

ERADICATION OF FOOT-AND-MOUTH DISEASE IN THE AMERICAS

Background

The etiologic agent of foot-and-mouth disease is a picornavirus that has high antigen variability, especially in partially immune animal populations that contribute to selection of new variants. However, it also has a relatively limited capacity to remain viable for any extended period under the environmental conditions characteristic of South American stock farming.

The domestic animal hosts susceptible to this agent belong to the bubaline (water buffalo), bovine, ovine, caprine, cameloid, and porcine groups. The same groups in the wild are also susceptible, while other wild species, including deer and capybaras, can become infected or diseased.

It should also be emphasized that infected animals need not display clinical signs to be highly efficient transmitters of the virus during the acute phase of the infection. Frequently (among cattle, antelope, and sheep in particular) the virus can live in the pharynx for long periods (sometimes for more than a year). Nevertheless, these carrier animals' participation in transmission of the virus appears to be no more than occasional.

The main pathway by which the virus is transmitted is the respiratory system. Elimination (upon exhaling) by animals in the acute phase of the infection and lodging (in the upper respiratory passages of others in contact with them) constitutes the commonest transmission mechanism. Such transmission can occur even among vaccinated animals, although in a population with high immunity viral transmission is less probable. Other important transmission pathways are ones involving the digestive system (in calves and hogs) and ones involving milk (by ingestion or mechanical transmission). The latter are of major significance in dairy farming areas, because of commercial milking.

Maintenance of the virus (endemism). For the virus to be kept endemic, an animal population has to be in continuous partial contact with sources of infection (infected individuals who are eliminating the virus). If there were no effective contact during the period of the viral elimination phase (peak elimination of the virus is observed between two and eight days after infection of the source, regardless of whether clinical signs of the disease are manifested), the endemic transmission cycle would be broken. On the other hand, if a population were simultaneously exposed, a high herd immunity would result, and the transmission cycle would also be broken so long as no new susceptible contacts were added to the herd. For these reasons, two characteristics of animal populations have a critical bearing on endemism: (a) the size of the exposed animal population (including all susceptible domestic and wild species with any probability of mutual contact); and (b) the density

of this population. The larger the herd and the lower its density, the greater the chances for endemic circulation of the virus.

Diffusion or transmission. The main transmitter of infection is the infected animal itself during the acute phase of virus multiplication. A young steer or heifer with little prior immunity, recently exposed before being moved from its herd of origin to a market or farm, thus constitutes an ideal vehicle for diffusion of the disease. Susceptible animal populations that come into contact with it when it is being moved run a high risk of infection. The factors most strongly influencing this transmission mechanism are the marketing system employed for the cattle (which presumably originate from endemic areas) and the management and density of the herds into which the potentially infected cattle are introduced.

Other transmission mechanisms, which play a lesser role, include the milking chain (milking and milk marketing); the feeding of hogs with contaminated feed or residues; mechanical transmission by people dealing with livestock; and possible aerial diffusion (a mechanism considered critical in Europe but one for which there is little evidence in South America). It should also be noted that the porcine population plays a special role in transmission, because the hog becomes infected with very small doses of the virus but multiplies and eliminates it in large quantities. On the other hand, unlike other species, it does not maintain it as a carrier, and so it depends on the bovine viral cycle.

The outcome of contagion. This can be an aborted infection, in which case the animals exposed do not become new sources of infection for second contacts; an actual subclinical infection (the animals do not become sick but become new replicators and transmitters of the virus); or an apparent clinical infection, with consequent permanent or temporary loss of production of the affected herd. The tendency toward this latter outcome is governed by the species involved, the type and age of the contact animals, and by the exposed animals' immune status before exposure to the virus.

Tools for Combating Foot-and-Mouth Disease in South America

The technological instruments needed to combat and possibly eliminate foot-and-mouth disease from South America are at hand. The main ones are as follows:

Vaccines. The present production of foot-and-mouth vaccines is sufficient to meet the current demand of national programs. Official quality control measures instituted in Argentina, Brazil, Colombia, Paraguay, and Uruguay

have played a fundamental part in increasing the vaccine's efficiency, immunogenic potency, and biological safety. However, the vaccine in general use only protects vaccinated cattle for four months, which means that four-month vaccination cycles are required.

An oil-adjuvanted vaccine that confers six months of immunity upon animals vaccinated for the first time and 12 months upon subsequently revaccinated animals is now being produced by the Pan American Foot-and-Mouth Disease Center (PANAFTOSA) for demonstration as well as emergency and strategic use in almost all the affected countries of South America. It is also being produced by two government laboratories in Brazil, and production is beginning at private laboratories in Argentina, Brazil, and Paraguay, and at the VECOL laboratory in Colombia. In addition, two government laboratories for production of the oil-adjuvant vaccine are under construction in Argentina and Venezuela.

Epidemiologic surveillance. All of the South American countries have developed sound information systems for epidemiologic surveillance of foot-and-mouth disease. These systems include the field and laboratory organizations needed to monitor the disease, diagnose the virus, assess the degree of coverage provided by vaccines, record fluctuations in the animal population and its movements, and characterize the epidemiologic risk. Computerized systems were recently introduced to help manage and apply this information.

Control of virus variants and subtypes. Virus strains with small significant differences or even new virus subtypes frequently appear. These virus variations in the field depend largely on the animal population's immune status. Variants are relatively unlikely to appear in populations that are either totally susceptible or highly immune. On the other hand, poorly vaccinated cattle populations—ones that have received vaccines of dubious quality or been given only partial coverage—provide the sort of immunologic situation favoring variant selection.

All the national services involved have the ability to quickly detect any deviation by virus in the field from the strains used in the vaccine. Depending on the degree of variation, its epidemiologic significance, and the vaccination history of the exposed population, the services may (a) administer the next vaccination ahead of schedule (in order to strengthen the secondary immune response and broaden the spectrum of antigens involved); (b) broaden the vaccine's antigen spectrum by incorporating a new virus strain to adequately cover the field variants; or (c) occasionally prepare a monovalent vaccine with the field variant and, if need be, replace the existing vaccine strain with it.

Other measures. While variations exist between countries regarding coverage and adjustment to the needs of present or future programs, the field structures needed to track down and eliminate foci, establish quarantines, disinfect affected areas, and so forth are generally in place. The legal foundation required is also present, although this will have to be modified to fit new

strategic proposals recently recommended by the South American Foot-and-Mouth Disease Control Commission (COSALFA), proposals that are now starting to be implemented in some countries or affected local regions.

Control and Eradication

Since the foot-and-mouth disease eradication campaign in Mexico in the late 1940s and early 1950s, a picture has been built up of alternative and exclusive control and eradication strategies, certain measures being associated with control and others with eradication. Specifically, vaccination has become associated in the public mind with control, while slaughter of potentially infected animals and other damage control measures have become associated with eradication.

In fact, nothing could be further from the truth. For example, assume that a rational and intensive vaccination program succeeds in effectively immunizing the cattle within an ecosystem where the virus has been endemic. It is probable that the virus will maintain itself for a certain time in other susceptible domestic or wild species. It is also likely that the infection will maintain itself for a time in the "epiendemic" ecosystems (fattening and other intensive stock-raising areas where conditions for maintaining the virus are especially favorable); and occasional migrations of wild animals or possible movements of cattle carrying the virus may give rise to sporadic outbreaks. However, exclusion of the numerous cattle present on large ranches from the endemic transmission cycle is bound to gradually reduce the probability of effective transmission between sources of infection and susceptible hosts, thereby inevitably changing the equilibrium necessary for maintaining the disease cycle. Moreover, the gradual reduction of transmitters and elimination of susceptible cattle (by means of immunization) in such areas will soon eliminate the conditions favoring infection in the epiendemic ecosystems, infection that is maintained by movement of sources of infection and susceptible animals into the areas where intensive stock-raising is conducted. In other words, effective immunization of cattle in an endemic ecosystem will sooner or later lead to eradication of the disease.

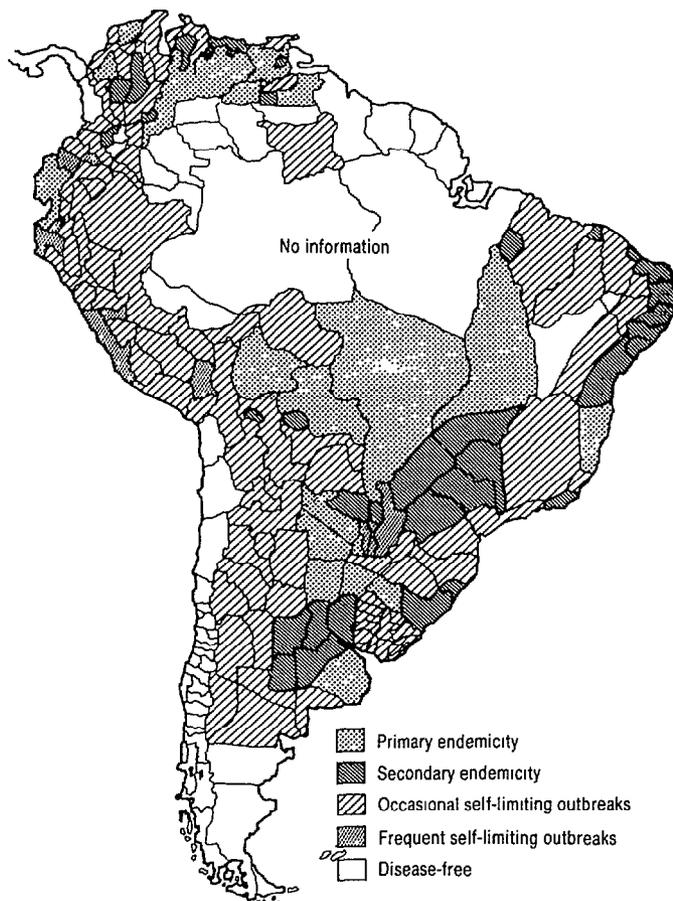
If, on the contrary, one were to slaughter all the diseased and exposed cattle in an intensive fattening area (an epiendemic ecosystem) with a view to stamping out the disease, one would not achieve eradication. That is, so long as sources of infection and susceptible stock continued to be brought in from surrounding endemic areas, this wholesale slaughter would not readily succeed in eliminating the disease.

The Regional Plan of Action

During 1985 the national foot-and-mouth disease programs of the Americas, which were given priority in most of the affected countries, incurred expenditures close to US\$80 million.

As a result of these programs, foot-and-mouth disease has been eradicated in Chile. In the rest of South America, the incidence of the disease has been cut from 13 to 20 cases per thousand head annually in the early years of the programs to around 1 or 2 cases per thousand in recent years—a reduction exceeding 90%. Similarly, morbidity has declined from an estimated 20 to 30 cases per thousand head of cattle to around 0.7–0.8 cases per thousand today. (Figure 1 shows patterns of occurrence of foot-and-mouth disease prevailing in South America in 1985.) In addition, the disease has been kept out of the disease-free area of Panama,

FIGURE 1. Prevailing patterns of foot-and-mouth disease in South America, 1985.



Central America, the Caribbean, and North America, and the risk of its introduction into this area has been greatly reduced.

However, these epidemiologic gains have slowed in recent years, essentially because of the control method employed. This method has simply relied on regular four-month vaccination of the cattle and sheep populations in the infected countries, together with standard sanitary measures that have taken no account of the geographic, ecologic, socioeconomic, and epidemiologic settings of the specific livestock populations affected. Besides requiring an ongoing investment exceeding US\$150 million per year, this method has been unable to end the loss of animals from infected herds or to end sanitary restrictions on the local, regional, and international trade in livestock and animal products. It has also prevented rationalization of investments and expenditures in keeping with strategic and tactical considerations specific to each particular livestock region or area involved.

Faced with this emerging state of affairs, from 1978 onward the nations of the Americas adopted resolutions at a series of international meetings¹ directed at establishing areas free of foot-and-mouth disease in South America as a medium-term approach to eradication.

This regional program retains the goals of eradicating foot-and-mouth disease in the infected countries of South America and establishing preventive measures for blocking its reintroduction. However, for purposes of attaining these objectives the following specific targets have been set:

- Establishment and development of a subregional project for the eradication of foot-and-mouth disease in the River Plate Basin, to be carried out in two stages. (Stage 1 targets, 1987–1992—Argentine Mesopotamia (northeastern Argentina); Rio Grande do Sul, Brazil; and Uruguay; Stage 2 targets, 1989–1996—the rest of Argentina; eastern Paraguay; and Santa Catarina, Brazil.)

- Establishment and implementation of an Andean subregional project for the eradication of foot-and-mouth disease in three stages. (Stage 1 targets, 1988–1995—Peru, the Bolivian Alti-

¹ The Hemispheric Meeting on Foot-and-Mouth Disease and International Trade held at Buenos Aires, Argentina, on 1–7 November 1978; the VII Regular Meeting of the South American Commission for the Control of Foot-and-Mouth Disease (1980); and the IX Regular Meeting of the South American Commission for the Control of Foot-and-Mouth Disease (1982).

plano, and southern Ecuador; Stage 2 targets, 1989–1996—the Atlantic coast of Colombia and eastern Venezuela; Stage 3 targets, 1990–1997—the rest of Colombia, Ecuador, and Venezuela.)

- Establishment and implementation of a subregional project for the eradication of foot-and-mouth disease in the Amazon Basin, to be carried out in two stages. (Stage 1 targets, 1988–1996—Amazonia and west-central Brazil, eastern Bolivia, and the Chaco in Paraguay; Stage 2 targets, 1989–1997—the rest of Brazil.)

Given what we now know about the disease, new procedures and approaches to epidemiologic diagnosis, the existence of a highly potent and reliable vaccine, and identification of the disease agent's modes of geographic distribution and movement associated with the economic organization of livestock production, it is now feasible to undertake a foot-and-mouth disease eradication program directed at the gradual conversion of endemic and epizootic ecosystems into occasionally infected and disease-free areas.

This area strategy permits the creation and expansion of regions free of the disease—starting with livestock areas whose health status, for commercial reasons, influences large numbers of stock farms operating within them.

In countries free of the disease, a strategy of prevention must seek subregional integration of national emergency plans based on an epidemiologic characterization of the risk of introducing exotic diseases into the Americas.

The active and informed participation of stock farmers and the industries processing their products is essential to implementation of the regional program. Equally vital is political commitment of the governments involved, not just to execute the program but—more important—to ensure a successful outcome.

Regional coordination. Since the foot-and-mouth disease problem offers an appropriate avenue for working toward the social and economic development of stock farming as a whole, coordination of the regional program—in its subregional components—is viewed as the first step in a specific, objective effort by the ministries of agriculture of the member countries toward the technological, commercial, and economic integration of the livestock sector. It is accordingly recommended that “livestock integration commissions” be established in the several subregional projects to coordinate the subregional foot-and-mouth disease eradication programs and to serve as forums for discussion of common problems in the sector.

The plan is for each of these subregional commissions to designate a representative of one of its member countries, and for these representatives to join with others from the disease-free subregions of Middle America, the Caribbean, and North America to form a Regional Committee for the Eradication of Foot-and-Mouth Disease.

This regional committee is to receive technical and financial support from regional and international agencies.

The secretariat of PAHO's Pan American Foot-and-Mouth Disease Center will be in charge of the program's coordination, guidance, and evaluation.

Another important task will be to strengthen the functions of the South American Commission for the Control of Foot-and-Mouth Disease (COSALEA). Over the past 14 years this commission has played a key role in programming and executing control activities in the countries of the Region.

Subregional projects. The steps to be taken in setting up the three aforementioned subregional projects include:

- preparation and organization of the subregional projects;
- conclusion of multilateral agreements for the conduct of joint operations between countries;
- establishment of international coordination mechanisms for the implementation of these subregional projects; and
- preparation of technical cooperation projects to support the operations of the subregional projects and obtain resources for their implementation.

Country projects. Projects for the eradication of foot-and-mouth disease will have to be prepared or restructured to fit arrangements for the coordination of subregional operations. These country projects will have the following features: (a) the goal of eradicating foot-and-mouth disease; (b) a strategy consistent with the applicable subregional project; (c) restructuring of the country's animal health services for optimal use of operational resources and personnel; (d) formulation of and adherence to strict technical guidelines that include epidemiologic information and surveillance systems, implementation of strict measures for biological safety and the elimination of foci, availability and rationalized production and distribution of vaccines conferring longer-lasting immunity, and greater government involvement in large-scale immunization in the endemic areas; (e) ongoing personnel training; (f) revision of legislation designed to bring that legislation into line with the technical requirements of eradication; (g) establishment and pursuit of an active social communication program; and (h) planning for provision of the local budgetary resources needed and for any external financial support required for execution of the project.

Establishment and Implementation of the Regional Program

The Pan American Health Organization, in conjunction with the Regional Committee for the Eradication of Foot-and-Mouth Disease in South America, and with the technical and financial support of the Food and Agriculture Organization of the United Nations (FAO), the Inter-American Institute for Cooperation on Agriculture (IICA), the Inter-American Development Bank (IDB), and other international, regional, and subregional agencies, is to draw up a Regional Program for the Eradication of Foot-and-Mouth Disease in South America embodying the goals and strategies described above. This process is to be completed

within 12 months (before 1 May 1988). The program will cover (a) the standards, needs, and arrangements to be made for regional coordination, technical cooperation, and evaluation; (b) subregional projects for the River Plate Basin, the Andean subregion, and the Amazon Basin; and (c) adaptation of the country programs to the goals of these subregional projects.

The Committee for the Eradication of Foot-and-Mouth Disease in South America will have five members, one for each of the following subregions: (1) the Southern Cone of South America, (2) the members of the Cartagena Agreement, (3) the Amazon Basin, (4) Middle America and the Caribbean, and (5) North America.

The Pan American Foot-and-Mouth Disease Center will serve as the committee's secretariat, in which capacity it will receive support from FAO, IICA, IDB, and other interested regional and international organizations.

The committee's task will be to frame the policy and technical guidelines for the program, and to identify and negotiate with appropriate sources of financing. The committee will make specific proposals including guidelines for (a) the design, financing, execution, and evaluation of the subregional projects needed for the multinational coordination of the programmed measures; and (b) the preparation, financing, execution, and evaluation of the specific national projects for eradication of the disease, in keeping with the guidelines of the subregional programs. In addition, the committee is to set up permanent structures for the coordination, regulation, technical guidance, and evaluation of the Regional Program for the Eradication of Foot-and-Mouth Disease in South America.

Overall, it appears that the many years of dealing with foot-and-mouth disease in South America have produced a considerable body of knowledge about specific factors influencing the epidemiologic behavior of the disease in different areas. Application of this knowledge should make it possible to reduce the public and private costs of livestock health care and achieve eventual eradication.

The tools needed for this task are available here and now. The form of methodologic organization needed to apply them rationally is also known. What is still needed is the decision to go ahead and gradually realign existing efforts in an appropriate manner, so as to change the cycle of endemicity and disease transmission by influencing certain causal factors present in specific and differing ways in different places. The regional program's principal aim is to accomplish a realignment of this kind.

Sources: Pan American Health Organization, document RIMSA 5/6, The Foot-and-Mouth Disease Situation in South America and the Technical Bases for Its Eradication, Washington, D C , 1986; and Pan American Health Organization, document RIMSA 5/13, Plan of Action for the Implementation and Development of a Regional Program for the Eradication of Foot-and-Mouth Disease in South America, Washington, D.C., 1987.