Elimination of foot-and-mouth disease in South America: lessons and challenges

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Foot-and-mouth disease (FMD) is a highly transmissible and economically devastating disease of cloven-hoofed livestock. Although vaccines are available and have been instrumental in eliminating the disease from most of the South American animal population, viral circulation still persists in some countries and areas, posing a threat to the advances of the last 60 years by the official veterinary services with considerable support of the livestock sectors. The importance of the disease for the social and economic development of the American continent led to the establishment in 1951 of the Pan American Centre for Foot-and-Mouth Disease (PANAFTOSA), which has been providing technical cooperation to countries for the elimination of the disease. The first FMD national elimination programmes were established in South America around the 1960s and 1970s. To advance the regional elimination efforts in the 1980s, countries agreed on a Plan of Action 1988–2009 of the Hemispheric Program for the Eradication of Foot-and-Mouth Disease. The Plan of Action 1988–2009 did not reach the goal of elimination from the continent; and a new Plan of Action 2011–2020 was developed in 2010 based on the experience acquired by the countries and PANAFTOSA during the past 60 years. This plan is now being implemented; several challenges are still to be overcome to ensure the elimination of FMD from the Americas by 2020, however, the goal is achievable.

1. Introduction

Foot-and-mouth disease (FMD) is a highly transmissible viral disease of cloven-hoofed animals. It is caused by several virus antigenic types and subtypes which are not evenly distributed in the regions of the world where FMD is present. Infection from one of the seven serotypes does not confer immunity against any of the others. Out of the seven serotypes, six have been reported from Africa (A, C, O, SAT-1, 2 and 3); four from Asia (A, C, O, Asia-1); and only three from South America (A, O, C). SAT-1 and SAT-2 have been sporadically reported in the Middle East. FMD is one of the most important animal diseases for the restrictions it causes to the trade of animals and animal products and its socioeconomic consequences. However, such restrictions have failed to prevent the spread of the disease from enzootic into free areas. Inactivated FMD vaccines are very important tools for the control and elimination of the disease and have proved effective for this purpose in South America. However, viral circulation persists in certain areas challenging regional elimination efforts and leading to the re-introduction of the disease into previously free areas with severe socioeconomic consequences. This paper has been written with a narrative approach to describe experiences in the elimination of FMD in South America, including the challenges and opportunities. The paper reaffirms that hemispheric elimination of FMD from the Americas is achievable and could represent a model to be adapted to other parts of the world.

2. Historical background of the disease in the Americas

The first outbreaks of FMD in the American hemisphere were recorded almost at the same time in 1870 in the United States of America (USA), Argentina and...
Uruguay, and some years later in Paraguay. Outbreaks were associated with cattle imported from Europe. In Brazil, the first case of FMD was reported in Uberaba, Minas Gerais, in 1895. In Peru and Bolivia outbreaks were recorded starting in 1910; in Chile in the 1920s; and in Venezuela, Colombia and Ecuador in the 1950s. In the Caribbean, FMD was detected in Jamaica in 1922, Aruba and Martinique in 1953, and Curaçao in 1957. FMD has never been detected in Central America or Panama [1].

After its introduction in the Americas, the spread of FMD followed drastically different pathways according to the underlying conditions and the responses of the veterinary services for containment and eventual elimination. In North America, the disease was introduced sporadically, mainly by imports of livestock from Europe, but also by the use of contaminated biological materials and animal by-products. The disease was characterized by limited dissemination, as a result of the livestock dynamics, with low intensity of animal movement (most infected animals were dairy animals). In addition, thanks to the political and technical initiatives of the governments and the livestock producers in the USA and Canada, the outbreaks were controlled through local efforts and the disease was eliminated in 1929 and 1952, respectively [2]. In the case of Mexico, the large outbreak that started in 1947 led to the creation of the Mexico–United States Commission for the Prevention of Foot and Mouth Disease, with the allocation of resources for its elimination. Initial attempts to control the disease via stamping out had poor results, and livestock producers strongly objected to these methods. This led to the use of vaccination starting in 1950, which made it possible for Mexico to eliminate the disease in 1952 [1].

In South America, unlike North America, after its introduction, FMD easily spread through bovine populations and reached an endemic–epidemic condition in practically every territory with large livestock populations. This spread was facilitated by the extensive bovine livestock production, which was expanding owing to the colonization and rapid occupation of large territories, leading to highly dynamic livestock movement. In the middle of the twentieth century, FMD occurred in an epidemic form, spreading between regions and countries, and causing major economic losses. At that time, FMD had no impact on the international trade as the region was not producing exportable surplus, except for Argentina, in which FMD was endemic and which exported meats mainly to Europe. During that time there were neither official nor private control programmes or activities, except for, in some countries, quarantine of affected properties, ‘symptomatic’ treatment of the disease and use of auto-hemotherapy [1,3].

3. The beginning of the fight against FMD in South America

The FMD control initiatives in South America were greatly influenced by a number of events and decisions, which occurred inside and outside the continent. Some of the most relevant are listed below. The USA prohibition of importation of animals and susceptible animal products in 1929 affected the region; the reappearance of the disease in Mexico in 1947 and in Canada in 1950, along with its introduction and spread to Colombia and Venezuela in 1950, and to Ecuador in 1956, caused enormous production and economic losses, and huge concern across the whole continent. Furthermore, the severe epizootic of Mexico (1947–1952) that led to the creation of the Mexico–United States Commission for the Prevention of Foot and Mouth Disease caused great concern to the governments of the Organisation of American States (OAS). The OAS’s Inter-American Economic and Social Council approved the creation of the Pan American Foot- and-Mouth Disease Center (known as PANAFTOSA, from its telex address name) in November 1951. PANAFTOSA was then established on 27 August 1951 under the management of the Secretariat of the Pan American Health Organization (PAHO), Regional Office for the Americas for the World Health Organization (WHO) and with the support of the Government of Brazil.

Another relevant factor that influenced FMD control in South America was the epizootic in the United Kingdom of 1967 associated with the importation of contaminated ovine meat with bone from this region. This event motivated the countries of the then European Community to prohibit the importation of meat with bone, which led to major reorganizations of the emerging South American export market [4,5]. Other important factors that influenced the fight against FMD in South America were: the elimination of FMD from Central Europe and the end of the vaccination campaigns in 1990; the establishment of the Sanitary and Phytosanitary Agreement (SPS) of the World Trade Organization (WTO) and the nomination of the World Organisation for Animal Health (OIE) as technical reference organization on animal health for the SPS; and the recognition by the OIE of FMD-free countries and territories, first as free countries and territories without vaccination, and then, starting in 1994, as FMD-free countries and territories with vaccination [6,7].

The first initiatives to control FMD in South America started with the establishment of PANAFTOSA that began working on the diagnosis and characterization of circulating viruses, training personnel and providing technical assistance to countries in order to establish national diagnostic laboratories. In addition, PANAFTOSA established a programme for the development and production of FMD vaccine. Studies were carried out on the antigenicity and immunogenicity of the strains of the circulating field viruses for their selection for vaccine production. The Frenkel method for producing virus was developed along with improved processes for the inactivation of the virus, so that countries could produce safe and effective vaccines on an industrial scale. In the 1960s, cell culture for antigen production was introduced [1].

Along with technical assistance and technological developments, the first FMD control programmes started in the 1960s as local initiatives using vaccine produced mainly by private laboratories based on the Frenkel method. Argentina was the first country that established a national FMD control programme in 1964. Subsequently, at the end of 1960s and 1970s, other countries started their FMD control programmes. The majority of these programmes were funded by loans granted by the Inter-American Development Bank (IADB).

By the mid-1960s, the livestock industry and some governments started to appreciate that the disease not only caused drastic direct economic losses by morbidity and mortality of animals, and production and reproductive losses, but it also represented a serious limitation to the trade of animals and animal products. As a consequence, the countries of the
South American countries concluded that, despite various national and regional initiatives, they would not meet the expected result of elimination. The consensus was that there was a need for a high-level political agreement, coordinated at the international level, to provide the political and strategic framework to the elimination programmes. Through various regional forums, the governments of South American countries, the organizations of the livestock sector, and the technical cooperation agencies agreed on the need to establish such a framework.

At that time, the economic situation of the South American countries was poor with low growth rates, high foreign debt and difficulties with repayment, high levels of poverty and many health problems. The livestock sector production systems were characterized by low efficiency, very low off-take rates, poor reproductive rates and low productivity. Production was maintained at levels of domestic consumption, without significant surplus for export. This situation did not encourage the use of technology and the investment required for improving pastures, genetics and management. As a consequence, rural areas were underdeveloped and experienced frequent productivity crises and shortages, with significant impacts on the living conditions of the rural population.

In this context, the sanitary situation influenced negatively the productivity of the livestock sector with several diseases causing losses and impairing the productive and reproductive efficiency. Among these, FMD had an obvious negative impact, hindering the trade of animals and animal products. The situation was worsened by the expenditure for improving pastures, genetics and management. As a consequence, rural areas were underdeveloped and experienced frequent productivity crises and shortages, with significant impacts on the living conditions of the rural population.

In the mid-1980s, after 30 years of fighting FMD, the Southern Cone of South America established agreements and initiatives to fight FMD, and requested PANAFTOSA to coordinate several of these efforts. These initiatives led to the creation of the South American Commission for the Control of Foot-and-Mouth Disease in 1972 (known as COSALFA from its Spanish acronym), which was ratified by the ministries of foreign affairs of the signatory countries as a permanent commission for which the Secretariat was entrusted to PANAFTOSA. With the establishment of COSALFA, PANAFTOSA started a systematic effort to collect information on the occurrence of syndromes compatible with FMD and on the control measures, vaccine production, animal population under the programmes and expenditures incurred by countries in their FMD control programmes [8]. To this end, at that time, the Continental epidemiological surveillance and information system (SIVCON) was developed to collect, analyse and disseminate weekly syndromic geo-referenced information [9].

Within the framework of COSALFA and with the support of PANAFTOSA, countries organized their FMD control programmes, with the application of systematic mass vaccination of their bovine populations. Crucial in the organization of the national FMD control programmes was the active participation of livestock producers. The livestock producers mobilized and became the principal actors in financing and implementing vaccination campaigns. Furthermore, they started advocating at the highest political levels for the public sector to invest in official FMD control programmes and in the capacity of the official veterinary services [10,11].

PANAFTOSA, as part of its technical cooperation, established a robust programme of capacity building and continuing professional development: the Animal Health Training Program for Latin American Countries (known as PROASA from its Spanish acronym) trained nearly 6000 professionals of the countries involved during two decades (1975–1995) both in laboratory diagnosis, epidemiological and surveillance information systems and management of programmes. The former Pan American Zoonoses Center of PAHO contributed to PROASA by providing advanced-level training on the planning and management of animal health programmes. It cannot be over emphasized that the key contribution of PROASA, implemented by PANAFTOSA and financed by a grant of the IADB, was the strengthening of human resources of countries. As a result of this massive-capacity development and training initiative, both at managerial and technical-operational levels, practically all the veterinary services of the Latin American countries upgraded their capacities and technical competencies, decisively influencing the effectiveness of the national FMD elimination programmes. The vast majority of the national programmes were structured on the basis of the technical cooperation provided by PANAFTOSA and the financial support of IADB [12].

The FMD control strategy was based on reducing the susceptibility of bovine populations through systematic mass vaccination campaigns, together with the control of livestock movement and responses to outbreaks. To meet the demand of the country control programmes large-scale vaccine production plants were built in the region. In its early stages, the FMD control programmes used aqueous vaccines applying 3–4 vaccinations per year [13]. However, problems with the quality of the vaccines, deficient supply and high costs of vaccination prevented the establishment of adequate immunological coverage, leading to large areas with viral circulation and FMD endemic conditions.

4. The Hemispheric Program for the Eradication of Foot-and-Mouth Disease

At the initiative of the governments and the stakeholders of the livestock value chain, the 10th Inter-American Meeting, at Ministerial Level, on Health and Agriculture (known as RIMSA from its Spanish acronym) requested PAHO/WHO to establish the Hemispheric Commission for Eradication of Foot-and-Mouth Disease (known as COHEFA from its Spanish acronym), and to develop a Hemispheric Program for the Eradication of Foot-and-Mouth Disease (known as PHEFA from its Spanish acronym). PANAFTOSA, jointly with a group of experts of the countries, drafted the Plan of Action 1988–2009 of the PHEFA, which was approved by the COHEFA in 1988 and ratified by the RIMSA in 1989. The Plan of Action 1988–2009 was based on the epidemiological knowledge of the disease in the continent and on the experiences gained by the countries and PANAFTOSA. The plan was used to direct FMD elimination efforts of the continent throughout its time period [15].

The Plan of Action 1988–2009 defined the goal of eliminating FMD by 2009 and established the strategies and action
objectives with the commitment and political will of the countries. Its key strategic approaches were: the use of the epidemiological characterization of the disease with its relation to the production systems to prioritize interventions; the joint effort of the private and public sectors; the development of sub-regional initiatives and plans; and the establishment of bilateral and multilateral agreements in the sub-regions. The technical and epidemiological foundations of the Plan of Action 1988–2009 were based on the large body of knowledge on the natural history of the disease and its determinants, particularly the implications of the bovine production systems on the epidemiology of the disease, along with the analysis of the health-disease process by applying an ecosystems approach developed by PANAFTOSA [16–18].


Immediately after establishing the Plan of Action 1988–2009, the countries of the Southern Cone (i.e. Argentina, Brazil, Paraguay and Uruguay) signed a technical cooperation agreement with PANAFTOSA for the implementation of the River Plate basin project. The Plan of Action 1988–2009 provided the framework for the execution of this project, which included all actions and components outlined in the Plan. This sub-regional project led to improved coordination, harmonization and adaptation of the national FMD elimination programmes, along with the establishment of a monitoring management system that included periodic and systematic meetings for evaluation accompanied by exchange visits carried out by staff of the countries. The participation of the livestock private sector was relevant for the implementation of this project.

Soon after the implementation of the project, a significant change in the way the disease occurred became evident. There was a reduction in disease incidence, as well as indicators of morbidity and mortality. During the implementation of the River Plate basin project a new tool was introduced: the oil-adjuvant vaccine. With the production of the oil-adjuvant vaccine on a commercial scale and its wide application in systematic mass vaccination campaigns in bovine and bubaline only, one of the most relevant tools for the control and elimination of the disease was introduced (figure 1a shows the dramatic effect of this vaccination strategy in one South American country). After 4 years of implementation of the River Plate basin project, the clinical incidence of the disease

![Figure 1](http://rstb.royalsocietypublishing.org/)

(a) Evolution of the FMD outbreaks and vaccine coverage in Brazil 1986–2011 [19] and (b) export of meat of FMD-susceptible species from South America. (Online version in colour.)
had drastically declined, and started disappearing from 1993. This situation made it possible for the countries to initiate the processes of being declared free, with the recently established status of disease-free with vaccination approved by the OIE in 1994. At the end of the 1990s, owing to the enthusiasm provided by the progress in the sanitary situation, some countries decided to move forward in the attainment of more advanced sanitary status, and began the process of withdrawing vaccination, and applying to OIE for the FMD-free without vaccination status. This process led to an abrupt setback in 2000–2001, with the spreading of a large FMD epizootic (owing to virus O and virus A) in these countries and areas already declared FMD-free, with dramatic economic and social consequences. This forced a sweeping review of the national programmes of the affected countries, and led to the reintroduction of systematic mass vaccination, which is still practiced today. This setback indicated that the decision to withdraw mass vaccination was taken with insufficient epidemiological evidence. Furthermore, the decision to withdraw systematic mass vaccination was taken without an associated strengthening of the veterinary services, and without implementation of effective systems for prevention, early detection and response, which were indispensable to managing increased susceptibility to the disease resulting from the withdrawal of vaccination [3,20,21].

To revive the political commitment to elimination, in March 2004, the Hemispheric Conference for Eradication of Foot-and-Mouth Disease was held in Houston, TX, USA, within the framework of the COHEFA. The Declaration of Houston led to the establishment of the Inter-American Group for Foot-and-Mouth Disease Eradication (known as GIEFA from its Spanish acronym). GIEFA had representatives from both the public and private sectors and the objective of advocating for elimination at the highest political level of the countries, and mobilizing resources. The Conference also revised the Plan of Action 1988–2009 for the remaining 5 years [22].

Progress towards FMD elimination in the countries and areas of the other sub-regions of South America (i.e. Andean and Amazon Basin) was uneven. Colombia and Peru advanced consistently in strengthening their official sanitary programmes, with the participation of the private sector, and obtained the OIE certifications of FMD-free areas with and without vaccination across large areas of their territories. Bolivia, Ecuador and Venezuela had major deficiencies in their national programmes and maintained viral circulation with occurrence of outbreaks. In addition, the north and northeastern regions of Brazil remained without clinical presentation of the disease; however, the structure and capacities of their veterinary services presented important weaknesses and could not ensure adequate interventions compatible with the international certification of FMD-free status.

Table 1. Health situation of foot-and-mouth disease of South America, as recognized by OIE (May 2010).

<table>
<thead>
<tr>
<th>Sanitary Status</th>
<th>Surface (km²)</th>
<th>%</th>
<th>Cattle and Buffalo Herds</th>
<th>No.</th>
<th>%</th>
<th>Cattle and Buffaloes</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free without vaccination</td>
<td>3 779 306</td>
<td>20.3</td>
<td>3 196 71</td>
<td>6.8</td>
<td>11 335 154</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Free with vaccination</td>
<td>8 814 564</td>
<td>47.3</td>
<td>2 670 199</td>
<td>56.9</td>
<td>272 578 829</td>
<td>81.0</td>
<td></td>
</tr>
<tr>
<td>Buffer zones</td>
<td>260 168</td>
<td>1.4</td>
<td>73 711</td>
<td>1.6</td>
<td>1 894 285</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Not free</td>
<td>5 794 691</td>
<td>31.1</td>
<td>1 628 167</td>
<td>34.7</td>
<td>50 546 192</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18 648 729</td>
<td>100</td>
<td>4 691 748</td>
<td>100</td>
<td>336 354 460</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Two decades after implementation of the Plan of Action 1988–2009, great progress in the control of the FMD in the continent could be observed, despite the fact that hemispheric elimination set for 2009 was not reached.

South America as a whole showed outstanding achievements on the commitments made through the 20 years of execution of the Plan of Action 1988–2009. Some 85 per cent of the bovine population (nearly 350 million cattle) were recognized by the OIE as FMD-free with or without vaccination (a summary of the principal indicators of progress of the PHEFA is shown in table 1). The significant progress made on FMD control by the South American countries led to improvements in animal production indicators and made it possible to establish the sanitary basis for sustaining a growing export market of animal products (mainly cattle and pork meat). In addition, it allowed South America, in particular Brazil and the other Southern Cone countries, to become the largest source of livestock production in the world. The extraordinary development achieved in the last two decades gave this region a privileged position in the world trade of meat and other animal products that reached more than 9 billion dollars per year in 2008 [23]. The resulting trade had undeniable economic and social benefits to the people of these countries (figure 1b provides information on the progress of the export of this commodity).

These are impressive results considering the magnitude of the challenge, the complexities of the social and economic situations of the countries involved, their production systems and initial epidemiological conditions, along with the difficulties faced during the development of the Plan. The technical and financial effort of the countries, the technical cooperation of PANAFTOSA and the commitment of the large majority of the nearly 4.5 million livestock producers all played a key role. This achievement has relevance at the global level, both for its technical challenges and the magnitude of the investment made, with nearly a billion US dollars invested per year, of which 70 per cent was financed directly by the private sector.

Despite the huge progress described above, by the end of 2009, there were territories in South America where infection was still circulating endemically. This situation, which prevails to this date, makes all South American countries vulnerable, and endangers the tremendous investments of...
decades of implementation of FMD elimination programmes by the governments and livestock producers along with the other stakeholders of the livestock production chain. FMD still is the principal sanitary barrier to the trade of animals and their products. Indeed, in the areas that are not FMD-free, there are critical deficiencies in the capacities of the official veterinary services along with weaknesses in the sanitary work of the livestock producers. These shortcomings include: low vaccination coverage, with declared vaccination coverage inconsistent with the epidemiological situation; and difficult relationships between the public and private sectors resulting in different policy visions and approaches, which have negative consequences on the implementation of the national FMD elimination programmes.

Ecuador and Venezuela did not reach the objective set by the Plan of Action 1988–2009 of eliminating clinical cases of the disease by 2009. Ecuador reported its last outbreak in August 2011; the current favourable epidemiological situation is owing to improvements of the national FMD programme. Venezuela reported its last outbreaks in October 2011. Improvements of the intervention capacities of the national FMD programme on small livestock holders have been observed; however, there are still deficiencies on interventions on medium- and large-scale livestock holders. In Bolivia, despite no clinical cases having been reported since 2007, weaknesses have been identified in the vaccination campaigns, the epidemiological surveillance system, and the control of animal movement. These weaknesses could affect the ability to detect the disease in this country. By the end of 2009, in the north and northeastern regions of Brazil, the risk characterization of FMD was not yet completed. Today the situation has changed owing to improvements in the structure and capacity of the veterinary services as well as the implementation of disease surveillance and extensive risk characterization studies that should soon lead these regions to reach the FMD-free with vaccination status. The High Surveillance Zone established in the border areas of Argentina, Bolivia, Brazil and Paraguay with an agreement with the OIE to address the sporadic detection of the disease in such areas have proved effective in allowing the countries to regain the FMD-free with vaccination status lost with the outbreaks of 2005 and 2006. On the other hand, it is still necessary to consolidate the efforts of the interventions in other border areas such as those of the Andean countries of Colombia, Ecuador and Venezuela, in which intensified surveillance activities have been implemented [24–26].

From a detailed examination of the outcomes of the Plan of Action 1988–2009 and other information available at PANAFTOSA (e.g. country reports to COSALFA, technical cooperation country missions) it can be concluded that where the Plan was fully implemented it led to progress from endemic status to the absence of the clinical disease. However, in those areas or countries where there were deficiencies in the implementation of the Plan, the disease is still endemic. The data made available through SIVCON provide important insights into trends of the disease. Figure 2 illustrates the spatial and temporal progression of FMD reported outbreaks from 1978 to 2013 in South America. Figure 3 provides information on the number of reported cases of vesicular disease, FMD and vesicular stomatitis from 1972 to 2011; and information on cases of type O, A, C of the FMD virus from 1972 to 2011. Boxes 1 and 2 list some of the factors that positively contributed to and negatively affected the Plan of Action 1988–2009 of the PHEFA, respectively.


As the first Plan of Action 1988–2009 did not lead to the elimination of FMD, in 2010, the South American countries decided to establish a second Plan of Action, setting the goal of elimination to 2020. To this end, the countries supported the preparation and later approved a new Plan of Action 2011–2020 of the PHEFA [27]. The Plan of Action 2011–2020 of the PHEFA is
the tangible contribution of the Americas to the FAO/OIE Global Foot and Mouth Disease Control Strategy [28] as it was formally stated by the COHEFA in its 12th ordinary meeting in Santiago, Chile, 24 July 2012. Furthermore, COHEFA expressed support to the FAO/OIE Global FMD Strategy, making available the experience and tools developed in the region to the FAO/OIE Global FMD Strategy, along with reiterating that COSALFA, COHEFA, GIEFA and RIMSA are the governance mechanism of the PHEFA [29].

The Plan of Action 2011–2020 is facing a number of challenges. In the Southern Cone, the emergence of sporadic outbreaks still needs to be resolved (figure 4a), particularly those of unknown origin in areas previously recognized as disease-free. Such outbreaks might be a consequence of a concurrent very low level of virus circulation in the bovine population along with insufficient levels of herd immunity to halt virus circulation. This scenario highlights deficiencies in the quality of interventions and the sensitivity of the detection and response systems. Key amendments towards improving interventions where there is risk of viral circulation include: implementing targeted risk-based interventions; strengthening the structure and capacity of veterinary services to monitor vaccination where practised; implementing effective surveillance, early detection and response to suspected cases; and prompt reporting and notification. In this respect, there have been few instances when the disease was not promptly reported internationally, which caused concerns about transparency of notifications. This situation is similar to the FMD epidemic of 2000–2001, which occurred in previously free territories without vaccination and was first reported by farmers and at a later stage notified internationally.

On the other hand, the advances achieved in populations that are disease-free with vaccination are sustained by the systematic mass vaccination campaigns, with the application of 700 million doses annually, fully financed by livestock producers. For the livestock producers it is increasingly difficult to appreciate the need for continuing vaccinations since in the majority of the territories that have achieved the status of disease-free the disease has not been detected for more than 10 years. Furthermore, the vaccination campaigns have become routine and are not applied as a strategic tool tailored to the epidemiological risk of the prevailing sanitary scenarios to interrupt the epidemic cycle of the disease and prevent the reintroduction of the infection. Figure 4b reports the FMD situation in South America according to the OIE in May 2012.

Systematic mass vaccination needs to be maintained at the current level because of the persistence of the infection in South America. However, the perception of the livestock

Figure 3. Reported outbreaks of (a) vesicular disease, FMD and vesicular stomatitis and (b) type O, A, and C FMD virus. (Online version in colour.)
Box 1. Factors that positively contributed to the Plan of Action 1988–2009 of PHEFA.

Several factors contributed to the success of the PHEFA Plan of Action 1988–2009 in countries and areas where significant progress was reported:

— consolidation of the structure and function of the official veterinary services;
— application of the ecosystem approach [16–18] to guide the disease control strategy and action;
— political support;
— coordination with the private sector and other institutions;
— coordination of the national programmes with their sub-national programmes;
— awareness of the livestock producers and participation of the private sector in the implementation and financing of the control actions (e.g. vaccination, disease detection, biosafety);
— training of human resources;
— provision of technical cooperation by an International Organisation fully committed to the needs of the countries (i.e. PANAFTOSA); and
— coordination and permanent support of regional mechanisms such as the Permanent Veterinary Committee of the Southern Common Market (known as MERCOSUR from its Spanish acronym) and; the Andean Technical Committee on Agricultural and Livestock Health of the of the Andean Community (known as CAN from its Spanish acronym).

Box 2. Factors that negatively affected the Plan of Action 1988–2009 of PHEFA.

Several factors had negative consequences on the implementation of the PHEFA Plan of Action 1988–2009 in countries and areas where poor progress was reported:

— weak structure of the official veterinary services impaired the adequate implementation of the Plan in some Andean countries. This situation was aggravated by political decisions that led to frequent administrative changes;
— inadequate engagement and participation in the regional blocs of some countries;
— despite the government commitment to fulfilling the Plan, some countries did not apply the strategies according to the epidemiological and risk characterization;
— insufficient political commitment;
— lack of a resolute commitment by all the countries of the region on the need to achieve food security and food sovereignty;
— international trade as the almost exclusive driving force of the Plan;
— national plans that did not consider as part of their implementation a consolidation phase of the achievements so that technical decisions were overturned by political opportunistic decisions;
— managerial weakness in the application of the Plan;
— lack of a solid and explicit mechanism of the Plan for monitoring and evaluating progress that would timely identify deficiencies and recommend actions. PANAFTOSA did not take up this role at the regional level, nor did the sub-regional plans;
— lack of periodic and systematic processes of self-evaluation and external evaluation and lack of intermediate management indicators;
— gradual loss of operating capacity of PANAFTOSA, which was not able to closely follow the countries in the development and implementation of strategies to consolidate elimination;
— focus on national/sub-national priorities that impaired the coordination between and within countries and PANAFTOSA;
— sub-regional programmes did not provide the institutional support to the participating countries, which did not prioritize the disease and provide the necessary resources;
— different level of implementation of the sub-regional projects (Southern Cone, Andean Countries, Amazon Basin); and
— need for technical cooperation by international organizations with countries, especially in the Andean sub-region.

producers of a lack of progress in sanitary conditions along with their expectations for better commercial opportunities could easily discourage the maintenance of high vaccination coverage. This could lead to an increased susceptibility of the population to disease, increasing the risks of infection and of an eventual reappearance of the disease along with the consequent sanitary setbacks that would dramatically jeopardize all the efforts and progress to date. Available information show that in some countries the declared vaccination coverage does not reflect the real herd immunity. Some areas could have lower vaccine coverage, especially areas with small livestock producers and where the disease has not been recorded for more than 15 years.

Progress with the remaining livestock population that is not FMD-free is not a simple issue to address in the short term. The most difficult challenges that require full resolution include: maintaining the political commitment and support of the national governments; obtaining the allocation of national resources to sustain the elimination programmes; and obtaining the international support and solidarity of
human and financial resources to provide technical cooperation for elimination. Realistically, these challenges can be managed on the medium term (4–6 years).

7. Key implications of FMD elimination in South America

(a) Production and trade of meat and meat products

Advances in the FMD sanitary situation have led to significant improvements of production indicators, by removing the consequences of the disease in animals, and have made it possible to create the sanitary basis necessary to sustain a growing exporting process of animal products (mainly meat of cattle and pigs). Estimates indicate that in the next 20 years, world demand for meat will double, which brings a major comparative advantage to South America as the largest meat supplier in the world. Advances in production systems make it possible to increase productivity without increasing the area destined for livestock production. This favourable scenario of livestock production is shared by the majority of South American countries and poses new productive and sanitary challenges, in particular for the consolidation of the progress of the second Plan of Action 2011–2020 to achieve elimination.

The sanitary improvement has led to significant foreign exchange revenues for some economies of the region, with exports of livestock being among the most important sources of income of foreign currency, as well as increasing the participation of the livestock sector in the Gross National Product. The increase in consumption of meat at the global level and the consequent increase of the exports of species susceptible to FMD make the exporting process crucially dependent on the sanitary situation. The setbacks in the FMD situation of the last 10 years in previously declared free areas and the social and economic consequences owing to the suspension of trade, along with the high costs for the disease control programmes that the countries had to pay to regain their status, are a premonitory example of the implications of FMD on trade and its impact on the economy, highlighting the need for effective veterinary services and their role as a national public good.

Figure 4. (a) Selected reports of FMD virus type O occurrence in the countries of the Southern Cone of South America, 1998–2012. (b) FMD situation in South America according to the OIE, May 2012. (Online version in colour.)
(b) Social, economic and political implications
The FMD sanitary improvement served as the basis for the increasing export, profit and capital gain of the various segments of the livestock production chain of the exporting sector. However, these gains have been lower for the small and medium commercial livestock producers who do not have the means to enter into the export process. In the case of family small-scale livestock producers the cost-benefit of FMD control (improved income versus vaccinations and other health expenditures) are marginal or insignificant and FMD control is not being perceived as an investment but as a cost (often compulsory). A significant proportion of these family small-scale livestock producers have extremely low margins of profitability, some are living at or below the poverty line, with FMD objectively far from being a priority. To ensure that the sanitary programmes lead to satisfactory and sustained results, the participation and contribution of all livestock producers is imperative, along with the sharing of the benefits correlated to the contribution, and gains for the whole sector. All the livestock producers, large or small, exporting or not, should contribute to the control actions as a necessary and compulsory condition, yet the greater benefits are for the exporting sector. Such imbalance in the distribution of contribution and benefit can have important adverse effects in the progress of FMD control putting at risk the programme as a whole.

Another complex issue regarding the public investment in sanitary actions that can be observed at national and sub-national levels is the existence of different standards of public investment depending whether the production process is for export or not, leading to the application of different technological tools, certification processes and traceability. Many of these processes involve large investments by the public sector in order to adapt its structures and services to serve this important and growing demand. On the other hand, limited or no investments are made in the non-exporting sector, particularly family small-scale livestock producers.

Identifying which livestock producers are left behind in terms of the benefits acquired by the sector as a whole, and the implementation of redistributive mechanisms to close these gaps, such as fiscal benefits and collective support from the segment which benefits most, are measures that are both socially fair and highly profitable. The potential losses for the whole sector are much greater than the investment involved in redistribution. For these reasons, great attention should be given to the identification of family small-scale livestock producers and subsistence farming communities and to their epidemiological risk. Where inequality in benefits is present and progress is crucial, incentives and official assistance to support the sanitary actions should be implemented, by promoting the support of the livestock value chain.

(c) Institutional and political consideration of the national FMD elimination programmes
The processes of FMD intervention in South America have had various degrees of effectiveness, some making significant progress and others practically without progress with regard to the control of the disease. With regard to the countries that progressed (i.e. Argentina, Brazil, Colombia, Peru, Paraguay and Uruguay) their national FMD elimination programmes show important strengths, among them the political support and commitment, of sufficient resources to carry out and efficiently manage field operations. However, there is the need for improvement of various components of the programmes, particularly at the field operations level (Local Veterinary Units). The countries that still have to advance in the elimination process (i.e. Bolivia, Ecuador and Venezuela) generally show serious weaknesses in their implementation of activities and interventions.

The national FMD elimination programmes need strengthening on several of their strategic components or require changes in order to address the new epidemiological scenarios, both in countries and areas with a presence of the infection, and in those that need to consolidate the advances from disease-free with vaccination to disease-free without vaccination. The following sections review the most critical strategic components with regard to the support that these provide to the programmes, such as systematic vaccination, laboratory diagnosis, surveillance systems, alert and response, prevention, human resources and community participation.

With regard to the vaccination campaigns, these need to be strengthened particularly in the countries where the disease is still endemic. There are weaknesses with the conservation and application of the vaccine and weak correlation between the official vaccination coverage and the level of immunity of the population. Deficiencies in the planning of the vaccination campaigns are also observed as they do not consider the epidemiological situation and the risk characterization. In addition, with very few exceptions, there are no vaccine and antigen banks, which would be required to respond to emergency demands owing to a South American virus strain or introduction of exotic viruses into the region.

To reach elimination, a large animal population needs to move its sanitary status from disease-free with vaccination to free without vaccination. Such a change poses perhaps the greatest managerial and operational challenge, as it requires that the population remain without vaccination, rapidly increasing its susceptibility to the variants of the virus circulating in the region. The adverse experiences of the Southern Cone have indicated that the processes of withdrawing the vaccine should be extremely carefully planned. Emergency plans are vital, with vaccine banks aligned with the risk profile of the region. The establishment of antigen banks is also needed to rapidly prepare specific monovalent vaccines in order to respond to outbreaks when they arise.

With regard to laboratory diagnosis there are deficiencies in some of the countries in the implementation of viral diagnostic techniques for identification of the FMD virus, in the biosafety of the infrastructure, as well as in the mechanisms and capacities required to shorten the time from detection to diagnosis. In addition, there is the need for further studies on the standardization of the diagnostic kits recently introduced in the region for determining viral circulation and evaluating the immunity of the population.

With regard to the national information systems, increasingly there is the need to have access to historical and
real-time data in order to effectively manage the intervention activities and to provide transparency. In this regard, the existing regional information system, the SIVCON [9], would need to be further used by the countries. Deficiencies are also present in the usage of the data collected at the local level, on the standardization of data collection along with the criteria for analysis.

In addition to strengthening technical and managerial capacities, the processes of intervention should be accompanied by a policy of continuous professional development of the human resources responsible for managing interventions, at the national and sub-national levels. In this regard, there is a shortage of human resources in the official veterinary services caused by the departure of experienced and knowledgeable professional staff owing to movement to other jobs or retirement, a failure to recruit new staff for key vacant posts owing to budgetary constraints, and finally, the recruitment of new professional staff with limited experience in FMD. Furthermore, there are changes in the official veterinary services, which are moving from an emphasis on improving the sanitary status based on control and elimination programmes, to an emphasis on ensuring the sanitary status in order to support the export process. There are also changes in the general profile of the veterinarians, with new staff lacking the necessary experience and having a critical role, particularly in facing the challenge of moving from disease-free with vaccination to the status of free without vaccination. It is urgent and necessary to establish training and continuing professional development programmes to build analytical capacities and risk management, assessment and communication competencies tailored to the field situations and the need to progress the national programmes.

With regard to the disease surveillance, detection and response systems, given the progress of the programmes, the limited occurrences of outbreaks in the majority of countries and the significant changes in the professional profiles of the staff of the official veterinary services, there is a need for training in the use of new tools to increase the sensitivity of detection mechanisms, in particular, the use of geographical information systems and spatial risk analysis. With regard to the need to increase the sensitivity of the detection mechanism, this also requires a much greater participation of the livestock producers and the other stakeholders in reporting signs compatible with vesicular diseases. However, the majority of countries do not have specific mechanisms to promote the notification of suspected disease, such as compensation or indemnity.

Given the prolonged absence of detection of clinical disease and the absence of viral circulation shown by successive seroepidemiological studies, several sub-national authorities and organizations of livestock producers are now requesting their authorities to move forward with elimination and are carrying out feasibility studies in order to end vaccination and apply for FMD-free without vaccination status. They cite the State of Santa Catarina, Brazil and Chile as examples to be imitated. However, national authorities do not have sufficient information on the characterization of risk in order to evaluate the epidemiological, operational and economic feasibility required for this change. Some also recall with great concern the failure of the previous experiences of moving toward free without vaccination status, along with the serious economic consequences. Ensuring decision-makers at the political level understand the essential need for establishing rigorous prevention programmes along with effective outbreak alert and response mechanisms is a challenge. These prevention programmes require financial, human and material resources in order to prepare the official veterinary services for a scenario without vaccination and a population with maximum susceptibility.

9. Regional political scenario and integration initiatives

South American countries have established several integration initiatives and economic agreements. Together with the strengthening of the currently existing initiatives such as MERCOSUR and CAN, new initiatives have been established such as the Union of South American Nations (UNASUR), with the participation of all South American countries. These agreements are based on a shared interest in expanding trade among countries, including the movement of people and goods. The interest in favouring intraregional exchanges, the reduction in requirements for the movement of goods and the facilitation of customs processes include the establishment of sea corridors and the expansion of the routes of communication between countries. While these measures will foster the economic growth and development of the regions, they imply an increased risk of dissemination of animal diseases, and constitute a huge challenge for the official veterinary services as they involve exchanges among territories with very different FMD sanitary status. Furthermore, countries assign different political priority to their FMD sanitary situation, which leads to large differences between countries that have moved forward with elimination and those that have not. These last either do not assign the necessary priority to the elimination of the disease (e.g. Venezuela), or do not provide the necessary conditions for structuring the official veterinary services that are required for eliminating FMD (e.g. Bolivia). These political decisions are not related to FMD as such, but reflect political views on the role of the state in supporting (or not) sanitary processes that benefit medium and large livestock producers. These differences require urgent attention in order to reach the goal of elimination. Advocacy, at the highest political levels within the integration mechanisms, should negotiate minimum requirements for the implementation of the national FMD elimination programmes and the capacities of the official veterinary services on the principle that the health of livestock is a common good. Furthermore, there is the need for strengthening joint and coordinated action among the South American countries, along with the solidarity of economic and technical support being given by the countries that have more FMD elimination experience and resources to those more disadvantaged.

10. Conclusions

The results achieved so far by the two Plans of Action of the PHEFA can be regarded as very positive (see figure 4b). Systematic mass vaccination proved to be an effective tool for the elimination of FMD in South America. The establishment of the two Plans of Action was essential for the countries to address with clear and coordinated actions the elimination process through an international technical cooperation framework. The established political, strategic and technical governance mechanisms (i.e. COSALFA, COHEFA, GIEFA, RIMSA) provided continuous monitoring of the FMD
elimination plans and actions; and also promoted and articu-
alted the private–public partnership. The effectiveness of this
governance architecture has been proved by the significant
advances towards elimination in the majority of countries of
South America. The establishment of the Plans of Action of
the PHEFA is the expression of the political will of the govern-
ments that provide support and incentives to the various
stakeholders of the livestock production chain with a spirit of
cooperation and solidarity for a common good.

To conclude, the unfinished task of FMD elimination from
South America requires the strengthening of the national
FMD elimination programmes and technical cooperation,
along with collective and effective technical and financial assist-
ance to priority countries. The experience acquired in the
execution of the two Plans of Action of the PHEFA indicates that
it is feasible to eliminate FMD from the continent. The challenge
is to use this experience in the areas where implementation has
not reached an adequate level of execution.

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