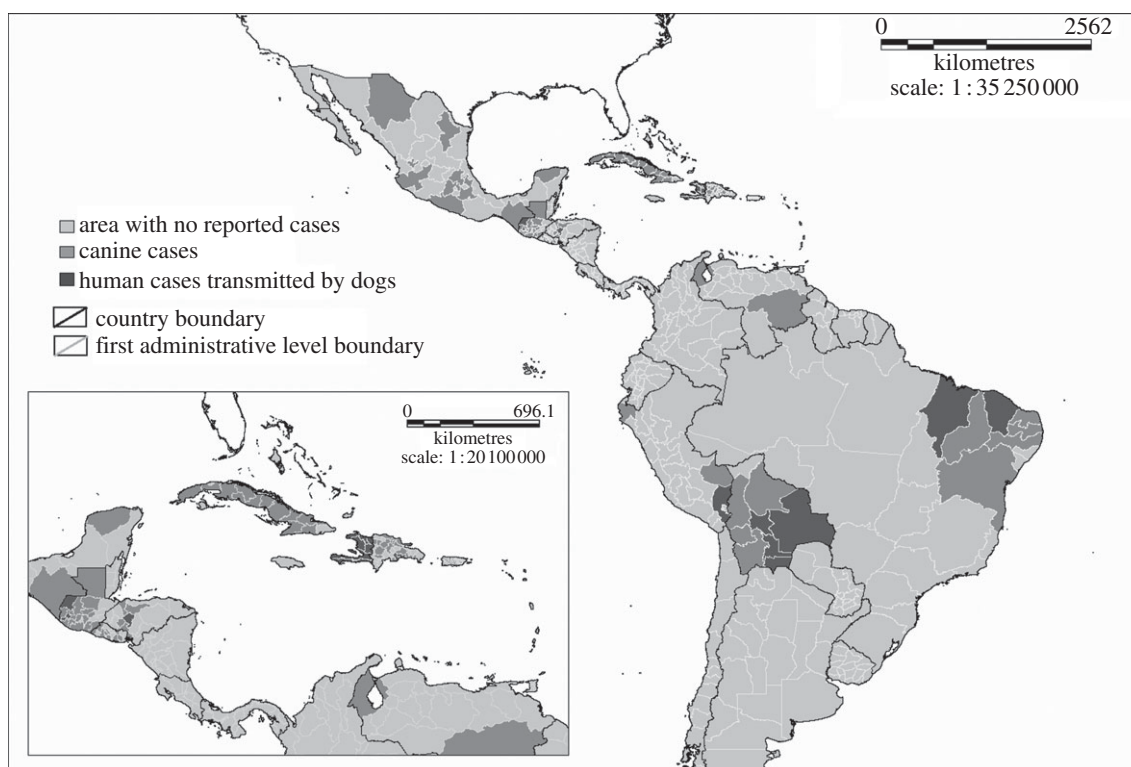


Figure 1. Occurrence of canine rabies and human rabies transmitted by dogs in LAC, 2009–2012. Source: SIRVERA (Panaftosa–PAHO/WHO).

Table 1. Dog-transmitted human rabies deaths in LAC, 2009–2012^a. Source: SIRVERA/SIEP—PANAFTOSA/PAHO-WHO, 2013.

countries	2009	2010	2011	2012	2013 ^b	total
Bolivia	3	0	5	1	0	9
Brazil	2	1	2	2	2	9
Guatemala	3	0	3	0	0	6
Haiti	0	1	13	2	0	16
Honduras	1	0	0	1	0	2
Peru	0	1	1	2	0	4
Dominican Republic	3	3	0	2	1	9
Venezuela	1	0	0	0	0	1
total	13	6	24	10	3	56

^aReported cases.

^bData updated March 2013.

were considered silent (group 4; figure 1). Group 5 comprised areas from Bolivia, northeast Brazil, portions of Venezuela and El Salvador [8].

Analysis of these basic geographical units showed that rabies cases in LAC were highly localized and affected only 0.2 per cent of second-level (municipality) communities. The highest proportion of individuals affected by rabies belonged to lower-income population groups located in the outskirts of large cities such as Puerto Principe (Haiti), San Salvador (El Salvador) and Fortaleza (Brazil). These impoverished urban outskirts pose a particular challenge due to the large numbers of free-roaming dogs that manage to escape vaccination campaigns [8,13]. In addition, the population in these areas has little information about the risks of the disease, limited access to quality health services and immunobiological

products for pre- or post-exposure prophylaxis and generally have poor living standards or working conditions.

3. Programmes for eliminating dog-transmitted human rabies

The 1983 decision by LAC to eliminate dog-transmitted rabies involved a strong political commitment to multi-national efforts as well as support and coordination from the PAHO. At the III Inter-American meeting on Animal Health (RIMSA III), the countries initially made ministerial-level commitments to eliminate human rabies from major cities by the end of the 1980s because of the great number of street dogs and cases of human rabies in the urban areas

in LAC. This commitment was ratified at the 31st meeting of the directing council of the PAHO held in 1983. The 'Action Plan for the Elimination of Urban Rabies' was approved the same year at the First Meeting of Directors of Animal Programmes for Rabies Prevention and Control (I REDIPRA) in Guayaquil, Ecuador [9], and further evaluated, respectively, at II and III REDIPRA in 1988 and 1989.

Regional advances were presented at RIMSA VII in Washington, DC (1991), and the PAHO's director recommended extending the Action Plan to rural areas and small villages. This resolution was corroborated by the PAHO's Directing Council's 35th meeting in September 1991, and countries were informed the following year about the plan's extension at the IV REDIPRA in Mexico City [8].

The role of LAC in the dog-transmitted human rabies elimination programme involved promoting canine mass vaccination, epidemiological surveillance and attention to people at risk through provision of pre- and post-exposure prophylaxis [9,13]. Domestic dogs and cats were the main source of infection for humans in LAC until 2004 when the number of human rabies cases transmitted by bats and other wildlife exceeded those by domestic dogs due to continuous national dog rabies elimination programmes. Prevention of human rabies transmitted by haematophagous bats (i.e. variant AgV3) is a challenge for the region to tackle in the longer-term; the number of bat-transmitted human cases of rabies has increased in recent years, predominantly in the countries of the Amazonian Region [7,16], but there are currently no proven effective methods of control of rabies in these reservoir populations.

PAHO's Veterinary Public Health Programme offers technical cooperation to LAC by providing tools for a disease notification system as well as assisting countries in complying with the standards discussed at the Inter-American and Rabies Experts meetings. Additionally, PAHO coordinates actions among the Ministries of Agriculture and Health in LAC and the executive councils of both the WHO and the World Organization of Animal Health (OIE; [8]).

The rabies elimination programme has received support from non-governmental organizations (NGOs), animal welfare organizations and public-private partnerships. These organizations support and significantly contribute to other entities, such as local health networks, local agencies connected to the Ministry of Agriculture, and communitarian and international organizations [17,18].¹

This cooperation has also exerted a good deal of influence and effort on community-based education, as community involvement plays an important role in the last mile, particularly by ensuring participation in mass dog vaccinations. The educational resources assembled through the partnership include the website for the Global Alliance for Rabies Control (GARC), which the Food and Agriculture Organization and European Commission developed to present the Blueprint for Rabies Prevention and Control—a novel operational toolkit for rabies elimination. The website was recently translated into Spanish and Portuguese, making it more accessible to LAC. The effect of this operational toolkit should be evaluated in the near future in coordination with PAHO and GARC [17].

Mass canine vaccination campaigns are one of the most important actions for rabies control, and the regional programme recommends vaccinating 80 per cent of the estimated canine population as a strategy for decreasing virus circulation via susceptible hosts. These canine mass vaccination campaigns

are coordinated annually or biannually by the health authorities in the majority of the LAC countries, and there is no additional cost for the communities. The key to success for these campaigns was the promotion of the vaccination strategy in mass media (radio, folders, schools, community centres, health facilities, etc.) aimed at convincing the community to bring their dogs to be vaccinated in fixed posts during specific dates. An inter-sectoral approach is always used during the planning, promotion, execution and evaluation (see electronic supplementary material). A survey of the status of dog-transmitted human rabies in LAC during 2001 and 2003 indicated that, on average, 81 per cent of animals were vaccinated [8]. Vast areas surpassed the goal, and some countries, such as Mexico and Brazil, have almost 100 per cent coverage.

Approximately 51 million doses of canine vaccine are produced annually in LAC. Most of it is for use in Mexico and Brazil, which have the largest dog populations in LAC, estimated at 16 and 25 million dogs, respectively. However, low coverage (23.2–40%) in some regions has also been reported, so canine vaccination programmes must still be improved, as well as the awareness strategies currently implemented to engage the community to participate in the vaccination control programme [8,19]. These areas of low coverage are the areas where canine rabies is still circulating among dogs and eventually result in transmission to humans. Vaccinating the canine population in these remaining areas of canine rabies circulation poses a challenge and is crucial for successful elimination.

Post-exposure prophylaxis (PEP) is another effective tool used in human rabies prevention. Post-exposure prophylaxis consists of wound washing, passive immunization with rabies immune globulin and a series of four to five doses of rabies vaccine [6]. It is broadly available in LAC, and about a million people (0.2%) are referred to health services annually after being exposed to the risk of rabies (mainly because of dog attacks), with 25 per cent receiving free immune prophylaxis [2,4,13]. Centralization of rabies treatment, even in areas with a lower prevalence of rabies, may represent a risk to public health, especially in the case of rabies re-emergence [8]. Consequently, the health systems for rabies treatment are decentralized in LAC countries, and most states/departments have a maximum rate of 100 000 inhabitants per local care unit (average of 34 383 inhabitants/care unit). Between 2001 and 2003, the average of PEP delivery reached 25.4 per cent of the population that reported dog bite and were assisted by local healthcare in the LAC, ranging from 3.2 per cent in Cuba to 58.4 per cent in Brazil [11]. These data still need to be analysed based on epidemiological risk, because these variations may not solely reflect disease incidence, but also inadequate coverage, unnecessary treatment or failure of medical assistance in some regions.

The current challenge for PEP in LAC is to ensure administration of immunoglobulin to seriously exposed bite-victims according to the WHO recommendations. Just over a third of the LAC countries did not meet this requirement until 2004 [8]. The utilization of more potent, safe and effective cell-culture vaccines for humans represents another challenge in many of the LAC countries. More than 2 500 000 doses of human vaccine are used annually, but some few countries in LAC are still using suckling mouse brain vaccines for human pre- and post-exposure prophylaxis, which are associated with severe neurological adverse events [7,8]. Ensuring PEP is delivered to those at risk of rabies is essential to preventing

human rabies deaths while rabies is still circulating at low levels, but ultimately vaccination of the domestic dog reservoir is needed to interrupt indigenous transmission.

Epidemiological surveillance is another important factor for rabies control in LAC, especially in rabies-free areas bordering with regions where rabies is still endemic. There are several large areas free of human rabies transmitted by dogs and canine rabies, but the disease persists in neighbouring territories; for example, the Region of Puno, in Peru on the border with Bolivia where rabies still persists due to local conditions. This area is an important tourist route (Titicaca Lake) and an international border with active commerce. In these border areas, high standards of surveillance are essential as rabies can emerge easily. Overall, enhanced epidemiological surveillance in areas where there is no information about routine surveillance must be included in each country's agenda. There are 141 decentralized laboratories for diagnosis and surveillance of the disease in LAC, and more than 74 000 samples are tested annually for rabies [7,8,15]. A significant percentage of LAC countries are conducting excellent surveillance, including Mexico, Peru, Argentina and Brazil. By contrast, Haiti, Ecuador, Colombia and some areas of Venezuela (less than 0.01% of samples tested annually) still have inadequate surveillance [8,20]. The internal risk factors for each country, as generated by inequalities and regional characteristics, should also be considered in preventing re-emergence of rabies [7,8,19–21]. The target countries for improving surveillance of human rabies transmitted by dogs and canine rabies are those where the disease still persists. These countries need continuous support from health authorities and veterinary services to improve their laboratory facilities including improvements in their capacity for sample collection and submission.

4. Political commitment of Latin America and the Caribbean to rabies programmes

The PAHO is responsible for coordinating the rabies elimination programme as well as performing epidemiological surveillance. PAHO's information system, SIRVERA, is an important tool for conducting epidemiological surveillance and obtaining detailed geographical information on rabies in LAC. The surveillance system provides important data for evaluation of trends in rabies occurrence. However, as the system is dependent upon notification by country, one cannot rule out the possibility of underreporting in some regions, with incidence underestimated as a result. The regional programme for the elimination of dog-transmitted rabies involves compulsory notification in 21 LAC countries: Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Uruguay and Venezuela [15].

Annual reports on rabies containing data provided by these countries are discussed and updated approximately every 2 years at the REDIPRA meeting, resulting in recommendations and strategies for rabies control in PAHO member countries. REDIPRA meetings can be considered a model for coordination and governance in the world [9,20].

In the REDIPRA meetings, every country in the Americas has full participation with its rabies programme coordinator representative, from public health and veterinary services

authorities. During this meeting, countries share the results of the rabies strategy of prevention and control, in both successful and challenging cases. The participation of other institutions such as WHO Collaboration Centres of Rabies in the Americas is important to maintain a high scientific level. The presence of other international agencies (FAO, IICA, OIRSA and others) and other international organizations (OIE, WSPA, GARC and others) brings to REDIPRA an inter-institutional approach for rabies elimination. The main achievements of the REDIPRA meetings are summarized in the electronic supplementary material [8].

5. Challenging areas of canine rabies transmission

In LAC, there are areas of continuous transmission of rabies from dogs to dogs and from dogs to humans. These areas, include Haiti, Cuba, Nicaragua, Colombia, Ecuador, Venezuela and northeast Brazil (Maranhão State), and border areas of Mexico, Guatemala, Honduras, El Salvador, Bolivia, Argentina and Peru [7,8,16,19]. These areas are characterized by people living under unfavourable conditions and by a large amount of unvaccinated stray dogs [7,8,10,13,19]. Many factors, including poverty, geographical and environmental limitations, social, cultural, political and economic variables, have also affected canine rabies control programmes in these countries.

The elimination of rabies in these areas depends on the implementation of specific local strategies, widespread participation of the population and multinational technical cooperation [4,10–12,21]. In Haiti, the Dominican Republic and Cuba, mass vaccination has not been consistently implemented because of a lack of resources, therefore a steady supply of vaccines is required to improve mass dog vaccination campaigns. Honduras and El Salvador also need to strengthen their canine vaccination campaigns and increase coverage and ensure that there are laboratories for rabies diagnosis. Argentina, Bolivia, Peru and Brazil require strong regional rabies programmes in their international border areas, whereas Chile and Peru need to extend monitoring and reinforce their support of national laboratories [8,14].

There are currently 590 million individuals living in LAC. This region is considered the most unequal region of income distribution worldwide (table 2). Approximately 6.5 per cent of the inhabitants of LAC live below the international poverty line (less than US \$1.25/day), but the figures differ widely among countries, ranging from 77 to 1.2 per cent. This great inequality is reflected in various health indicators, such as the infant mortality rate, which can be five times higher in some areas and groups than in others [21,22]. Economic inequalities are also reflected in the epidemiology and control of rabies. In general, the entire population has free access to post-exposure prophylaxis and dog vaccination. However, if governments lack human and financial resources, it becomes quite difficult to provide these services to the population as a whole. Treatment may also be available in a municipality, but socio-economic limitations may prevent people from travelling to obtain the necessary healthcare assistance [8,20].

According to SIRVERA, Haiti and Bolivia were responsible for 53.5 per cent of dog-transmitted human rabies between 2008 and 2011 and for 63.3 per cent between 2010 and 2011. Over the past 7 years, Bolivia and Haiti have experienced the greatest burden of dog-transmitted human

Table 2. Characteristics of LAC countries that could contribute to challenges in rabies elimination.

countries	total population	life expectancy	GDP per capita	population in poverty ^{a,b} (%)	last report of human rabies transmitted by dogs (SIRVERA/SIEP—PANAFTOSA/PAHO-WHO, 2013)
Argentina	40 764 561	76	9.74	0.9	1998
Bolivia	10 088 108	66	2.04	15.6	2012
Brazil	196 655 014	73	10.72	6.1	2013
Colombia	46 927 125	73	6.11	8.2	2007
Dominican Republic	10 056 181	73	5.24	2.2	2012
Ecuador	14 666 055	75	4.14	4.6	2001
El Salvador	6 222 491	72	3.48	9.0	2008
Guatemala	14 757 316	71	2.87	n.a.	2011
Haiti	10 123 787	62	0.7	77	2012
Honduras	7 754 687	73	1.97	17.9	2012
México	114 793 341	77	9.24	1.2	2005
Nicaragua	5 869 859	74	1.17	n.a.	1996
Paraguay	6 568 290	72	2.97	7.2	2004
Peru	29 399 817	74	5.50	4.9	2012
Venezuela	29 278 000	74	11.92	n.a.	2009

^aThe World Data. See <http://data.worldbank.org/indicator>. n.a. not available.

^bPopulation living with US \$1.25/day.

rabies [15]. Natural disasters, socio-cultural components and economic limitations have affected canine rabies control programmes in these countries [7,8].

Haiti has 10 123 782 inhabitants, 77 per cent of whom are classified as below the national poverty line [22]. In 2010, Haiti was affected by large-magnitude earthquakes, and the annual economic growth was as low as -5.4 per cent [10]. The hard times experienced by Haiti existed decades prior to these natural disasters and have been accompanied by political instability and severe socio-economic crisis. In 2003, there were approximately 50 000 vaccinated dogs in Port-au-Prince (20% coverage). The rabies regional programme in Haiti has few financial resources for the implementation of vaccination campaigns or surveillance. Furthermore, there are no human resources for rabies control, and the amount of post-exposure prophylaxis is still low and is limited to the capital (Port-au-Prince; [8,22]). To help address these difficulties, the country has received technical support from countries such as the Dominican Republic as well as donations of vaccines produced in Brazilian laboratories.

Bolivia has 10 088 108 inhabitants, 60 per cent of whom live below the national poverty line (15.6% living on less than US \$1.25 a day; [22]). The country has impoverished suburbs on the outskirts of large cities, with a large population of stray dogs, and limited funds to develop massive dog vaccination campaigns and animal birth control programmes [7,8]. In Bolivia, dogs are responsible for more than 74 per cent of human rabies cases. Although the disease prevalence has declined since 1983, financial limitations led Bolivia to prioritize vaccination of urban centres, leaving some rural areas unprotected. An epidemiological survey conducted between 2001 and 2004 identified critical rural areas where vaccination coverage was below 50 per cent

and post-exposure prophylaxis rates were below 10 per cent for the population exposed to rabies, suggesting that the focus in the last mile should be on these weakly vaccinated rural areas. To reach 80 per cent coverage, this country needs to produce approximately 2 million doses of vaccine per year [8,20]. Like Haiti, Bolivia heavily depends on technical cooperation and donations from other governments and institutions that aim to eliminate rabies in LAC [20,23].

6. Together for one goal

The availability of strategies for rabies control in LAC and the successes of the past decade have created a basis for advancing the goal of eliminating dog-transmitted human rabies. The historical solidarity built among the LAC countries, combined with the support of the scientific community, bolsters the expectation that this goal will be reached in the coming years. The final push to overcome the challenges ahead for eliminating dog-transmitted human rabies in LAC depends on strengthening medical care and increasing rabies vaccination coverage of dogs in several areas ([20,23]; box 1).

In some countries and critical areas, it is vital to ensure a supply of rabies biologicals for human exposures and of vaccines for mass canine vaccinations. The quantity and quality of these supplies must be balanced with appropriate cost and effectiveness [20,23], and the transportation of the serum supplies and rabies vaccines must be via safe and established means for immunobiological international transport [12]. Additionally, special attention must be given to Haiti due to their losses caused by the natural disasters of 2010 [13,21,23].

The procedure for declaring areas free of canine rabies involves the interruption of type 1 and type 2 virus

Box 1. Necessary steps for eliminating dog-transmitted human rabies in LAC [20,23].

- Technical cooperation aimed at reducing inequalities of rabies control in different countries.
- Quality assurance for biological products and the replacement of vaccines produced in suckling mouse brains by WHO-recommended vaccines aimed at providing rabies prophylaxis to exposed individuals.
- Establishing protocols to ensure early prophylaxis and monitoring by coordinating the activities of health centres with other institutions to support patients with complete post-exposure prophylaxis.
- Training and motivating the staff of health centres to provide the necessary input for and participation in mass vaccination campaigns reinforcing rabies health education, especially for school children.
- Control of the canine population through dog population management, including community participation and the involvement of NGOs and public and private sectors.
- Projecting realistic figures for the biological doses needed to stock national laboratories and managing established mechanisms of acquisition to prevent supply shortages.
- Maintain efforts and allocate budget to ensure the infrastructure required to increase the production of vaccines and hyper immune sera, meeting the recommendations established for bio-safety and quality control.

circulation as well as the absence of notifications of human cases for three consecutive years [14]. Countries also need to implement reliable reporting and medical care systems with 100 per cent post-exposure prophylaxis for those exposed [6]. Clinical and laboratory diagnosis should be consolidated for over 3 years and possess a 100 per cent processing capacity of suspicious samples that includes differential diagnoses of other neurological diseases. Active surveillance and the analysis of samples from 0.01 to 0.02 per cent of the estimated dog and cat population should also be conducted [19].

Over the coming years, most LAC countries are expected to self declare free of human rabies transmitted by dogs and/or canine rabies. The next challenge will be to identify and control wildlife-transmitted rabies. Rabies-free areas will need to implement an intervention system that is capable of reducing the risks of rabies re-emergence by controlling animal movement while also developing a contingency plan if AgV1 and AgV2 viral strains are detected, and the rabies virus spills over from wild to domestic animals [8].

7. Conclusions

Examples of control and elimination of diseases such as smallpox, polio and measles from LAC with the availability of effective and safe vaccines, improvements in the healthcare infrastructure and the implementation of new strategies emphasizing primary healthcare, show that it is possible to eliminate human rabies transmitted by dogs in these areas, with the implementation of specific local strategies, widespread participation of the population and multinational technical cooperation.

The elimination is aided by the provision of tools for rabies notification, such as the system of the PAHO's Veterinary

Public Health Programme, as well as offering technical cooperation to priority target countries in complying with the standards discussed at the Inter-American and Rabies Experts meetings. Additionally, PAHO coordinates inter-sectorial actions among the Ministries of Agriculture and Health in LAC and the executive councils of both the WHO and the OIE.

We have presented the successful strategies used in countries that have eliminated rabies as well as the complexities in countries where this disease is still endemic and challenging. The main challenges in eliminating dog-transmitted rabies in the near future are to achieve and maintain high levels of canine rabies vaccination coverage, establish intensive surveillance and continue training and communication with local communities.

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Endnote

¹Some examples of the organizations involved are: FAO, OIE, ARC (Agricultural Research Council), WSPA (World Society for the Protection of Animals), ILCA (International Livestock Centre for Africa), OIRSA (Regional International Organisation for Plant Protection and Animal Health), CAN (International Climate Action Network), CVP (Standing Veterinary Committee of the Southern Cone), OTCA (Open the Cages Alliance) and others.

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