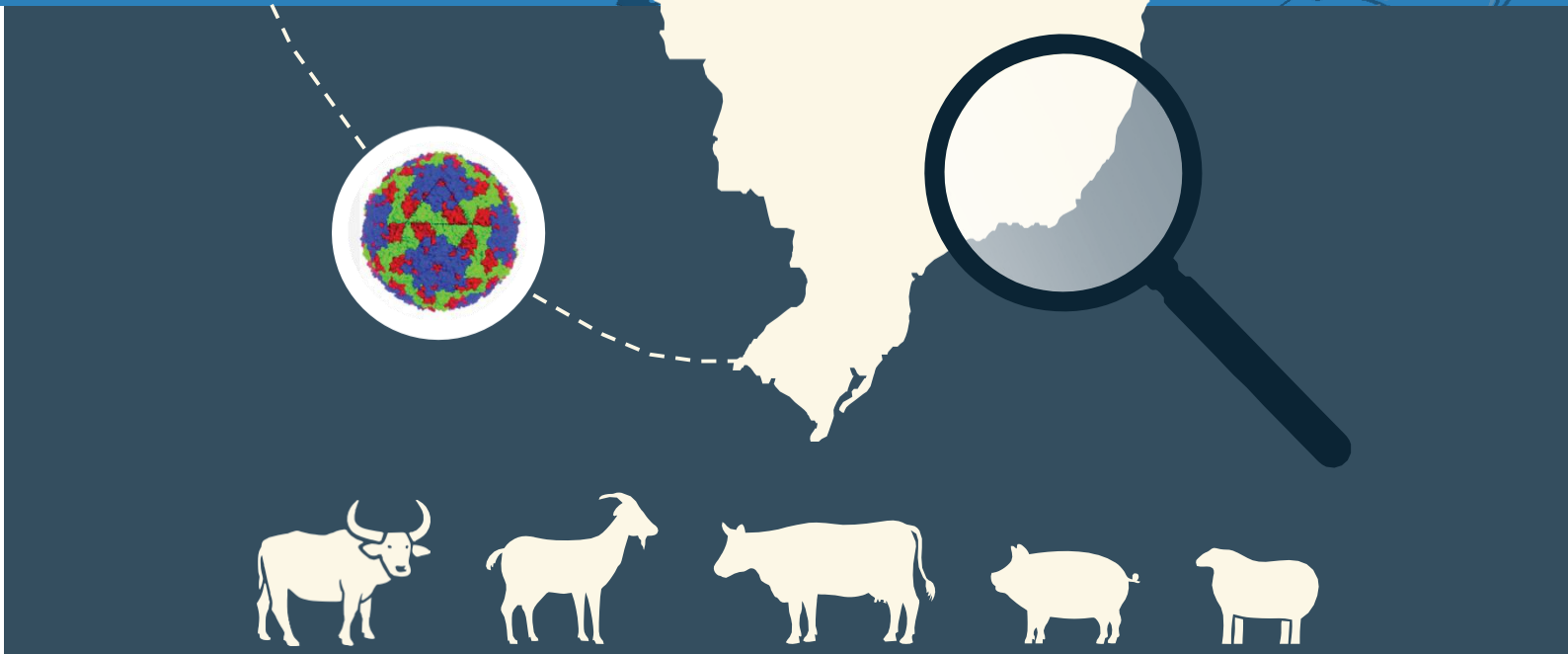
FOOT-AND-MOUTH DISEASE
SURVEILLANCE PLAN



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Foreword

Intervention against foot-and-mouth disease in Brazil, as well as in all of South America, presents itself as a rich history of our animal health system. In over sixty years, this work has generated a lot of knowledge and content to be learned, from specific scientific topics – in the areas of epidemiology, information systems, pathology, diagnosis and immunization – to dialogues with the parties involved, including the public and private sectors. The action to control and eradicate foot-and-mouth disease, therefore, has been a continuous exercise of scientific evolution, with important economic and social consequences in our country.

Starting in 2006, particularly, after the last occurrences of FMD in Brazil, the National Program for Surveillance of Foot-and-Mouth Disease entered the phase of consolidation of the eradication process, with the evolution and maintenance of areas free of foot-and-mouth disease. Preventing the reintroduction of the viral agent and demonstrating its absence in the national territory are important challenges currently imposed on the Brazilian animal health system. The preparation for early detection of any incursion of the virus and its prompt elimination are also part of this challenge. To face these challenges, it is necessary to have an appropriate preparation and that everyone involved in this issue is aware of it. Thus, **the present document** is among the technical products that are continually being updated by the Department of Animal Health.

The present **Foot-and-Mouth Disease Surveillance Plan** is the result of team work, with the participation of professionals from state veterinary services, technicians from the Pan-American Foot-and-Mouth Disease Center, and representatives from academic centers. It addresses **animal health surveillance**, which currently plays a leading role in international discussions and has increasingly become the central objective of public policies. According to the World Organization for Animal Health (OIE), surveillance means "the systematic ongoing collection, collation, and analysis of information related to animal health and the timely dissemination of information so that action can be taken". This definition – as well as other definitions available in different technical texts – shows the importance and complexity of a surveillance system, assuming that structure, organization, training and planning are available for its full functioning.

Along these lines, this publication makes an important contribution to the organization of the foot-and-mouth disease surveillance system in Brazil. Written in a simple and straightforward manner, it addresses the main elements that make up the components of the foot-and-mouth disease surveillance system in clear language that is accessible to all participants.

It is part of a set of publications that complement each other and are continually updated by the Department of Animal Health. These documents include the Manual on Investigation of Vesicular Diseases and the Contingency Plan for Foot-and-Mouth Disease – at tactical and operational levels.

This **Foot-and-Mouth Disease Surveillance Plan** is presented as a reference

document for the planning of actions to be carried out within each state, which requires strong participation of the technical teams of the Federal Superintendencies of Agriculture (SFA/MAPA) and of the Animal and Plant Health Executing Agencies (OESA). Since it addresses a dynamic topic, it relies on the participation and contribution of all users for its continuous improvement and updating.

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Ministry of Agriculture, Livestock and Food Supply

1. Introduction

The present Foot-and-Mouth Disease Surveillance Plan is an update of the "MANUAL ON VETERINARY SURVEILLANCE OF VESICULAR DISEASES", published by the Department of Animal Health (DSA) in October 2007, which outlines the general principles and guidelines for the veterinary surveillance of vesicular diseases and includes guidelines for standardizing the activities of the Official Veterinary Service (SVO) and its reports. The purpose of this plan is to serve as a theoretical framework for the components of the foot-and-mouth disease surveillance system in Brazil. Its target audience is the set of stakeholders in the Brazilian National Program for the Surveillance of Foot-and-Mouth Disease (PNEFA) of the public or private sector.

This document summarizes PNEFA's surveillance activities. For further information and managerial and operational details about this plan, there are more detailed documents available to the Official Veterinary Service and all stakeholders (strategic plans, management guides, procedure manuals, and fact sheets[1]).

2. History of Foot-and-Mouth Disease in South America

FMD is not a disease that is native to the Americas, and for its introduction and endemism to be understood, it must be contextualized with the origin of susceptible animal herds in the region.

In the initial stage of livestock, after the animals were introduced by the colonizers, "semi-wild" herds (known as "feral") were formed, which would later be commercially exploited. With the subsequent organization of this economic activity and with the industrialization of meat (dried salted meat), a process of professionalization of this activity began. With the introduction of breeders there was a natural genetic improvement of the herds, which was necessary for the continuity of the production chain. In this context, foot-and-mouth disease was introduced in the continent having come from Europe. The first records in the Rio da Prata region date back to the 1870s. Favored by the permanent supply of animals susceptible to foot-and-mouth disease and even by the movement of herds between regions for trade in consumption centers, the virus reached a state of permanent cycles of recurrence, which led to it becoming endemic.

The need to reduce the impacts caused by foot-and-mouth disease became pivotal for the continuity and feasibility of livestock chains. Thus, control programs were structured and surveillance systems were organized in the region, as happened in Europe and North

[1] https://www.gov.br/agricultura/pt-br/assuntos/sanidade-animal-e-vegetal/saude-animal/programas-de-saude-animal/febre-aftosa/manuais-e-relatorios

America; they were led by officials, but had the broad participation of the main interested party – the farmers. As it is a transboundary disease, fighting FMD as a unilateral or individual policy for each country would be extremely difficult and costly. The initiative of the setting-up of the Pan-American Foot-and-Mouth Disease Center (PANAFTOSA) – an agency currently linked to the Pan American Health Organization (PAHO/WHO), a technical reference for Latin America and a Reference Laboratory for Foot-and-Mouth Disease - PANAFTOSA (1951) – allowed the problem to be addressed in the regional context and drove international cooperation. The evolution of controls and the challenges posed to achieving this goal led to the creation of many multi-country organizational structures such as the Inter-American Group for the Eradication of Foot-and-Mouth Disease (GIEFA) and the Hemispheric Committee for the Eradication of Foot-and-Mouth Disease (COHEFA). In particular, the South American Commission for the Fight Against Foot-and-Mouth Disease (COSALFA), under the coordination of PANAFTOSA, has been a fundamental forum in the process of eradicating FMD in South America, directing efforts, mobilizing both the public sector (governments and their structures) and the private sector (farmers and their representative institutions) in the execution of national programs (Figure 1). The significant progress achieved in the training of veterinary services in the region is clear, including the strengthening of scientific knowledge and the structuring of an information network, which served as the basis for the continental surveillance system. Through its action plans (1988-2009 and 2011-2020), the Hemispheric Program for the Eradication of Foot-and-Mouth Disease (PHEFA) catalyzed the processes for obtaining FMD-free areas in a progressive and sustainable manner, standardizing strategies for all countries in the region and encouraging collaboration among them.

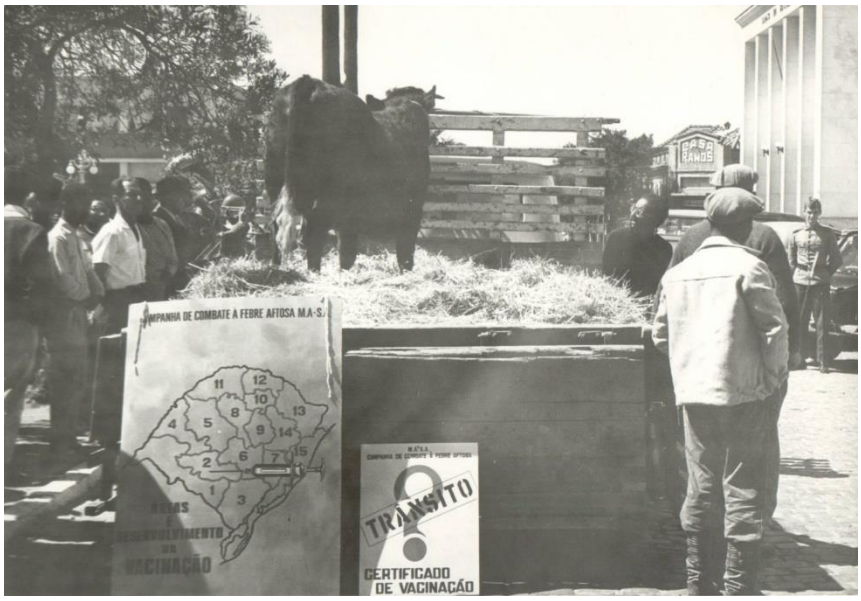

Figure 1. First vaccination campaign against foot-and-mouth disease carried out in Brazil in 1965.

3. History of PNEFA

The Brazilian National Program for Surveillance of Foot-and-Mouth Disease (PNEFA) has 60 years of history, but the first actions to control foot-and-mouth disease in Brazil date back to much earlier years. Here is a brief timeline of the most remarkable moments for the eradication of FMD in the country:

- **1919:** publication of the Health Police Code by the Ministry of Agriculture, Livestock and Food Supply (MAPA);
- **2. 1921:** due to the concern about the damage caused by the disease, the Health Police Code was restructured and improved;
- **3. 1934:** the Federal Government approved the regulation of the animal health service, which included prophylactic measures for foot-and-mouth disease (Decree No. 24,548 of July 3, 1934);
- **4. 1950:** the 1st Brazilian National Conference on Foot-and-Mouth Disease, held in Rio de Janeiro from September 5 to 11, brought together health authorities, researchers and scholars, who promoted a wide-ranging and rich discussion on the reality of the disease in the country and presented recommendations for initial strategies.
- **5. 1951:** as a result of the proposals made in the 1st Brazilian National Conference on Foot-and-Mouth Disease, a national program to fight foot-and-mouth disease was implemented, but due to the lack of financial and human resources and the absence of an efficient vaccine failed to achieve any satisfactory results; the Pan-American Foot-and-Mouth Disease Center (PANAFTOSA) was founded;
- **6. 1963:** based on Decree No. 52,344, of August 9, 1963, the Federal Government established the campaign against foot-and-mouth disease (CCFA) within the Ministry of Agriculture, and created a technical team to manage it;
- **7. 1965:** the Program to combat foot-and-mouth disease was implemented as a pilot program in the state of Rio Grande do Sul;
- **8. 1966:** the program was extended to other southern and southeastern states, as well as to the states of Bahia, Mato Grosso, Goiás and Sergipe;
- **9. 1968:** a loan was provided by the Inter-American Development Bank (IDB) to finance the then national project to combat foot-and-mouth disease in three stages;
- **10. 1972-1975:** the first stage of the project was carried out using the financed resources;
- **11. 1975-1977:** the second stage of the project was carried out using resources from national funds and incorporated the rabies of herbivores and bovine brucellosis programs;
- **12. 1977-1982:** the third stage of the project was carried out;
- **13. 1982:** development of research on trivalent oil vaccine against foot-and-mouth disease;
- **14. 1989:** adoption of the compulsory use of foot-and-mouth disease vaccine with oil adjuvant throughout the country, allowing for an increase in the interval between the vaccination steps;
- **15. 1992:** the foot-and-mouth disease program was reformulated;

- **16. 1993:** implementation of livestock circuits;
- **17. 1995:** standardization of movement records, with the issuing of Animal Movement Permits (Guias de Trânsito Animal - GTAs);
- **18. 1998:** international recognition of the first FMD-free zone where vaccination is practiced in Brazil;
- **19. 2007:** the FMD-free zones where vaccination is practiced comprise most of the Brazilian territory; The state of Santa Catarina is recognized as an FMD-free zone where vaccination is not practiced. Reformulation of PNEFA, with the publication of Normative Instruction No. 44/2007;
- **20. 2011:** launch of the 2nd PHEFA Action Plan (2011-2020);
- **21. 2017:** publication of the PNEFA 2017-2026 Strategic Plan, which was aimed at the gradual expansion of FMD-free zones where vaccination is not practiced within a sustainable perspective and with the participation of the public and private sectors;
- **22. 2018:** recognition of the entire country as being FMD-free by the World Organization for Animal Health (OIE);
- **23. 2020:** Updating of PNEFA, with the publication of Normative Instruction No. 48/20;

For more detailed information on the Brazilian National Program for Surveillance of Foot-and-Mouth Disease (PNEFA) and its historical evolution, read the publication "The Livestock Circuits and Foot-and-Mouth Disease in Brazil" ("Os circuitos pecuários e a febre aftosa no Brasil"), available on MAPA's official website[2].

4. Current context

In the last ten years, there have been profound advances in the eradication of foot-and-mouth disease – most of the herds in South America are located in FMD-free countries or zones where vaccination is either practiced or not practiced (95% of the geographical area, 95% of the herds), including countries that are being recognized as FMD-free where vaccination is not practiced, either entirely or partially.

In 2017, the PNEFA Strategic Plan was launched and it was designed to be executed over a 10-year period, starting in 2017 and ending in 2026. The Plan is in line with the OIE Terrestrial Animal Health Code (Terrestrial Code) and with the guidelines of the Hemispheric Program for the Eradication of Foot-and-Mouth Disease (PHEFA), which are aligned with efforts for eradicating FMD in South America. One of its objectives is the gradual replacement of vaccination against foot-and-mouth disease throughout the Brazilian territory with the adoption and improvement of various surveillance actions, which are grouped by components and operations (Figure 2) and involve the official veterinary service, the private sector, farmers, and political players, in the different spheres of the country.

[2] https://www.gov.br/agricultura/pt-br/assuntos/sanidade-animal-e-vegetal/saude-animal/programas-de-saude-animal/febre- aftosa

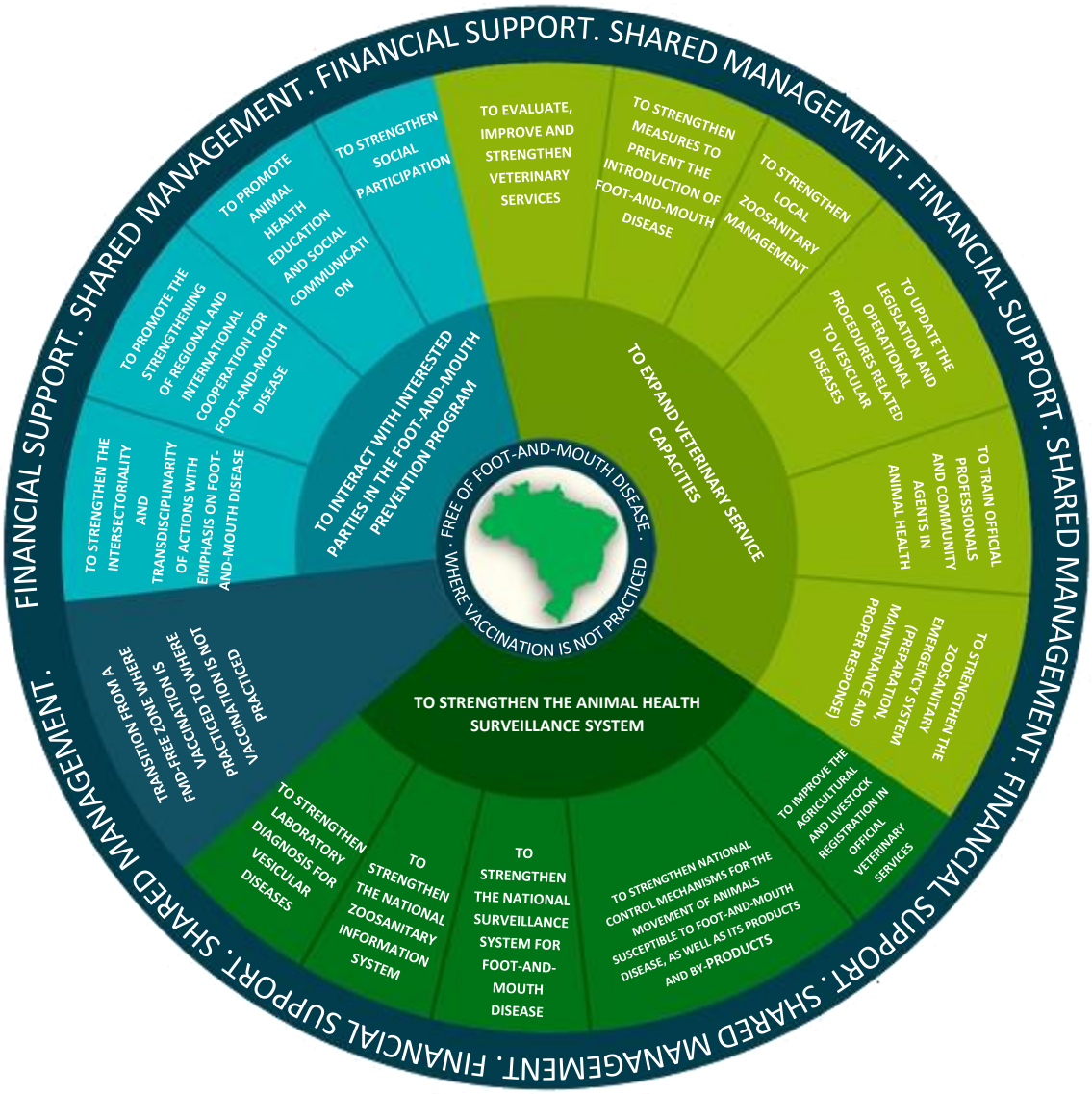

Figure 2. Infographic of PNEFA's 2017-2026 Strategic Plan.

5. Surveillance System

Surveillance is currently defined as the systematic (ongoing and repeated) measurement, collection, filtering, analysis, interpretation, and timely dissemination of animal health data on a given population and geographic region so that action can be taken.

An important player in the animal surveillance system is the official veterinary service (SVO). In Brazil, the official veterinary service comprises areas of the government institutions that carry out procedures and provide services related to animal health, such as the Ministry of Agriculture, Livestock and Food Supply (MAPA) – which represents the central and superior government – and the state animal health agencies, which represent the intermediate and local governments. The official veterinary service is the organization responsible for implementing measures to prevent, control, and eradicate diseases (which are internal or external threats). In this context, the main objective of surveillance is to provide information to the official veterinary service in order to assist the adoption of effective health measures.

The information obtained by using the tools of surveillance systems allows us to assess the risk of a particular disease in a given population and guide health measures for its mitigation. Thus, the different components of a surveillance system regularly produce information that helps to make decisions based on an accurate, timely, and objective risk assessment. Surveillance actions must be separated from health management actions.

Inspections at points of entry in the country (airports, ports, bus stations, and international border posts) and mobile inspection posts, for example, are health management actions established by a health authority to mitigate a certain risk effectively. When health measures aim to mitigate a specific risk, it is preferable to call them risk mitigation actions. Therefore, risk mitigation is the response that is carried out based on the risk assessment provided by the surveillance system.

In FMD-free territories, where vaccination is either practiced or not practiced, surveillance has two purposes:

1) To demonstrate the absence of disease/infection; and
2) To detect the disease early if it has been introduced into the target population.

Thus, the foot-and-mouth disease surveillance plan presented in this document sought to establish guidelines and principles to achieve these two purposes, depending on the health status of the region (FMD-free where vaccination is practiced or FMD-free where vaccination is not practiced).

5.1. Concepts and Principles for Meeting Surveillance Objectives

There are different possible approaches to surveillance, and each of them has its own advantages and disadvantages. To determine which surveillance approach might be useful for different purposes, it is necessary to be able to describe and compare surveillance systems based on a variety of characteristics.

Some important surveillance characteristics include:

1. Timeliness: this describes how quickly the surveillance system is able to produce information, and is related to the frequency of surveillance. Some surveillance activities are continuous (data are collected all the time), others are regular (e.g. they occur at monthly intervals), and still others are ad hoc (surveillance is performed only occasionally, when necessary).

2. Population coverage: this describes the proportion of the target population that is covered by the surveillance system. Some surveillance actions (e.g. investigations) are able to sample only a relatively small part of the population, while other systems have nearly complete coverage.

3. Representativeness: this describes whether the animals under surveillance are representative of the population. The surveillance sample may be:

- representative: the proportion of animals likely to have the disease in the sample is similar to the proportion of animals likely to have the disease in the population.
- risk-based: the proportion of animals likely to have the disease in the sample is greater than the proportion of animals likely to have the disease in the population.
- biased: the proportion of animals likely to have the disease in the sample is not the same as (usually smaller than) the proportion of animals likely to have the disease in the population.

5.1.1. FMD-free zone where vaccination is practiced – demonstration of freedom from disease and early detection

The surveillance components are designed to generate continuous data, and the association of the information generated with their respective sensitivities allows us to determine the likelihood of this system finding at least one sick (infected) animal, based on the assumption that the population is infected with a very low prevalence. The confidence measure of being free of foot-and-mouth disease is strongly linked to the sensitivity of the surveillance system.

It is important to note that, due to the vaccination of animals, there is a lower likelihood of classic clinical signs of the disease in animals vaccinated in a viral transmission scenario, when compared to areas where vaccination is not practiced.

Thus, the serological surveillance of vaccinated animals coordinated by the official veterinary service is more important than the clinical surveillance to demonstrate an FMD-free status, and its performance increases the sensitivity of the surveillance system for this purpose considerably.

On the other hand, the early detection of the disease – through the complete investigation of clinical conditions compatible with vesicular diseases (passive surveillance) – is a continuous type of surveillance that covers all species susceptible to foot-and-mouth disease in Brazil. It is essential for rapid response and prevention of the spread of the disease if it is reintroduced.

5.1.2. FMD-free zone where vaccination is not practiced – early detection

Early detection plays a more critical role among surveillance objectives in the FMD-free zone where vaccination is not practiced. It allows the rapid identification of occurrences, a reliable diagnosis, and guidance for a timely and effective response, which prevents dissemination of the disease. As a result, it is expected that the strengthening of the surveillance system will allow detection of FMD when it is still on a small scale of infected animals in population terms, which allows control as soon as possible and avoids dissemination and devastating losses.

The clinical detection of foot-and-mouth disease in populations without immunity provided by the vaccine is easier, given the disease's characteristics **of** infection and dissemination, which facilitates the perception of clinical signs and its notification by interested parties. Thus, the role of farmers and of people who work daily with the animals as a source of notification of suspected cases, through the daily observation of animals in their routine, becomes essential. Therefore, the official veterinary service must pay attention to the participation of these stakeholders and– together with representative entities of the productive sector – promote communication and education actions related to animal health, aiming to improve their ability to detect and immediately notify suspected cases.

For the annual certification of their health status by the OIE, the zones or countries – especially exporters, such as Brazil – must demonstrate that there is no evidence of infection by the foot-and-mouth disease virus, through the combination of actions of each of the components of the surveillance system. It is noteworthy that, among all components of the foot-and-mouth disease surveillance system, serological surveys and studies associated with serological surveillance are of low relevance in FMD-free zones where vaccination is not practiced (unlike FMD-free zones where vaccination is practiced) and they may be exempted from these surveys and studies.

6. Geographical area

The Surveillance System for Foot-and-Mouth Disease (SVFA) covers the entire Brazilian territory. However, given the size of Brazil (8.5 million km^2), there is a wide diversity of ecosystems, production systems, social circumstances, and geographical specificities that may influence the risks related to FMD and, therefore, the implemented surveillance system.

This being the case, and taking into account regional specificities, the Surveillance System for Foot-and-Mouth Disease seeks to establish programs aimed at identifying the disease and acting more strongly in areas at higher risk for the occurrence of FMD in different regions of the country, aiming at better efficiency and effectiveness.

7. Target population

The animal species that are the target of direct surveillance by PNEFA are bovines, buffaloes, sheep, goats and pigs (Figure 3). There are approximately 215 million bovines, 2 million buffaloes, 24 million sheep, 13 million goats and 41 million pigs in Brazil, distributed across approximately 2.5 million farms, according to data from the official veterinary service in 2020.

It is noteworthy that, in the history of FMD eradication in South America, other species susceptible to foot-and-mouth disease, including wild and feral species, have not demonstrated epidemiological relevance, as shown by studies carried out by PANAFTOSA in the 1970s. According to the Brazilian production system, most domestic ruminants are bred extensively, which allows them to come into direct contact with free-living wild species. Thus, the surveillance of domestic species reflects the health status of free-living species.

Figure 3. Animal species targeted by PNEFA's direct surveillance.

8. Stakeholders

Stakeholders in the Surveillance System for Foot-and-Mouth Disease are players that benefit from the results directly, notably farmers and agribusinesses. Other players are also involved, by virtue of legal responsibility (the official veterinary service), by imposition (official delegations, laboratories), or those that are benefited indirectly, such as service providers and input suppliers. Table 1 shows the matrix of responsibilities of the segments involved or interested in the Surveillance System for Foot-and-Mouth Disease in Brazil.

The Surveillance System for Foot-and-Mouth Disease (SVFA) is a responsibility that is shared among all parties. In FMD-free areas where vaccination is practiced, greater participation of the official veterinary service is required for the coordination of epidemiological studies associated with serological surveillance, while in FMD-free areas where vaccination is not practiced, there is no need for these studies, and clinical surveillance becomes more important and must be carried out by all stakeholders, especially farmers (Figure 4).

Figure 4. A surveillance activity with farmers, the main stakeholder in PNEFA.

Table 1. Matrix of responsibilities of stakeholders in the Surveillance System for Foot-and-Mouth Disease in Brazil.

Stakeholders	Description	Responsibility	Type of surveillance performed
Official Veterinary Service	Veterinarians and assistants directly linked to the official service by institutional association	Health Authority: to standardize, manage, and maintain the database, and analyze and disseminate information	Clinical, serological, virological
Farmers	Owners of susceptible animals of one or more species	Notification of suspected cases; adoption of good practices (regarding documentation and biosecurity)	Clinical
Industry	The agro-industrial segment of animal products and producers of livestock inputs	Notification of suspected cases; dissemination of information; providing indirect surveillance information	Clinical
Approved Professionals	Private practice veterinarians with invested powers by the official veterinary service to carry out specific actions	Notification of suspected cases; generating information of interest (productivity reports); biosecurity; dissemination of information	Clinical
Service Providers	Professionals that provide occasional or permanent services, such as: farm administration, pregnancy diagnosis, artificial insemination, clinical care, animal transportation, milk collection, resale of agricultural products, event promoters, diagnostic laboratories, semen centers, collection of dead animals	Notification of suspected cases; dissemination of information; adoption of good practices	Clinical

9. Data sources and usage

The main data sources that PNEFA uses are:

- The register of properties and herds in databases of State Veterinary Services (SVE), including their geolocation, which is updated routinely. In FMD-free zones where vaccination is not practiced, the updating of herd balances and the register data of farms must be carried out at least once a year. The consolidation of state registration data comprises the national base of registers and is allocated in the Agricultural Management Platform (PGA) under the responsibility of MAPA and is used by PNEFA to structure and plan surveillance actions.

- Records of animal movement, based on the issuing of Animal Movement Permits (GTAs), which are carried out by the State Veterinary Service. The consolidation of animal movement data is also allocated in the Agricultural Management Platform and used by PNEFA to structure animal health management actions such as inspection of animal movements. It is also used to characterize and identify "hub" farms in the movement network of each state, which supports surveillance activities.

- Records of slaughter establishments are data consolidated both by MAPA (establishments under federal inspection) and by the State Veterinary Service (state and municipal slaughter establishments). Together with the information on animals slaughtered in each plant, they are used by PNEFA to analyze surveillance in slaughterhouses.

- Records of those venues where animals gather are data kept by the State Veterinary Service; together with the information on the inspected animals, they are used by PNEFA to plan surveillance in animal gatherings.

- Notifications and investigations of suspected cases of vesicular disease are the responsibility of the State Veterinary Service; they are recorded in the computerized module of the Brazilian System for Veterinary Surveillance and Emergencies (e-Sisbravet), which is managed by MAPA. PNEFA uses these data to assess surveillance from notification of suspected cases.

- Records of retail establishments that sell FMD vaccine are maintained by the State Veterinary Service. Together with the records of establishments that sell veterinary products, which are maintained by MAPA, they are used by PNEFA in FMD-free zones where vaccination is practiced.

- Data on the steps of vaccination against foot-and-mouth disease are controlled and consolidated by the State Veterinary Service (SVE) and reported to the Ministry of Agriculture, Livestock and Food Supply (MAPA). These data are important for PNEFA in FMD-free zones where vaccination is practiced in Brazil because it allows the monitoring of vaccination coverage in each municipality in the country. PNEFA has a manual for the control and evaluation of the steps of vaccination against foot-and-mouth disease, and all data are published every six months on the website[3] dedicated to FMD vaccination.

[3] https://www.gov.br/agricultura/pt-br/assuntos/sanidade-animal-e-vegetal/saude-animal/programas-de-saude-animal/febre-aftosa/campanha-febre-aftosa

- Records of data from twice-yearly surveillance and animal health management activities related to PNEFA are consolidated by the State Veterinary Service and provided to MAPA, serving as a basis for analyses to assess the surveillance system for foot-and-mouth disease in the country.
- Records of the human, financial and structural resources of the State Veterinary Service, emergency funds and the Ministry of Agriculture, Livestock and Food Supply (MAPA) are updated and consolidated yearly by the State Veterinary Service and the Office of the Federal Superintendent for Agriculture, and serve as complementary data for carrying out PNEFA analyses.
- Records of international surveillance data are registered and maintained by MAPA and used by PNEFA, when necessary, for specific risk mitigation analyses.
- Records of data from official and approved laboratories for foot-and-mouth disease are maintained by MAPA and used by PNEFA for analyses related to surveillance based on notifications and serological tests.

10. Notification and Records

In Brazil, the notification of suspected cases of vesicular diseases is compulsory, and they must be reported immediately to the official veterinary service, within a maximum period of 24 hours. Notification can be made by farmers or other people in the community who are not related to farms, through the communication channels that are available to the public. The e-SISBRAVET notification portal allows any citizen to notify suspected cases online.

Notifications generate an investigation by the official veterinary service within 12 hours, and all information is recorded in the system, where it is possible to evaluate the time indicators of both the notification and the investigation by the official veterinary service.

11. Case Definitions

The definition of confirmed cases of foot-and-mouth disease in Brazil follows the recommendations of the OIE Terrestrial Animal Health Code.

The criteria used to define cases are the following:

Suspected case of vesicular disease: existence of one or more animals susceptible to foot-and-mouth disease with clinical signs compatible with vesicular disease; or positive/inconclusive FMD serological tests performed in approved laboratories;

Ruled-out suspected case: a suspected case of vesicular disease whose investigation by the official veterinary service has ruled out the existence of animals with compatible clinical signs;

Probable case of vesicular disease: the official veterinarian finds out that there are animals present that are susceptible to foot-and-mouth disease which are displaying clinical signs compatible with vesicular disease; or there is an indication of an epidemiological link with a confirmed case/outbreak of foot-and-mouth disease;

Confirmed case of foot-and-mouth disease: a probable case that meets one or more of the following criteria:

1. isolation and identification of the foot-and-mouth disease virus in samples taken from susceptible animals, with or without clinical signs of the disease; or

2. detection of an antigen or ribonucleic acid specific to the FMD virus in a sample taken from a susceptible animal with clinical signs compatible with foot-and-mouth disease or that is epidemiologically linked to a confirmed case or outbreak of foot-and-mouth disease, or that presents indication of previous contact with the FMD virus; or

3. detection of antibodies against structural or non-structural proteins of the foot-and-mouth disease virus, which are not a consequence of vaccination and are identified in a sample taken from a susceptible animal with clinical signs compatible with FMD, or which are epidemiologically linked to a confirmed case or outbreak of foot-and-mouth disease, or that shows signs of previous contact with the FMD virus;

Ruled-out case of foot-and-mouth disease: a probable case of vesicular disease that has not met the criteria for confirmation of an FMD case;

Foot-and-mouth disease outbreak: the epidemiological unit where at least one confirmed case of the disease has been identified.

Figure 5 shows an animal with clinical signs compatible with a probable case of vesicular disease, which was later confirmed as an FMD case in Brazil.

Additional information can be found in the Manual for Investigation of Vesicular Disease.

Figure 5. An animal with clinical signs compatible with a vesicular disease which was later confirmed as an FMD case.

12. Laboratory Diagnosis

The diagnosis of foot-and-mouth disease is authorized only in official laboratories of the official veterinary service – Federal Laboratories of Animal and Plant Health (LFDAs) – located in all regions of Brazil: in the North region, in Belém (Pará); in the Northeast region, in Recife (Pernambuco); in the South region, in Porto Alegre (Rio Grande do Sul) and in the Southeast region, in Pedro Leopoldo (Minas Gerais) (LFDA-MG), and in public laboratories approved by the Ministry of Agriculture, Livestock and Food Supply – currently, there is only one laboratory, in the Biological Institute, located in São Paulo (São Paulo state).

LFDA-MG is the authorized unit for handling viral strains, as it has a structure certified for Biosecurity classified as level 4 by the OIE.

Identification of the agent:

Samples of epithelium, swab, and vesicular fluid are directed to the primary detection of the agent, mainly by molecular techniques, and then later directed to viral isolation. In the event of any suspicion in the cell culture testing, the sample is submitted again to molecular techniques. In specific situations, when it is not possible to sample the epithelium or vesicular fluid, such as in ruminants tested for the purpose of movement and that have reactive results in the **serology test** for foot-and-mouth disease, the esophageal-pharyngeal fluid (EPF) can be sampled to support the investigation of vesicular disease in ruminants.

Serological tests:

The blood serum from livestock species susceptible to the FMD virus that is provided during the investigation of a suspected case of vesicular disease by the official veterinary service is subjected to serological techniques for the detection of antibodies against structural proteins (ELISA CFL), non-structural proteins (ELISA 3ABC and EITB), and complete viral particles (virus neutralization). Depending on the species and the type of vaccination practiced, these techniques can be used in combination to confirm or exclude a cross- or non-specific reaction. In unvaccinated populations, the virus-neutralization technique is considered confirmatory for the detection of both structural protein and non-structural protein. For bovines and buffaloes, above all in vaccinated herds, the EITB technique is confirmatory for the 3ABC ELISA, as it has greater specificity.

The flow and laboratory testing performed for foot-and-mouth disease in Brazil can be seen in Figure 6.

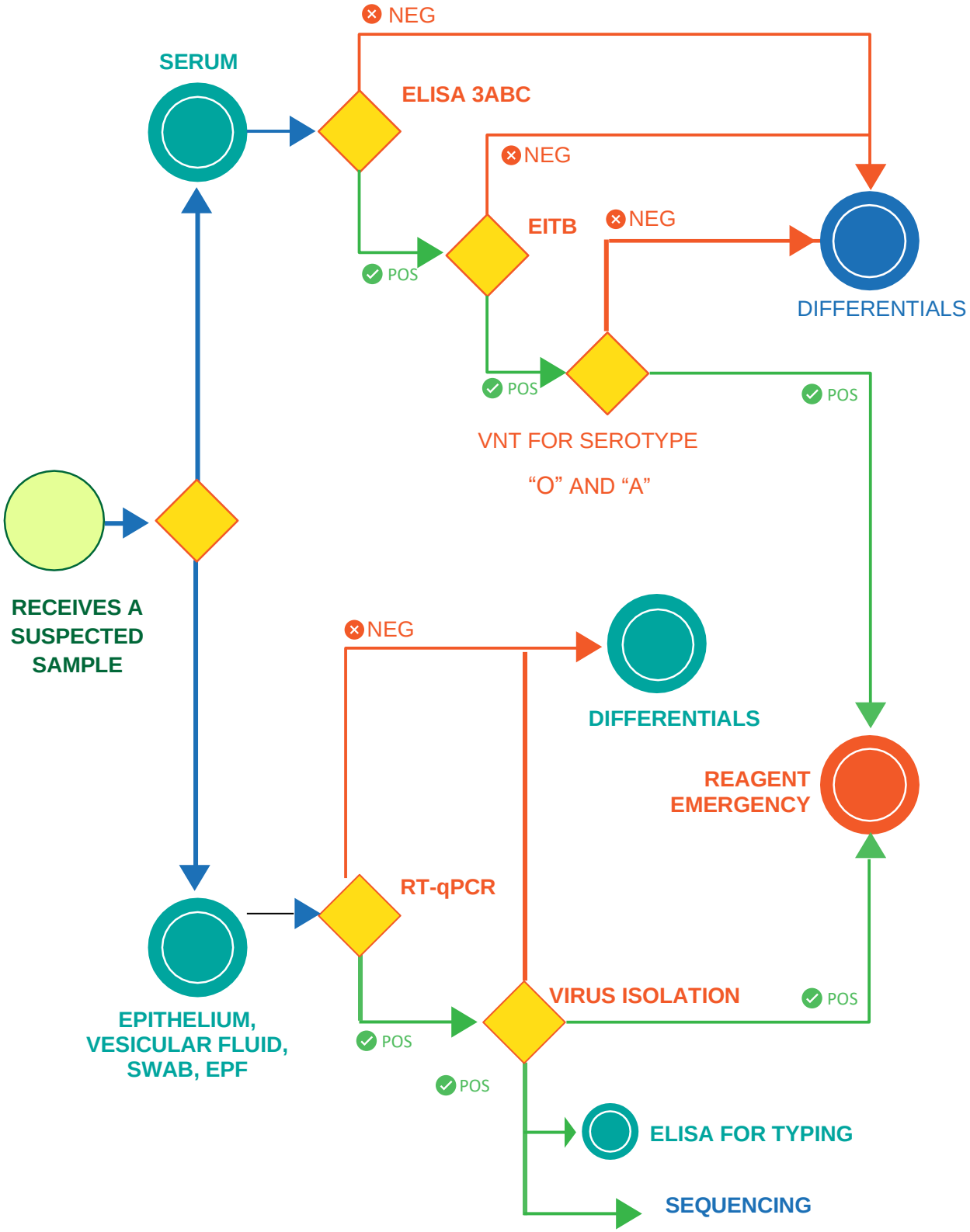

Figure 6. Flow of laboratory diagnosis for foot-and-mouth disease in Brazil.

13. Response to Suspicions and Outbreak Management

The guidelines and procedures for the investigation of suspected cases of vesicular disease and probable cases of foot-and-mouth disease are laid down in the **Identification of the agent Manual for Investigation of Vesicular Disease**.

The banning of farms (Figure 7) is one of the procedures that is defined in the document, when a probable case of vesicular disease is identified during the clinical and epidemiological investigation of a suspected case. If the occurrence of foot-and-mouth disease is confirmed, the actions laid down in the **Contingency Plan for Foot-and-Mouth Disease – at tactical and operational levels** must be followed.

Figure 7. A farm banned after the confirmation of a probable case of vesicular disease.

14. Components of the Surveillance System

By definition, a component of a Surveillance System comprises a single surveillance activity used in order to investigate one or more hazards in the target population. A surveillance system comprises the set of surveillance activities capable of producing data on the status of a particular disease or on the status of a specific population, and based on that, taking action.

The Surveillance System for Foot-and-Mouth Disease in Brazil is composed of five components, as illustrated in Figure 8 and described in Table 2.

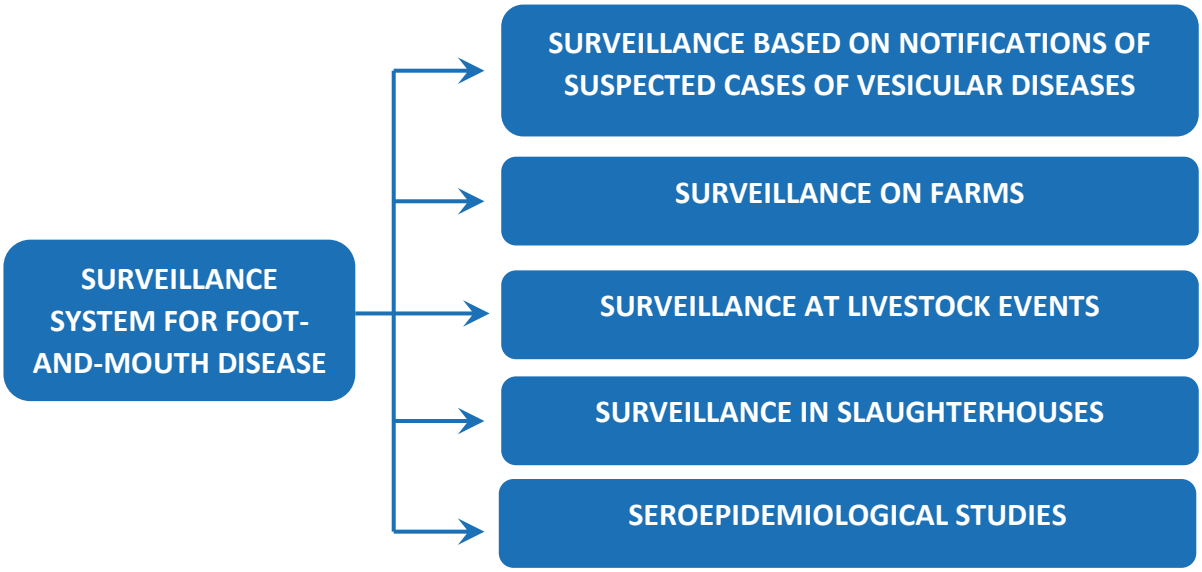

Figure 8. Components of the Surveillance System for Foot-and-Mouth Disease in Brazil.

14.1. Surveillance based on notifications of suspected cases

In FMD-free zones or countries, the notification of suspected cases by farmers and other people involved (see “stakeholders”) is essential for an early detection of the disease.

As described, Brazil has a notification portal that allows any citizen to notify any suspected cases online, and notification can be done by any other means (in person, by telephone, email, etc.). Regardless of the type of notification, all of them are recorded and monitored by the official veterinary service. The notification leads to an investigation by the official veterinary service within 12 hours (Figure 9).

It is crucial that data be collected in a complete and timely manner, in order to guide the epidemiological investigation.

All procedures performed by the official veterinary service in response to the occurrence are described in the **Manual for the investigation of vesicular diseases**.

Figure 9. Clinical inspection during an investigation of a suspected case of vesicular disease.

14.2. Surveillance on farms

In this component, surveillance is active and risk-based, and it takes into consideration the factors for the introduction, maintenance and spread of the FMD virus. When taking into account the risk factors for a specific disease, the probability of detection of an infected animal increases, without necessarily increasing the number of animals examined, when compared to a surveillance system that is not risk-based. That is, this technique increases the sensitivity of the system as well as its efficiency.

As a way of rationalizing the execution of surveillance actions – for inspection, education, and communication – the official veterinary service uses multi-criteria risk analysis studies to identify areas and farms at higher risk for the occurrence of foot-and-mouth disease, taking into account factors associated with the introduction, maintenance and spread of the disease in the population. By the end of PNEFA's 2017-2026 Strategic Plan, these studies should be carried out in all 27 states of the country to determine the areas and farms that must be prioritized in FMD surveillance, especially in this new context where vaccination is not practiced.

The risk factors that are used for this characterization include:

1) Proximity to laboratories that handle FMD virus, especially adjacent establishments that have species susceptible to foot-and-mouth disease.

2) Proximity to international and state borders; a specific assessment of the health status regarding foot-and-mouth disease in the neighboring country or state, and the presence of natural barriers, access roads and flow of people and animals in the region, should be carried out;

3) Proximity to quarantine stations, especially adjacent establishments that have species susceptible to foot-and-mouth disease;

4) Farms that run the risk of feeding pigs with products and by-products of animal origin, including those where pigs have access to sites where these products are disposed of, such as garbage dumps.

5) Intense movement of animal species susceptible to foot-and-mouth disease. Analysis studies carried out on the movement network can be used to identify municipalities and farms that have greater importance (both for receiving and dispersing animals);

6) Proximity to border inspection posts, bus stations, ports, airports and railway stations that carry out international travel, especially adjacent rural establishments and those that have backyard pig farms, which require a specific assessment related to the country of origin of these movements;

7) Farm settlements, tribes of native Brazilians or other groups of people where there is great interaction and internal movement of people, animals susceptible to foot-and-mouth disease and the products of these animals, which require a specific assessment related to the type of grouping, the geographic location, and the existence of natural barriers;

8) Farms whose owners keep animals in different establishments, especially in other countries or states, or farms whose workers or veterinarians also work for establishments in other countries or states, which require a specific assessment regarding the health status related to foot-and-mouth disease of these countries or states;

9) Farms whose owners are reluctant to adopt the health measures established by the official veterinary service, such as the animal movement permit or the updating of herd balances;

10) Other factors may be identified and adopted in each state, according to the risk characterization and study carried out to identify rural areas and farms at greater risk for the occurrence of foot-and-mouth disease, such as those with large movements of vehicles and people (farms dedicated to milk production, for example).

With this characterization and identification of rural areas and farms at higher risk for the occurrence of foot-and-mouth disease, we seek to improve the efficiency of the Surveillance System for Foot-and-Mouth Disease in Brazil. This surveillance also provides for the collection and recording of information regarding herds of animals susceptible to foot-and-mouth disease and the interaction of the official veterinary service with those in charge of handling animals for the development of education and communication actions related to animal health (Figure 10).

Other supplementary, non-targeted inspections and supervisions of the official veterinary service on farms with animals susceptible to foot-and-mouth disease, for different purposes, can contribute to the production of data and information on FMD surveillance.

Figure 10. Surveillance carried out by the official veterinary service on a farm.

14.3. Surveillance at livestock events

All animal gatherings carried out in Brazil are inspected by an Official Veterinarian or supervised by a Veterinarian approved by the official veterinary service, with the aim of checking the health documentation and inspecting the animals.

Auctions, trade shows, and exhibitions are recognized as the most important occasions for the dissemination of FMD, due to the high potential for the spread of the infection. Examples of this situation are the foot-and-mouth disease epidemic in Uruguay in 2001, and the outbreaks recorded in Paraná in 2006.

Therefore, surveillance to detect FMD in gatherings and to ensure the traceability of animals (Figure 11) plays a key role in identifying compatible clinical signs and extending surveillance to farms of origin of the animals.

Figure 11. Surveillance in a bovine gathering event (auction).

14.4. Surveillance in slaughterhouses

Slaughterhouses for animals susceptible to foot-and-mouth disease are an important source of information for the Surveillance System for Foot-and-Mouth Disease. Routine ante-mortem inspections (Figure 12) can detect the presence of clinical signs in animals, and routine post-mortem inspection can direct surveillance actions to the establishments of origin of the animals.

Surveillance in slaughterhouses is commonly used as a form of active surveillance. The main advantages are: a) low cost, as the animals are already inspected for other purposes; b) a large number of animals inspected; c) relatively constant supply of data; d) it allows the collection of data, in a few places, from a large number of animal farms and with a standardized method for detecting clinical and pathological signs, which are in general more specific than the observations of the owners; e) it is a way of monitoring the other components of the surveillance system, because if there are detection failures at the field level, in this last phase it is possible to detect probable cases of the disease.

Its main disadvantages are: 1) the slaughtered population is not representative of the entire target population, so that the bias inherent to the component must be balanced with the advantages of low cost, better sensitivity, and a large number of animals inspected; and 2) it o ccurs at the end of the chain, therefore, it is a late detection in the

Surveillance System for Foot-and-Mouth Disease.

Figure 12. Ante-mortem inspection of bovines, which is carried out prior to slaughter.

14.5. Seroepidemiological Studies

Seroepidemiological studies (Figure 13) are intended to support the certification of the absence of virus transmission or to assess the level of immunity of the population in FMD-free areas where vaccination is practiced.

A risk-based sampling (which targets individuals most likely to have FMD) is more appropriate in studies that assess viral transmission because it can provide a similar level of confidence in the absence of the disease, despite involving a smaller sample size, in a more efficient approach to surveillance.

Thus, in each study carried out, it is necessary to consider the predominant geographical, epidemiological and livestock-raising scenario, and to adapt technical and operational procedures to existing sets of circumstances. The sampling design is carried out by the Ministry of Agriculture, Livestock and Food Supply (MAPA), with the support of PANAFTOSA and in accordance with the general recommendations of the OIE, with the publication of specific technical manuals which describe the methodology for clinical, serological and virological surveillance.

Figure 13. Clinical inspection, collection and processing of serum from bovines for serological studies

The description of the components of the FMD surveillance system can be seen in Table 2. It includes the classification according to the source of information, frequency of actions, potential representativeness of the population, epidemiological unit, target population, the person in charge of surveillance, the geographic region of the country under surveillance, as well as the forms for recording actions and the computerized systems.

Table 2. Description of the components of the foot-and-mouth disease surveillance system

Criterion	Surveillance based on notifications of suspected cases	Surveillance on farms	Surveillance at livestock events	Surveillance in slaughterhouses	Seroepidemiological studies
Source of Information	Passive	Active	Active	Active	Active
Frequency of surveillance actions	Continuous	Periodical	Continuous	Continuous	Periodical
Potential representativeness of the population	Representative	Risk-based	Not representative	Not representative	Risk-based
Epidemiological unit	Any establishment	Farm	Gathering location	Slaughter plant	Farm
Target population	Species susceptible to FMD	Species susceptible to FMD	Species susceptible to FMD	Species susceptible to FMD	Species susceptible to FMD, especially those vaccinated (bovines and buffaloes)
Responsible individuals	Stakeholders in the livestock production chain	Official Veterinary Service	Official Veterinary Service and Approved Veterinarians	Official Veterinary Service and veterinarians from the private sector	Official Veterinary Service
Geographic region under surveillance	Zone with vaccination Zone without vaccination	Zone with vaccination Zone without vaccination	Zone with vaccination Zone without vaccination	Zone with vaccination Zone without vaccination	Zone with vaccination
Forms for recording actions	e-Sisbravet standardized investigation forms of the official veterinary service	Standardized surveillance forms of the official veterinary service	Animal movement permits (GTAs) inspected in animal gatherings; standardized forms of the official veterinary service	Animal movement permits (GTAs) inspected in slaughterhouses; ante and post-mortem inspection	Standardized forms of the official veterinary service
Computerized systems	e-Sisbravet	Surveillance forms of the official veterinary service; System for Management of Epidemiological Studies (SIGEP)	Surveillance systems of the official veterinary service;	Information systems of the official veterinary service	System for Management of Epidemiological Studies (SIGEP)

15. Performance: Planning of the Analysis and Evaluation of the Surveillance and Control System

Surveillance systems are considered complex and subject to epidemiological, economic, social, and environmental factors. Many organizations or institutions have developed their own approaches to conducting assessments of the surveillance system and providing appropriate recommendations. Recognizing the fact that surveillance systems vary widely in scope, objectives and methods, the assessment must be flexible enough to account for these variations. In a systematic review, 49 attributes were identified for evaluating a surveillance system, and 17 of them were selected for the evaluation of the System for Management of Epidemiological Studies (SVFA) in the country. They were then grouped into four different categories (Table 3):

1. Effectiveness: coverage, opportunity, representativeness, sensitivity, and positive predictive value
2. Functionality: acceptability, stability, flexibility, data quality, and simplicity;
3. Economic: cost; and
4. Organizational: internal communication, external communication, sampling strategy, data management, data analysis, and performance indicators.

Periodic assessments seek to highlight the value of each component in the surveillance system and to obtain maximum efficiency, allocating more resources to components with greater sensitivity and providing health programs with data and information for the evaluation of the impact of intervention measures and for the definition of strategies. At the national level, the assessment of the components of the Surveillance System for Foot-and-Mouth Disease is carried out on a yearly basis.

Table 3. Components of the Surveillance System for Foot-and-Mouth Disease (SVFA) in Brazil and distribution of the attributes evaluated

Criterion	Attributes	Response to notification of suspected cases	Surveillance on farms	Surveillance at animal gatherings	Surveillance in slaughterhouses	Seroepidemiological studies
Effectiveness	Coverage, timeliness, representativeness, sensitivity, and positive predictive value	Coverage, timeliness, representativeness, sensitivity, and positive predictive value	Coverage, sensitivity	Coverage, sensitivity	Coverage, sensitivity	Coverage, sensitivity
Functionality	Acceptability, stability, flexibility, data quality, and simplicity	Acceptability, stability, flexibility, data quality, and simplicity	Data quality	Data quality	Data quality	Acceptability, stability, flexibility, data quality, and simplicity
Economic	Cost	Cost	Cost	Cost	Cost	Cost
Organizational	Internal communication, external communication, sampling strategy, data management, data analysis, and performance indicators	Internal communication, external communication, sampling strategy, data management, data analysis, and performance indicators	Internal communication, external communication, sampling strategy, data management, data analysis, and performance indicators	Internal communication, external communication, sampling strategy, data management, data analysis, and performance indicators	Internal communication, external communication, sampling strategy, data management, data analysis, and performance indicators	Internal communication, external communication, sampling strategy, data management, data analysis, and performance indicators

16. Disclosure of Results: The transparency of the Process

Stakeholders must receive reports or disclosures with analyses and actions carried out based on the data entered in the surveillance system (Figure 14). It is extremely important that they reach the local level and permeate through all the links of this system.

Feedback demonstrates the transparency of the system and keeps the communication chain active among stakeholders, providing appropriate information and stimulating interest in cooperation, due to the perception of the importance of their contribution to the system. This way, it guarantees its effective implementation and the quality of the data obtained.

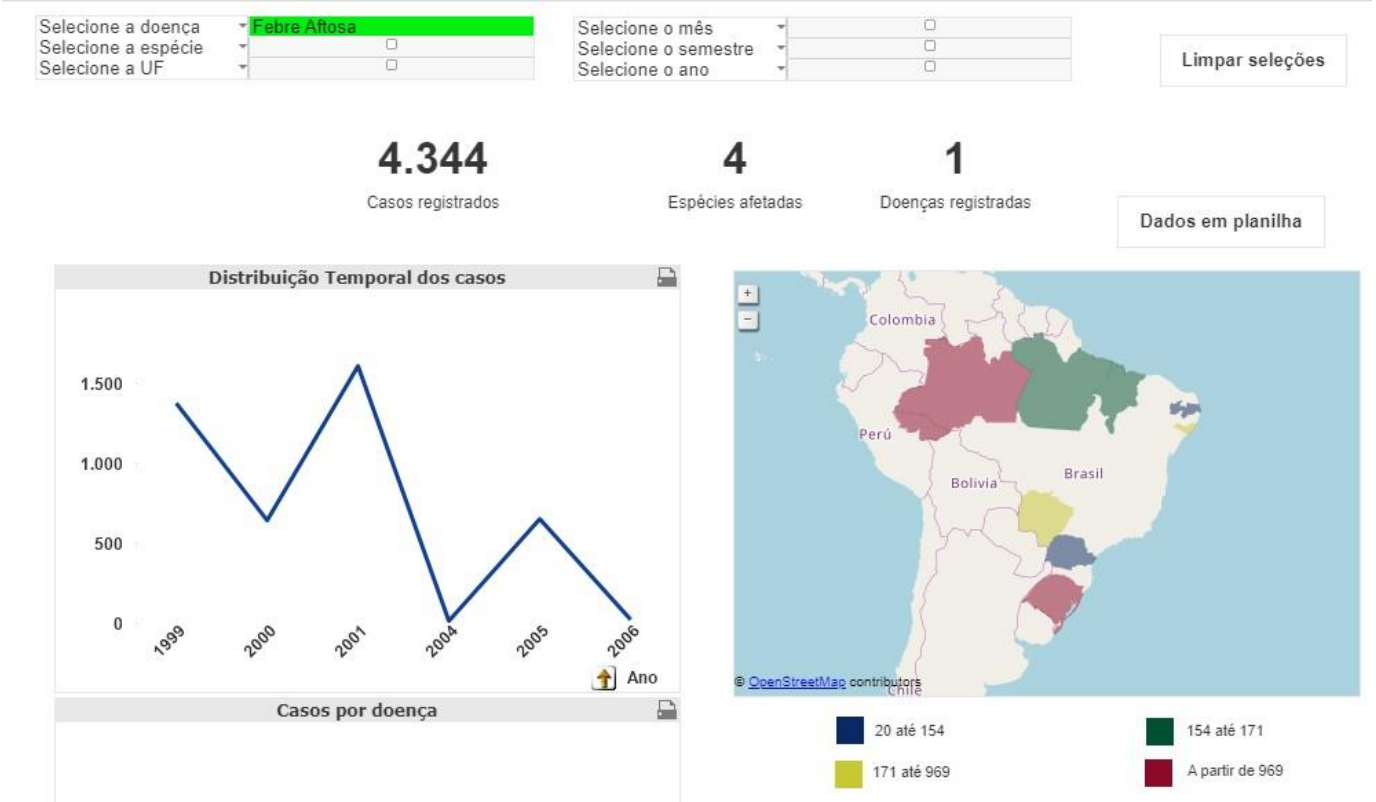

Figure 14. Dynamic analysis of surveillance system data in Brazil (indicators.agricultura.gov.br/saudeanimal)

17. Literature consulted

AMAKU, M. et al. Infectious disease surveillance in animal movement networks: An approach based on the friendship paradox. **Preventive Veterinary Medicine,** v.121, p.306-313, 2015.

BRASIL, Ministério da Agricultura, Pecuária e Abastecimento – MAPA. **Elimination of the outbreaks of the FMD occurred in the state of Rio Grande do Sul, Brazil.** Report to the FMD and other Epizooties Commission of the **Animal World Health Organization – OIE** – aiming the restitution of the sanitary condition of the FMD free zone with vaccination for the States of Rio Grande do Sul and Santa Catarina. Brasília, DF, p. 199, out. 2002.

BRASIL, Ministério da Agricultura, Pecuária e Abastecimento – **MAPA. Relatório Anual do Programa Nacional de Erradicação da Febre aftosa – PNEFA.** Brasília, DF, p. 10, 2014.

BRAZIL. Ministry of Agriculture, Livestock and Food Supply. Decree no. 9013 enacted March 29, 2017. Official Gazette of the Federal Executive, Brasilia, DF, 2017.

BRASIL, Ministério da Agricultura, Pecuária e Abastecimento – MAPA. Programa Nacional de Erradicação e Prevenção da Febre aftosa (PNEFA), Instrução Normativa No 44, de 02 de outubro de 2007. **Diário Oficial da União,** Brasília, DF, 02 out. 2007b.

BRAZIL. Ministry of Agriculture, Livestock and Food Supply. **Plano de ação para Febre aftosa. Secretariat of Animal and Plant Health.** Brasilia, DF, 2009.

CALBA, C. et al. Surveillance Systems Evaluation: a systematic review of the existing approaches. **BMC Public Health.** 15: 488, 2015. DOI 10.1186/s1288889-015-1791-5

CAMERON, A. R. Manual of basic animal disease surveillance. Interafrican bureau for animal resources, 2012. Available at: < http://www.au-ibar.org/component/ jdownloads/finish/76-tmt/1546-manual-of-basic-animal-disease-surveillance>

CAMERON, A. R. The consequences of risk-based surveillance: Developing output- based standards for surveillance to demonstrate freedom from disease. **Preventive Veterinary Medicine,** v. 105, n. 4, p. 280–286, 2012. Available at: <http://dx.doi. org/10.1016/j.prevetmed.2012.01.009>.

CAMERON, A.R. **Risk-based Disease Surveillance: A Manual for Veterinarians.** Italia: The Food and Agriculture Organization of the United Nations (FAO), 2009.

CARPENTER, T. E. et al. Epidemic and economic impacts of delayed detection of foot and-mouth disease: a case study of a simulated outbreak in California. **Journal of Veterinary Diagnostic Investigation,** v. 23, n.1, p. 26-33, 2011.

CDC, CENTERS FOR DISEASE CONTROL AND PREVENTION. **Updated Guidelines for Evaluating Public Health Surveillance Systems: Recommendations from the Guidelines Working Group.** MMWR. Recomm rep. v. 50, n. RR13, p. 1–35, 2001.

CDC, CENTERS FOR DISEASE CONTROL ANDE PREVENTION. **Framework for evaluating public health surveillance systems for early detection of outbreaks: recommendations from the CDC Working Group.** MMWR. Recomm rep. v. 53, n. RR- 5, p. 1–11, 2004.

CIPULLO, R.I. **Comparação e análise da rede de movimento de bovinos em propriedades positivas para brucelose no Estado de Mato Grosso.** São Paulo: Universidade de São Paulo, 2013. 59 p. Dissertação (Mestrado em Ciências Acadêmico) – Faculdade de Medicina

Veterinária e Zootecnia, Universidade de São Paulo, 2013.

DÔLIVEIRA, C.F.D et al. **Análise Custo Benefício do Programa Nacional de Prevenção e Erradicação da Febre aftosa (PNEFA).** Capítulo brasileiro de GALLACHER, Marcos. (Coordenador). Análisis Costo/Benefício de Sistema Veterinarios Oficiales. Proyecto de la RR Americas. OIE, 2009.

FAO - FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. **Risk-based disease surveillance: A manual for veterinarians on the design and analysis of surveillance for demonstration of freedom from disease.** Rome, 2014.

GARNER, M. et al. Comparison of alternatives to passive surveillance to detect foot and mouth disease incursions in Victoria, Australia. **Preventive Veterinary Medicine** 128, 78– 86, 2016.

GRISI-FILHO, J.H.H. **Caracterização de circuitos pecuários com base em redes de movimentação de animais.** São Paulo: Universidade de São Paulo, 46p., 2012. Tese (Doutorado em Ciências) – Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, 2012.

HOINVILLE, L. J. et al. Proposed terms and concepts for describing and evaluating animal-health surveillance systems. **Preventive Veterinary Medicine,** v. 112, n. 1–2, p. 1–12, 2013. Available at: <http://dx.doi.org/10.1016/j.prevetmed.2013.06.006>.

KLAUCKE D.N. Evaluating public health surveillance systems. In: Baker EL, Halperin W, Monson RR, editors. **Public health surveillance.** Toronto: Wiley; p. 26-41, 1992

KNIGHT-JONES, T. J.; RUSHTON, J. The economic impacts of foot and mouth disease - what are they, how big are they and where do they occur? **Preventive Veterinary Medicine,** v. 112, n. 3-4, p.161-173, 2013.

LYRA, T.M.P.; SILVA, J.A.A Febre aftosa no Brasil, 1960-2002. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia.** Belo Horizonte, v. 56, n. 5, p. 565-576, Oct. 2004

MANSLEY L.M. et al. Early dissemination of foot-and-mouth disease virus through sheep marketing in February 2001. **Veterinary Record,** . 153 p. 43–50, 2013.

MARTIN, T.; CAMERON, A. Documenting Freedom from Avian Influenza Report on International. **EpiLab, Project 4.** Copenhagen, Nov. 30, 2002.

MARTÍNEZ-LÓPEZ, B.; PEREZ, A.M.; SÁNCHEZ-VIZCAÍNO, J.M. Social network analysis. Review of general concepts and use in preventive veterinary medicine. **Transboundary and Emerging Diseases,** v.56, p.109-120, 2009 a.

MORAES, G.M de; BRISOLA, M. V.; GONÇALVES, V. S. P. Os circuitos pecuários e a Febre aftosa no Brasil: uma análise histórico-institucional. **Savannah Journal of Research and Development,** v. 1, n. 1, p. 39-47, 2017.

MORAES, G.M. de. **Estudos epidemiológicos para fundamentar a implantação de zonas livres de Febre aftosa no Brasil.** 2018. xxiv, 230 f., il. Tese (Doutorado em Saúde Animal)—Universidade de Brasília, Brasília, 2018.

MÜLLER, C.A.S. **Avaliação econômica do programa de erradicação da Febre aftosa no Brasil.** Viçosa: UFV, Dissertação de Mestrado, 2004, 113p.

NEGREIROS, R. L. Caracterização e análise de rede de movimentação de bovinos no Estado de Mato Grosso. P. Tese (Doutorado em Ciência) – Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, São Paulo,

NOGUEIRA, J.M.; DÔLIVEIRA, C.F.D. Análise Custo-Benefício de Estratégias de Controle da Febre aftosa. Avaliação exposta de um programa de controle nacional e avaliação ex-ante de uma proposta regional alternativa. Lições de experiências brasileiras. Anais do Congresso da Sociedade Brasileira de Economia, Administração e Sociologia Rural, 2012.

OIE - WORLD ORGANISATION FOR ANIMAL HEALTH - **Manual 5: Surveillance and epidemiology.** 2018. Available at: [https://rr-asia.oie.int/wp-content/uploads/2019/09/seacfmd-manual-5.pdf]

ORTIZ-PELAEZ, A.; PFEIFFER, D.U.; SOARESMAGALHAES, R.J. et al. Use of social network analysis to characterize the pattern of animal movements in the initial phases of the 2001 foot and mouth disease (FMD) epidemic in the UK. **Prevent Veterinary Medicine,** v.76, p.40-55, 2006

OSSADA, R. et al. Modeling the dynamics of infectious diseases in different scalefree networks with the same degree distribution. **Advanced Studies in Theoretical Physics,** v.7, n.16, p.759-771, 2013.

PANAFTOSA-CENTRO PANAMERICANO DE FIEBRE AFTOSA. **Guía Técnica de trabajo para última etapa del Programa Hemisférico de Erradicación de Fiebre Aftosa – PHEFA. Documento aprovado na 5ª Reunión Cosalfa Extraordinaria.** Cuiabá: PANAFTOSA/OPS/OMS, 2015. Available at: <http://bvs1.panaftosa.org.br/local/File/ textoc/PAHEFA-Guia-Tecnica-Ultima-Etapa-PHEFA-2016>. Retrieved on: Oct 02, 2017.

PEYRE, M. et al. Network analysis of surveillance system evaluation attributes: a ay towards improvement of the evaluation process. **Presented at the International Conference for Animal Health Surveillance (ICASH);** 7-9 May 201, Havana, Cuba.

SANTOS, D.V. **Avaliação de riscos: emprego da técnica pelo serviço veterinário oficial e identificação de áreas de risco para a Febre aftosa no Rio Grande do Sul.** 2016, 120f. Tese (Doutorado em Medicina Veterinária Preventiva) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2016.

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