Historical perspective of the public-private partnership for the control of Foot and Mouth disease in Paraguay

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Abstract

Foot and Mouth disease control in Paraguay requires a massive vaccination campaign of the national cattle herd. To implement it, the Official Veterinary Services of Paraguay are collaborating with an association of private producers in a public-private partnership. In order to provide relevant recommendations for the evaluation of this PPP, this study focuses on the analysis of its implementation context. The history of the FMD control program in Paraguay is analysed through the lens of the collaboration between the Official Veterinary Services and the private sector. Semi-structured interviews were conducted with the main actors of the FMD control program (n=10), both from the public and private sectors. Records, laws and regulations of the Statistics Department of the veterinary services, the Central Bank of Paraguay, the National Institute of Statistics, and the Pan-American Foot and Mouth Disease Centre were analysed. Cattle ranching began in 1545 in Paraguay, and in 1885 some of the ranchers joined to form the *Asociación Rural del Paraguay* (ARP). After the FMD outbreaks in Mexico, Venezuela and Colombia around 1950, the North American drive to control the disease in the continent, through the creation of the Pan-American Foot and Mouth Disease Centre and financial loans, allowed the emergence of public Veterinary Services and the onset of the control program in Paraguay in 1967. The establishment of an official FMD status by the World Organization for Animal Health in 1994 gave an impetus to the FMD control program and the evolution of Paraguayan regulations. Although the collaborative structure and governance system between the public and private sectors, through the producers' association of Paraguay, has evolved, the control program has always involved both sectors. Today, 100% of cattle population is vaccinated, and the vaccination operation is entrusted to the private sector, through a foundation recognized as a legal entity, and is supervised and evaluated by the Official Veterinary Services. The FMD program has enabled the expansion of veterinary coverage throughout the country and the implementation of a traceability system. The FMD-free status recognition since the last outbreak in 2012 has allowed an increase in the volume of beef product exports.

Abbreviations

ARP: Rural Association of Paraguay ("*Asociación Rural del Paraguay*" in Spanish)

ACONASA: The National Animal Health Coordinating Association ("*Coordinación de Comisiones de Salud Animal*" in Spanish)

CIRAD: The French Agricultural Research Centre for International Development

COSALFA: The South American Commission for the control of FMD ("*Comisión Sudamericana para el Control de la Fiebre Aftosa*" in Spanish)

FMD: Foot and Mouth disease

FUNDASSA: The private Foundation for Animal Health Services ("*Fundación de Servicios de Salud Animal*" in Spanish)

WOAH: World Organisation for Animal Health WOAH, funded as OIE.

PANAFTOSA: Pan-American Foot and Mouth disease Centre ("*Centro Panamericano de Fiebre Aftosa*" in Spanish)

SENALFA: National Foot and Mouth disease Control Services ("*Servicio Nacional de Lucha contra la Fiebre Aftosa*" in Spanish)

SENACSA: National Animal Health and Quality Service ("*Servicio Nacional de Calidad y Salud Animal*" in Spanish)

SIGOR: Computerised Management System for Regional Offices ("*Sistema Informático de Gestión de las Oficinas Regionales*" in Spanish)

SITRAP: Paraguay Traceability System ("*Sistema de Trazabilidad del Paraguay*" in Spanish)

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1. Introduction

Ensuring good animal health requires animal disease surveillance, prevention and control programmes. It also requires funding and human resources, for example to ensure massive vaccination campaigns (Knight-Jones and Rushton, 2013). Actors from both the private sector (producers, veterinarians, companies) and the public sector (such as Veterinary Services) need to collaborate in the implementation and maintenance of these animal disease management programmes. These collaborations can lead to public-private partnerships (PPPs) (World Organisation for Animal Health, 2020).

For example, in order for Paraguay, the sixth largest beef exporter in the world, to obtain the status of "FMD free with vaccination" from the World Organization for Animal Health (WOAH, founded as OIE), all 14 million head of cattle in the country must be vaccinated. To implement this massive vaccination campaign, SENACSA works in collaboration with a private producer association. The private sector is responsible for the practical implementation of this vaccination campaign and the Veterinary Services assesses and ensures that it is carried out to meet the required standards. This PPP corresponds to the "collaborative" category of PPP in the veterinary domain (Galière et al., 2019a). This category corresponds to PPPs driven by exports and/or commercial interests, initiated by both the Official Veterinary Services and the private sector. FMD is a contagious viral disease of cattle, swine, sheep, goats and other cloven-hoofed ruminants (World Organisation for Animal Health (WOAH), 2021). This disease affects the production of livestock and has an economic impact through direct losses (reduced livestock production) and indirect losses (costs of FMD control, poor access to markets) (Knight-Jones and Rushton, 2013). Effective control of FMD with vaccination requires high levels of vaccine coverage to develop herd immunity (Le Gall and Leboucq, 2004). It was the first disease for which the World Organisation for Animal Health (WOAH) established official status recognition in 1994 (World Organisation for Animal Health (WOAH), 2021). All countries that have eradicated FMD exclude beef imports from exporting countries whose herds show evidence of FMD. The control of FMD has therefore a strong commercial stake for meat exporting countries (Knight-Jones and Rushton, 2013).

Paraguay is a landlocked country in South America with a population of 7.13 million people. Income inequality has declined since 2003, but it is still high and 23.5% of the population living below the national poverty line. In 2020, the agriculture, forestry, and fishing, represented 11% of the national gross domestic product (World Bank, 2020). Informal economy, including rural activities related to livestock, could account up to 40% of GDP (World Bank Group, 2018). More than 14 million cattle are bred in the country and 70% of meat production is exported (Servicio Nacional de Calidad y Salud Animal, 2020). The national cattle herd increased by 40.6% between 2006 and 2020.

There are approximately 140,000 livestock owners, and many formal and informal workers directly or indirectly employed by the livestock production system (241,000 people directly and 450,000 indirectly) (World Wildlife Fund Paraguay and Germany, 2016). The social status of the livestock owner is highly variable, going from the subsistence farmer to the livestock owner-investor with up to 50,000 cattle. Among the livestock owners, the 15% with the largest herds own the equivalent of 85% of the cattle in the country. The livestock system is mostly extensive, pasture-based, and feedlot fattening is hardly ever used.

Evaluation is important for any programs, including PPPs in the veterinary domain, to plan, redefine strategies, initiate appropriate corrective actions, optimize resources and help to ensure the effectiveness of actions (Brousselle and Champagne, 2011). Evaluation can focus on the analysis of the context, of the process of the PPP (such as governance or collaboration), and of the results and impacts. A review of literature about evaluation of PPPs underlined the importance to analyse the context of implementation to provide relevant recommendations (Poupaud et al., Under publication).

In this study, we propose to conduct a historical review as a way to operationalize the context analysis, focusing on the emergence of PPP in Paraguay for the control of FMD. The purpose of this study is to try to understand what elements of the context influenced the emergence and implementation of the PPP, but also to try to understand the influence of the history of the PPP on its operating process.

2. Methodology

The researcher (MP) was introduced to public and private actors at national level by the WOAH delegate present in Paraguay. The fieldwork took place from January to March 2021. At the beginning of the study, a meeting was held between the researcher and the main PPP stakeholders from the public and private sector, where the researcher, the project and the evaluation framework were introduced.

The study was conducted in the capital city of Paraguay, Asuncion, and in four regions of Paraguay, corresponding to animal health commissions: Ñeembucú sur, Paraguarí, Amambay and Consanzo 17 (**Figure 1**). These regions were chosen because they correspond to different geographical situations. Three of the regions (Ñeembucú sur, Paraguarí, Amambay) are located in the eastern zone of Paraguay (located to the east of the Paraguay River), where 97% of the total population lives. Consanzo 17 is located in the western zone of Paraguay (located to the west of the Paraguay River), where 3% of the population lives, characterized by low precipitations and extreme temperatures, but which contains 50% of the cattle population. The Ñeembucú region borders Argentina, Amambay borders Brazil, and Consanzo 17 shares a border with Bolivia, while Paraguarí is a central region.

Semi-structured interviews were conducted at national and regional level, which involved key actors in the FMD control program: public actors from the Official Veterinary Services, the National Animal Health and Quality Service (SENACSA), and private actors from the private Foundation for Animal Health Services (FUNDASSA) (10).

Figure 1: The four regions of Paraguay included in this study. Paraguay shares borders with Bolivia, Brazil and Argentina.

Ten semi-structured interviews were conducted with key actors of the FMD control program from SENACSA (4) and from the private sector (6) (Foundation for Animal Health) at national and regional level following an interview guide (**Appendix 1**). The key actors were the WOAH delegate, the manager of the FMD program from the Official Veterinary Services at central and regional levels (in four regions), the national directors (technical and executive directors) of the private foundation, and the regional directors of the private foundation in four regions. The researcher had been previously trained in qualitative approaches. All semi-structured interviews were conducted in Spanish. Interviews took place in the office of public or private partners. The interviews lasted from 40 to 90 minutes. The discussions were recorded and transcribed in Spanish.

A unique number was given to each of the transcripts to ensure the anonymity of the interviewees. The transcripts were read and analysed through content analysis. We coded the information as follows: the

history of the collaboration (events classified by date if the date was mentioned), history of the legal framework, elements of the context influencing the history of the PPP. The interviews allowed us to have a first outline of the history of the PPP and to highlight important dates.

Next, a search of the grey literature allowed us to locate the data provided by the interviews, but also to detail them and to obtain various types of numerical monitoring. These figures relate to the size of the herd, the number of producers, the number of vaccinated cattle, the level of beef exports (in volume and price), the coverage of the Veterinary Services (number of veterinarians in the public service, number of offices in the regions and locations). The annual report from 1967 to 2020 of the Pan American Health Organisation and Pan American Foot and Mouth Disease Centre (PANAFTOSA) were consulted[1], as well as the different laws and regulations[2]. The statistical data from the Statistics Department of SENACSA, which contain data from 2007 to 2020, were analysed[3]. This department also allowed the collaboration from the National Institute of Statistics, which provided access to archive from General Statistics and Census from 1967 to 1997 of the Statistical Yearbook of Paraguay, drafted at the time by the Ministry of Finance (General Directorate of Statistics and Census - *Dirección General de Estadística y Censo*). The foreign trade bulletins published by the Central Bank of Paraguay, from 1961 to 2021, from the Department of Statistics of the Foreign Sector were also analysed[4]. A detailed report was sent to key actors of the program in October 2021 in order to check the validity of the results.

3. Results

3.1 The history of the Public-Private Partnership for FMD control in Paraguay (1545-2021)

3.1.1 The beginning of livestock raising and implementation of FMD control strategy in South America and in Paraguay and the creation of the Private Rural Association (1545-1965)

Cattle were introduced in 1545 in Paraguay (ARP, 2011). FMD was first detected in 1870 in South America. By the end of the 19th century, FMD had spread to many countries including Paraguay (Correa Melo and Lopez, 2002; Rosenberg and Goic, 1973).

In 1885, the Rural Association of Paraguay (ARP), a private non-profit organization, was founded in order to bring together agricultural producers from all over the country, and whose mission is to make livestock production an instrument for Paraguay's development, (ARP, 2011).

[1] available on https://iris.paho.org/;
[2] available on https://www.bacn.gov.py/leyes-paraguayas
[3] available on https://www.senacsa.gov.py/index.php/informacion-publica/estadistica-pecuaria
[4] available on https://www.bcp.gov.py/boletin-de-comercio-exterior-trimestral-i400

In 1917, Paraguay began exporting meat in the form of corned beef, for example through the Liebig Company (Asociación Rural del Paraguay, 2011). In 1917, a livestock Service was established in Paraguay, under the Ministry of Agriculture and Livestock, in order to guarantee meat quality and safety, and the first Animal Health Law, Law 269, was drawn up. That year, the first Animal Health Unit was created (Faculty of Veterinary Science, 2021). In 1950, the four first health regions were created as well as the first rural medicine centre in the country (zonal unit) with a veterinarian. In 1954, the Faculty of Agronomy and Veterinary Medicine was created under the Ministry of Agriculture and Livestock. The Faculty of Agronomy and Veterinary Science became part of the National University of Asunción on 1956 (Facultad de Ciencias Veterinarias, 2021).

Between 1928 and 1930, the importing countries of canned beef and meat products demanded that the inspection of slaughtered livestock and processed products be carried out by Veterinarians, so the General Directorate of Livestock hired three Uruguayans, since there are records that in the period between 1900 and 1939, the country had only five veterinary professionals. The participations in the field of Animal Health and Zootechnics were sporadic; there were no Animal Health Inspectors in any area of the country (Faculty of Veterinary Science, 2021). In 1942, the Paraguayan state granted scholarships for young Paraguayans to train in Veterinary Medicine abroad (Uruguay and Argentina). In 1950, the first sanitary regions were created in Caazapá, Villarrica, Concepción and Misiones, and the first rural medicine center in the country (zonal unit), with a veterinarian, was created in the department of Guairá. In 1954, the School of Agronomy and Veterinary Medicine (*Escuela Superior de Agronomía y Veterinaria*) was created, under the Ministry of Agriculture and Livestock. The Faculty of Agronomy and Veterinary Science became part of the National University of Asunción in January 1, 1956 (Faculty of Veterinary Science, 2021).

In 1938, the first effective FMD vaccine was developed in Germany. The vaccine was produced in South America in 1940 (Argentina, Brazil, Chile, Peru, Uruguay) (Rosenberg and Goic, 1973). The introduction of FMD into Mexico in 1946, and then into Venezuela and Colombia in 1950, marked the beginning of the development of FMD control throughout the Americas. In 1951, the United States, through the Organization of American States, initiated the establishment of the Pan-American FMD Centre (PANAFTOSA). The Pan-American FMD Centre was created through an agreement between the Organisation of American States, the Pan American Sanitary Bureau of the WHO and the Government of Brazil (Correa Melo and Lopez, 2002).

3.1.2 Creation of Paraguay's Veterinary Services (1965-1994)

In 1965, the Inter-American Development Bank offered financial loans for the development of FMD control plans in South American countries (PANAFTOSA, 2018). With this loan, the Veterinary Services of Paraguay were created in 1967 (Law 1267/1967) and followed guidelines of the Pan-

American FMD Centre PANAFTOSA for their FMD control programs (Rosenberg and Goic, 1973; Servicio Nacional de Calidad y Salud Animal, 2020). The main objective of the Public Veterinary Services was FMD control and they were initially called "SENALFA" for National FMD Control Services ("Servicio Nacional de Lucha contra la Fiebre Aftosa") (Servicio Nacional de Calidad y Salud Animal, 2020a). Law 1267/1967 announced the onset of the campaign to control FMD. This law created a tax on farmers when selling their cattle to finance the national campaign against FMD (Paraguay National Government, 1967).

In 1969, vaccination campaigns began in the eastern part of the country and in 1972 in the western part. From the beginning, the private sector has played a major role in the implementation of FMD vaccination. Indeed, at first, owners were responsible for vaccinating their cattle, and the Public veterinary services staff vaccinated a minority of the cattle. The Rural Association of Paraguay was in favour of this vaccination campaign since the beginning and, thanks to its presence throughout the country, encouraged the breeders to vaccinate their livestock. In 1970, one third of the cattle population was vaccinated (Pan American Health Organisation-PAHO, 1970).

Since 1970, Paraguay has been producing its vaccines in both a public and a private laboratory (PAHO, 1970). In 1972, the FMD programme had more than 60 veterinarians, most of them distributed in the countryside (Rosenberg and Goic, 1973). The programme faced difficulties such as lack of resources and lack of personnel to cover producers, especially small producers who were less motivated to vaccinate their cattle (PAHO, 1970).

In 1977, the public veterinary services' (SENALFA) activities were extended to the control of rabies, brucellosis and bovine tuberculosis, and they were renamed SENACSA for "National Animal Health and Quality Service" ("*Servicio Nacional de Calidad y Salud Animal*") by Law 675/1977. This law defines the Public Veterinary Services SENACSA as an institution with technical and administrative autonomy and a legal entity (Paraguay National Government, 1977). Since 1981, the Public veterinary services SENACSA's budget has been fully covered by the institution's own income and does not depend on foreign financial loans such as that of the Inter-American Development Bank.

Since its creation in 1951, the Pan-American FMD Centre PANAFTOSA has been influencing the different national FMD control programmes in South America, including Paraguay, by establishing guidelines that these programmes should follow. In 1972, through the collaboration between the public and private sectors in South America, the South American Commission for the control of FMD (COSALFA) was created, composed of the directors of animal health services and representatives of the production sector of the South American countries. In 1988, PANAFTOSA's Hemispheric FMD Eradication Programme (PHEFA) was created, along its first action plan (1988-2009), setting forth guidelines for national programmes for the eradication of the disease in the different countries (Pan-American FMD Centre, 2018).

In 1994, the World Organisation for Animal Health (WOAH) developed standards to allow a system of official recognition of FMD-free member countries with animal health status (World Organisation for Animal Health, 2020).

3.1.3 The beginning of the official collaboration between the Public veterinary services and the private sector (1996-2001)

The WOAH's creation of FMD status gave a new boost to the eradication program. In 1996, Law 808 declared the national FMD eradication programme mandatory throughout the country. This law officially initiated the collaboration of the veterinary Services with the private sector through the creation of Inter-Institutional Commission for FMD eradication (Articles 7 and 8). Such Commission, composed of representatives from both the public and the private sector through the Rural Association of Paraguay, were intended to support the Public veterinary services SENACSA in the execution of vaccination. This law also established the resources of the Inter-Institutional Commission by imposing on producers a percentage of the estimated value of each animal traded (Paraguay's National Government, 1996). This tax now represents about 60% of the Public veterinary services' funds.

> *"This money was administered by the Rural Association (ARP) and SENACSA, through an inter-institutional commission [...] Some of this money was used by the programme workers, and some was kept in a savings account so that, should there be an emergency, the money would be immediately available. And not to be dependent on the state."* [semi-structured interview, public actor at national level of the PPP]

In May 1997, Paraguay was certified as an FMD-free country with vaccination by the WOAH SENACSA, 2020).

In August 1999, vaccination against FMD was suspended, with the aim of achieving "FMD-free and vaccination-free status". Mass vaccination was resumed in 2001 following reports of animals with lesions consistent with FMD (PAHO, 1999).

3.1.4 Restructuring of the FMD programme and start of the official PPP (2002-2012)

In 2002, the WOAH certification was suspended due to the reintroduction of the disease (SENACSA, 2020). This FMD outbreak highlighted the need to better organize the program.

> "*There was a lot of FMD and we wanted to export... but we had to stop lying and saying we didn't have the disease! We had no guarantee that the producers were doing their job properly,*

and that the cold chain was respected...“ [semi-structured interview, private actor at national level of the PPP]

The Public veterinary services SENACSA and the Rural Association of Paraguay (ARP) sought another organizational system to improve their program and were inspired by the Argentinian model.

“*We saw experts from Argentina to help us. In Argentina, the Public Veterinary Services delegated the work to a private foundation for animal health.”* [semi-structured interview, private actor at national level of the PPP]

In 2003, the Rural Association of Paraguay, which was already well structured throughout the country and had local offices, decided to create non-profit animal health commissions in each of the 20 health regions of the country. The Public veterinary services SENACSA then relied on the well-organised Rural Association of Paraguay network and its animal health commissions for the implementation of the vaccination (Antonio Esteban Vasconsellos Portas, 2008).

"The Rural Association of Paraguay is the mother of all this programme... the animal health commissions were part of the ARP". [semi-structured interview, private actor at national level of the PPP]

Law 2426/2004, which set forth the current Public Veterinary Services SENACSA, clearly defined the competent authority and chain of command, and gave them full powers to exercise control and enforcement mechanisms, including penalties and sanctions (Paraguay National Government, 2004; World Organisation for Animal Health, 2014). This law made vaccination against FMD mandatory (Article 50). It formalised the relationship with the Rural Association of Paraguay (ARP) and its Animal Health Commissions with the possibility of carrying out vaccination by third parties (Article 54) and to create Animal Health Commissions (Article 78).

"*This law [2426] is the basis of the PPP.*" [semi-structured interview, public actor at national level of the PPP]

While the collaboration between the private sector and public veterinary services SENACSA has been in place since the beginning, the PPP officially began in 2004. The Animal Health Commissions, which replaced the Interinstitutional Commissions, are public-private, non-profit auxiliary bodies that collaborate on the FMD eradication programme and other programmes that the public veterinary services SENACSA deem appropriate (Animal Health Commissions, Coordinating Board, 2012).

Since 2004, the Animal Health Commissions have been responsible for the planning and control of vaccination campaigns, by employing officials who received training as a prerequisite for their accreditation.

In January 2005, Paraguay recovered the WOAH status of “Freedom of FMD with vaccination” (SENACSA, 2020). In 2006, in order to demonstrate the absence of virus circulation on its territory, the public Veterinary Services SENACSA set up an epidemiological surveillance programme and initiated serological sampling for the evaluation of the immunity level to FMD vaccination. Following the recommendations of an audit from the WOAH, zones called "high surveillance zone" were defined, comprising a 15 km wide strip on either side of the border with neighbouring countries (Argentina, Brazil, Bolivia) (PAHO, 2007). In 2010, the second action plan (2011-2020) of the Hemispheric FMD Eradication Programme of the Pan-American FMD Centre PANAFTOSA was approved (PANAFTOSA, 2018).

In 2010, the Rural Association of Paraguay created the new National Animal Health Coordinating Association (ACONASA), with the purpose of unifying the 20 animal health commissions, centralising resources and unifying decisions related to FMD control. ACONASA was a legally registered non-profit civil entity (Antonio Esteban Vasconsellos Portas, 2008). In 2011, the "high surveillance zone" was also recognized as free from FMD by the WOAH and record export levels were at their highest, reaching almost 70 open markets (Antonio Esteban Vasconsellos Portas, 2008).

3.1.5 The last FMD outbreak (2012-2017)

On September 2011 and January 2012, FMD outbreaks occurred, and the official status granted by the WOAH was lost. The social and economic cost of these outbreaks were high, with thousands of direct jobs lost, exports went down by 29% (in 2010 the volume of beef and by-products exported corresponded to 918 million dollars, and in 2011 to 750 million dollars), and the indirect impact is still difficult to determine (SENACSA, 2011; FAO, 2012).

After this outbreak, resolution 2031/12 of the public Veterinary Services SENACSA officially approved the organisation of the 20 animal health commissions and extended their functions. Since this resolution, the official role of these commissions was to be the operational managers of FMD vaccination throughout the country. The entire vaccination process, from planning, vaccination, issuing of documents such as work orders, to the recording of vaccination records, is controlled by the public Veterinary Services SENACSA (Pan-American Foot and Mouth disease Centre, 2012).

In 2014, the WOAH Scientific Commission concluded that the two zones of Paraguay meet the requirements for the reinstatement of FMD free status with vaccination "Country with two FMD free zones where vaccination is practised" (SENACSA, 2020).

3.1.6 Current situation (2017-2021)

The same year, the private Animal Health Services Foundation (FUNDASSA) was created, grouping the 20 private animal health commissions and replacing ACONASA. The creation of the foundation was driven by the need to make the private animal health commissions less vulnerable to political changes.

> *"We [the animal health commissions] were handling a lot of money and the politicians wanted to get their hands on it... they wanted to do something political and not technical. We were very vulnerable."* [semi-structured interview, private actor at national level of the PPP].
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> "*ACONASA [the National Animal Health Coordinating Association] was directly under the control of SENACSA [the Public veterinary services]. A president of SENACSA could decide overnight that the commission no longer existed.* " [semi-structured interview, private actor at national level of the PPP]

The Animal Health Services Foundation FUNDASSA was recognised as a legal entity by Executive Decree No. 7331/2017 (Paraguay National Government, 2017). A cooperation agreement was signed between the Public veterinary services SENACSA and FUNDASSA for a 10-year collaboration (SENACSA and FUNDASSA, 2017). All the obligations that the animal health commissions had assumed in support of the Public veterinary services SENACSA were maintained, including those related to vaccination against FMD. The foundation "may collaborate, coordinate, develop and carry out the activities necessary for the prevention, control and eradication of contagious animal diseases in the field of animal health, especially those carried out to comply with the country's FMD eradication programmes and others within the framework of the National Animal Health Plan" (SENACSA and FUNDASSA, 2017). In 2018, Paraguay started applying a bivalent vaccine (A and O strains) instead of the trivalent vaccine (A, O, C strains) previously used, as the C strain is no longer circulating in the country (Pan-American Foot and Mouth disease Centre, 2018).

The Animal Health Services Foundation FUNDASSA structure is officially separated from the Rural Association of Paraguay, but often at the local level the chair of the animal health commission of the foundation is also the local chair of the Rural Association of Paraguay. The President of the Rural Association of Paraguay is also present at all weekly meetings at national level and participates fully in decision-making. Today, the Paraguayan private sector is actively involved in regional and global animal health issues both as Rural Association of Paraguay and the animal health services foundation FUNDASSA, and international organisations recognise the participation of the private sector in animal health programmes. For example, the private sector is invited, together with the Public veterinary services, to the annual conference of the WOAH, to the annual meetings of the South American Commission for the control of FMD (COSALFA), or to support the implementation of the hemispheric FMD eradication plan of PANAFTOSA (Antonio Esteban Vasconsellos Portas, 2008).

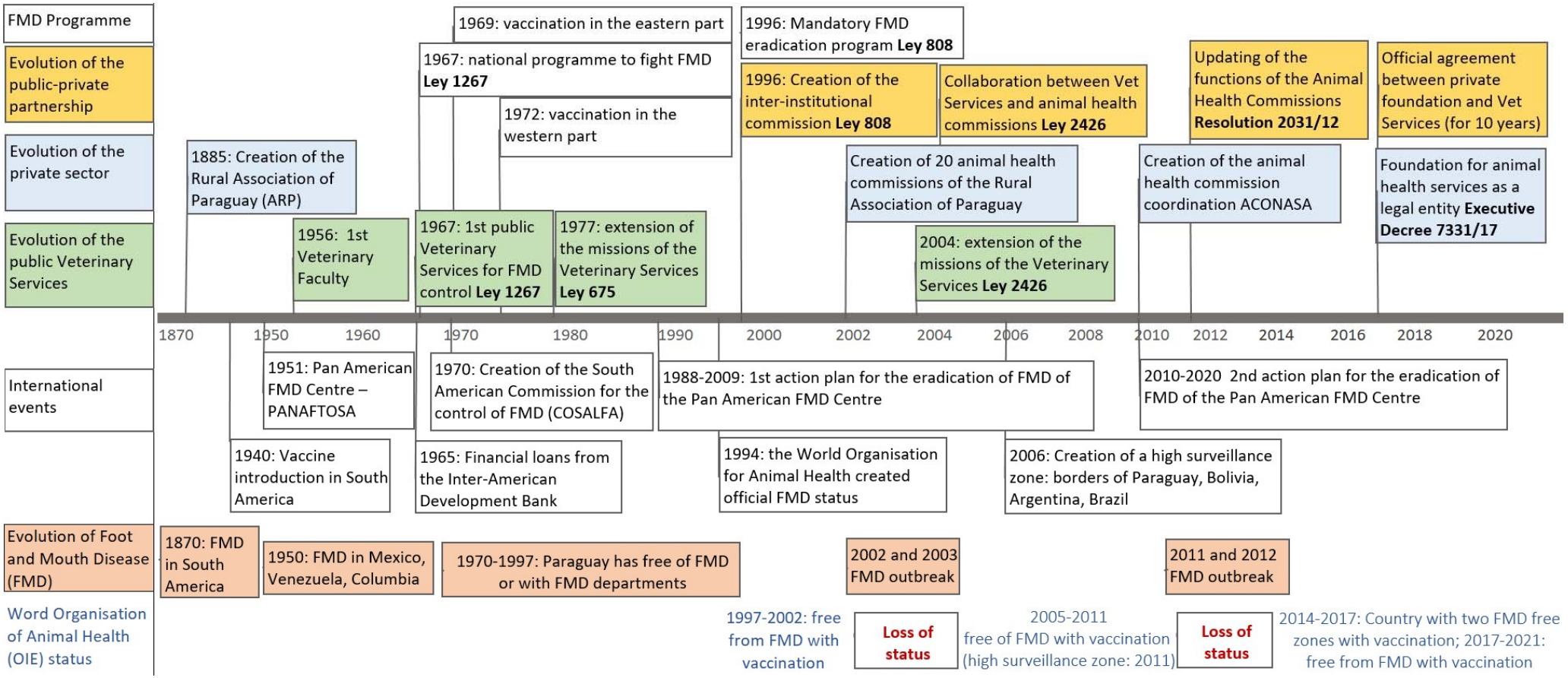

Figure 2: History of the foot-and-mouth disease (FMD) programme (top white squares) and of the public-private partnership (yellow square) in Paraguay from 1870 to 2020. The evolution of the private sector is described in the blue squares, and the Public veterinary services in green squares. The international event which influenced the programs are described below in white squares. The evolution of the disease is described in red squares. The statuses of the FMD situation in Paraguay given by the World Organisation for Animal Health (WOAH) are in blue and red text.

3.2 Evolution of the governance system of the PPP and consequence on the process of the PPP

The forms of governance of collaboration between public and private systems for FMD control have evolved over time. The private sector, particularly through the Rural Association of Paraguay, which has been in place since 1885, before the Public veterinary services existed, has been involved in the FMD programme from the very beginning, notably through participation in the meetings and programme of the Pan-American FMD Centre PANAFTOSA. Indeed, in South America, the private sector, through producers' association, became interested in FMD control, first for zootechnical reasons to improve the productivity of their livestock, and then for commercial reasons, especially since the creation of the WOAH status in 1994. They realized that being part of a FMD disease-free circuit would improve their profit (Astudillo, 1997).

Vaccination against FMD became compulsory by law in 1996, following the creation of the WOAH status. The official governance of the collaboration between the Rural Association of Paraguay and the Public veterinary services started in 1996 with the creation of Law 808, legitimising the inter-institutional commission and the support of the Rural Association of Paraguay for the implementation of vaccination. The inter-institutional commission ensured that money for the FMD program, mainly from a levy paid by farmers, and payment for vaccines, did not flow through the ministries. Stakeholders said this was an important step for the management of the program, denouncing the risks of government corruption.

In 2003, following an outbreak of FMD and the loss of WOAH "free from FMD with vaccination" status, the creation of the 20 animal health commissions of the Rural Association of Paraguay (ARP), which were easily set up because the association was already well structured throughout the country, boosted the implementation of the FMD control programme. The collaboration with these animal health commissions of the Rural Association of Paraguay and the veterinary services was legitimised two years later by Law 2426 of 2004. Through the commissions, the private sector is therefore fully responsible for the implementation of vaccination, which became mandatory by law in 1996, and the public sector, through SENACSA, is entrusted with monitoring the adequate implementation of said vaccination.

The Rural Association of Paraguay network has enabled SENACSA to ensure vaccination locally, and to develop their own network at the local level as well. The local units of SENACSA have almost always developed alongside the offices of the animal health commissions of the Rural Association of Paraguay (which are now the commissions of the Animal Health Services Foundation FUNDASSA). In view of the need to harmonize the ways in which the different health commissions operated, and to harmonize the financial resources of each commission, the National Animal Health Coordinating Association ACONASA was created in 2010. ACONASA has enabled greater solidarity between the commissions, redistributing financial resources and supporting certain commissions that are in deficit (mainly because

they are made up of small farmers which increases the number of farms to be vaccinated and makes logistics more difficult). Finally, the current structure, the Animal Health Services Foundation FUNDASSA, was created in 2017, officially separated from the Rural Association of Paraguay.

Indeed, the actors of the health commissions felt vulnerable to a political change and being recognised as a legal entity by executive order (Decree 7331/2017) grants them a 10-year protection period. Once again, the legislation followed the needs of actors on the ground. In 2018, a 10-year official agreement was then signed between SENACSA and the private foundation. It is therefore not the legal environment that allowed the emergence of this PPP, but rather the networks of actors that influenced the legal evolution according to the identified needs to strengthen the program.

3.3 PPP's outcome on the animal health system: evolution of the Veterinary Services

Until 1939 there were only 5 veterinarians in the country. Although there was a livestock service and an animal health unit since 1917, it only existed to guarantee the quality of the meat and there was no support for animal health at field level in any part of the country (Faculty of veterinary Science, 2021). Before 1968, there were roughly a dozen of veterinarians working in the interior of the country. The Public veterinary services of Paraguay really emerged in 1969 at the beginning of the control of FMD in South America. The loan from the Inter-American Development Bank, which feared the introduction of FMD in their country, was pivotal, and in 1967, the public Veterinary Services were created specifically for the control of FMD, (called "National FMD Control Services"), and only 10 years later, in 1977, the missions of the Veterinary Services were extended to other diseases. In 1969, Public veterinary services had 50 veterinarians in the FMD programme. In 2020, the Public veterinary services had 1620 employees including 400 veterinarians, 276 of which belong to the FMD programme.

Since 1977, the public Veterinary Services are no longer limited to the control of FMD, but their tasks include the following: control of rabies, brucellosis and bovine tuberculosis, and were renamed SENACSA (National Animal Health Service, and in 2004, National Animal Health and Quality Service). In 2021 the veterinary Services have competence in animal health and food safety, and are responsible for 9 sanitary programmes (FMD, bovine spongiform encephalopathy, avian influenza, classical swine fever, bovine brucellosis, bovine rabies, bovine tuberculosis, equine infectious anaemia, Newcastle disease) (SENACSA, 2020). The bovine brucellosis control programme officially started in 2016, and the strategy is to rely on the same system as the FMD control programme and to entrust the operation of vaccination to the private animal health foundation FUNDASSA.

3.3.1 PPP's indirect outcome on the animal health system: veterinary health coverage in the country

Local veterinary coverage of the Public veterinary services has expanded over the years, mainly in order to carry out the FMD control programme. The extension of this coverage was also made possible by the presence of the private sector, particularly the Rural Association of Paraguay, which was already structured at country level. Thus, the local offices of the public sector were built next to or in front of the association's offices. In 1950, the first five sanitary regional zones and the first local veterinary unit supervised by a private veterinarian were created (Faculty of Veterinary Science, 2021).

In 1989, there were 12 sanitary regional zones and 47 local veterinary units and 58 veterinarians from the Public veterinary services (SENACSA) in the field (Pan-American FMD Centre, 1989). In 2016 a new position of "head of zonal unit" of the Public veterinary services was created, and 50 professionals were recruited at field level (veterinarians, administrative staff). In 2020, there are 20 sanitary regional zones, 13 regional coordination units, 87 local veterinary units, and 159 veterinarians of the Public veterinary services SENACSA at local level (SENACSA, 2020) **(Figure 3)**.

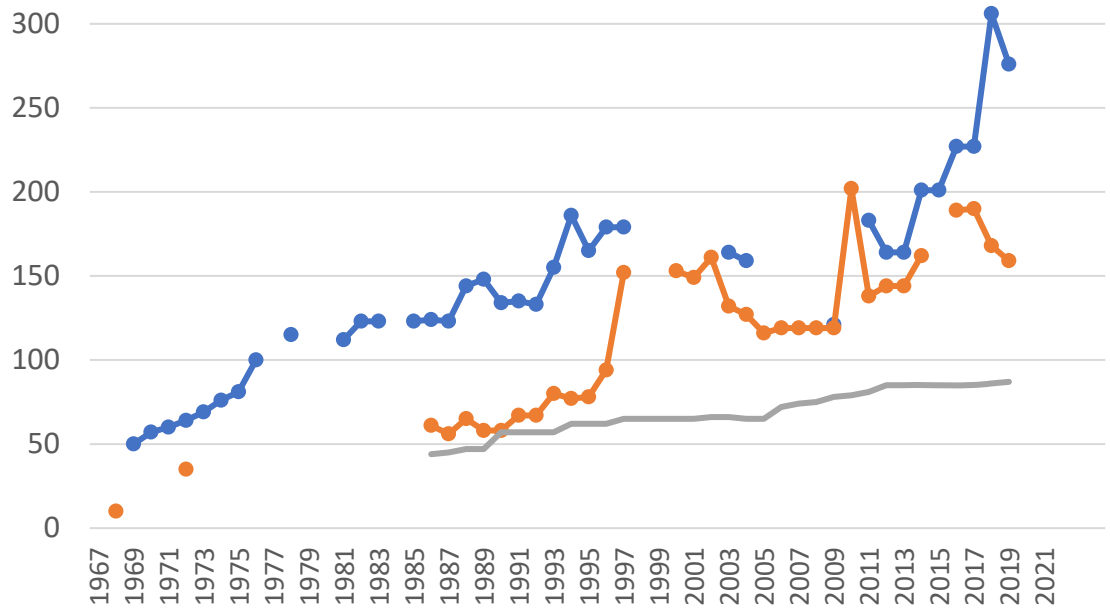

Figure 3: Evolution of the veterinary services coverage in Paraguay from 1968 to 2020. Number of veterinarians of the public Veterinary Services for the FMD program (blue line), number of veterinarians of the public Veterinary Services in the field (red line) and number of the local rural veterinary unit (green line). Broken lines mean that data for these years were not found.

3.3.2 PPP's outcome on the animal health system: evolution of the animal traceability system

To enable the FMD programme to function properly, the country's traceability system has been developed, also through a partnership with the Rural Association of Paraguay. There are two traceability

systems in Paraguay: the systems SITRAP (Paraguay Traceability System) and SIGOR (Computerised Management System for Regional Offices).

The Paraguay Traceability System, SITRAP, is ruled by **Decree 2504/2004** and **resolution 1578/2008**, is a traceability system which requires individual identification with coded ear tags. This system is not compulsory by national legislation, but it is necessary for market demand (such as the European Union). This system brings together the most technically advanced and export-oriented farmers (Jori, 2012). The Rural Association of Paraguay is responsible for the implementation of Paraguay traceability system SITRAP under the authority of the Public veterinary services SENACSA, coordinated through a technical traceability commission. The remaining animals in the country are not individually identified, except for the fire brand which identifies them as property of a specific cattle holding.

The Computerised Management System for Regional Offices, SIGOR, is a network where all owners must be registered to declare their livestock, the movements and the health information of their bovines, particularly regarding FMD. Before every vaccination campaign, every livestock owner must update information on their cattle population. This system is key to the success of the FMD control programme because, until the herd is vaccinated against FMD, the livestock holding is blocked in the system and then the owner is not able to perform any cattle transaction until the situation is clarified (Jori, 2012). In addition to allowing a census of the number of vaccinated bovines, this system, initially developed for the control of FMD, is also used to carry out a census of other species, number of owners and other livestock holding data (geographical location, epidemiological coordinates, infrastructure). The first version of this system was developed in 2000, corresponding to a single non-connected computer with a software, followed by the second version in 2003, connected to the network (in the form of distributed data) that was set up in different local units (Pan American FMD Centre, 2003). In 2009, 99% of local units were equipped with this system. The third and current version of this system, developed in 2010, connects all computers of the local veterinary unit with the central networks of the Public veterinary services SENACSA (centralised database) (Jori, 2012). Since 2013 (resolution 2031), the entire vaccination process, from the planning to the recording of vaccination records, is carried out using Computerised Management System for Regional Offices SIGOR**.**

3.4 PPP's outcomes on the livestock system and on the economy: evolution of the cattle and of the meat exportation

Cattle breeding was introduced in Paraguay in 1545, and in 1800 there were 500,000 head of cattle. In 1969 there were 1.18 million head of cattle and this figure increased rapidly within a year to 4.34 million in 1970. The number of owners also increased rapidly, from 0.44 million in 1968 to 1.7 million in 1970. Thereafter, the increase remained virtually steady, reaching 14.03 million cattle in 2020 and 137,409 owners. Between 2016 and 2020 the number of owners decreased from 150,689 to 137,409 owners,

evidencing that some major cattle owners have more and more cattle (**Figure 4**). For example, in 2020, the top 15% of owners own 85% of cattle.

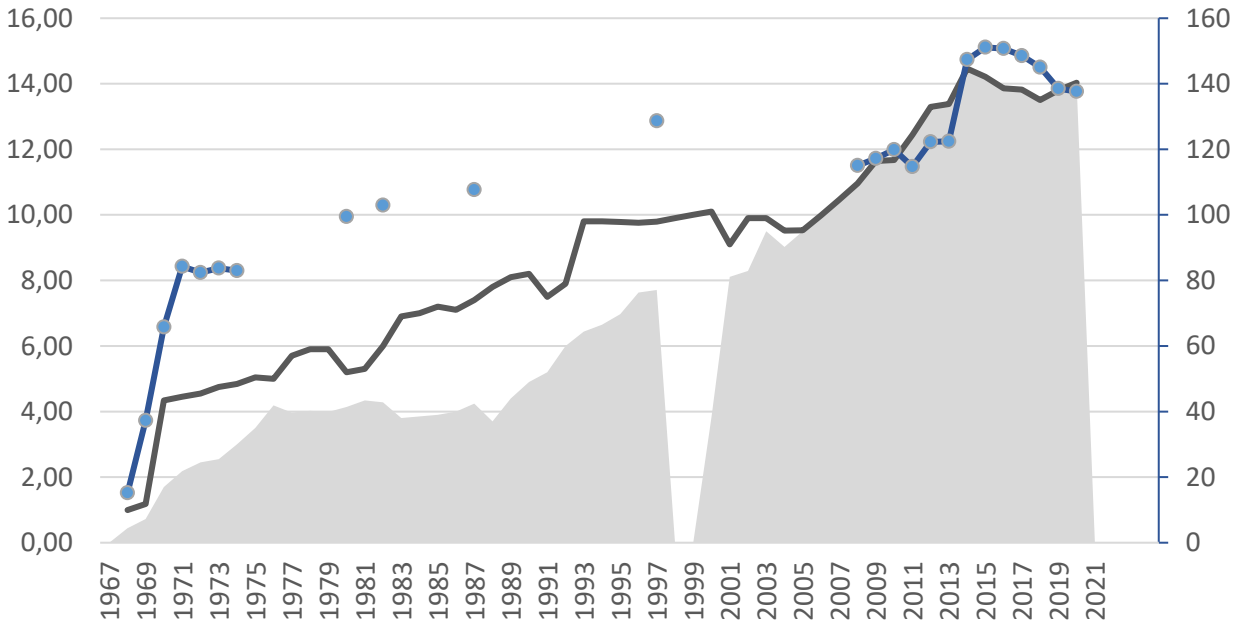

Figure 4: Evolution of the number of cattle and cattle owners in Paraguay from 1950 to 2020.

The black line corresponds to the number of cattle in millions and the top of the grey area to the numbers of vaccinated cattle (the corresponding figures are on the left). The blue line corresponds to the number of cattle owners in thousands (corresponding figures are on the right).

The exports volume (which is represented in millions of kg of and in millions of dollars in Figure 5) increased sharply since 2004, corresponding to the year of Paraguay's FMD-free status granted by the WOAH. A decrease can be seen in 2011 after the FMD outbreak. In 2020, the volume of exports reached 321,962 tons corresponding to USD 1,184 million (**Figure 5**).

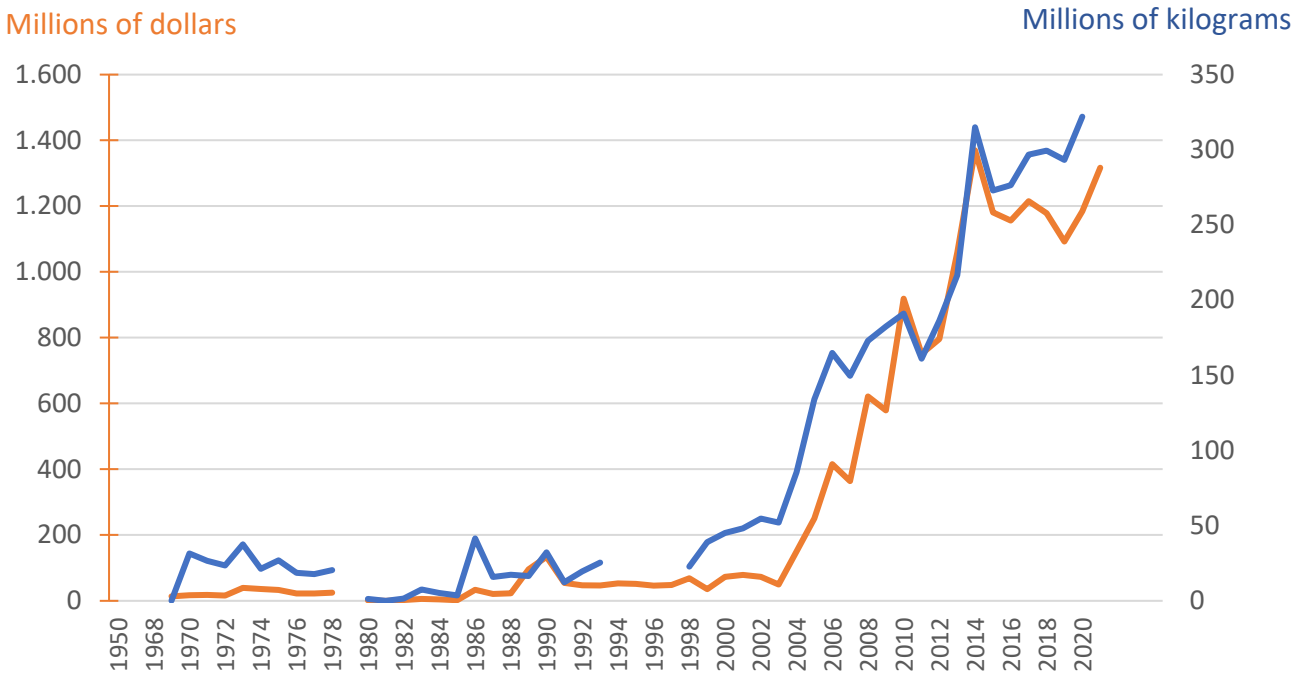

Figure 5: Evolution of the volume of meat offal, by-products and processed products exports and the corresponding financial value. The red line corresponds to the export value in millions of dollars. The blue line shows the export volume in millions of kilograms.

4. Discussion and conclusion

This historical perspective showed that the private sector has always collaborated with the Public veterinary services in the FMD programme, but such collaboration evolved through time in terms of organization and governance owing to various factors. It seems that the FMD program could not have been implemented without the collaboration of these two sectors. The Rural Association of Paraguay, the private producer association, was created in 1885, before to the public veterinary services. Since its creation, the veterinary service has been supported by the producers' association which had already existed for several decades and was already well structured throughout the country. From the beginning, the private sector has played a major role in the implementation of FMD vaccination, notably through its participation since the beginning in the meetings and programme of the Pan-American FMD Centre PANAFTOSA. The private sector, thanks to its structure, its human resources, and its influence and motivation to implement an efficient immunization program, has always been responsible for the operational implementation of vaccination, assessed by the public veterinary services. Today, 100% of cattle population is vaccinated, and the vaccination operation is entrusted to the private sector, through a foundation recognized as a legal entity, and is supervised and assessed by SENACSA.

Elements of the governance context (regulations and policies) and the economic context (trade standards for the import of meat products), at an international level, have influenced the FMD control program in Paraguay and the PPP. The United States, fearing the introduction of FMD into their country, influenced FMD control in South America by creating PANAFTOSA. Through international loans from the Inter-American Development Bank, Paraguay was able to create its veterinary service in 1967 (as many other countries in South America). The mission of the public veterinary service was only FMD control until 1977, when their missions were extended to other diseases. The creation of the official WOAH status led to the enactment of Law 808 of 1996 that made the FMD control program mandatory. International influence, such as the policies carried out by the veterinary services in Argentina or Brazil (neighbouring countries) or by the Pan-American Foot and Mouth Disease Centre (PANAFTOSA), or the influence of the European Union and its sanitary requirements for the import of meat, or of the WOAH and its performance evaluations and the issuance of statuses, could have been considered in more detail.

This study highlights several contextual elements that influenced the PPP. In terms of the sanitary context, which itself is influenced by the PPP and its results on animal health, it can be observed that the various disease outbreaks have led to the restructuring of the PPP and to organizational changes. In terms of the social context, it is worth mentioning the cultural importance of livestock breeding in the country, and therefore the influence of the breeders' associations. In terms of the economic context, the importance of livestock in the country's economy has greatly influenced the implementation of the PPP. Indeed, the export of beef to certain countries is conditional on obtaining the health status issued by the WOAH.

Several elements of the governance context influenced the PPP. We have already mentioned the influence of the policies of neighbouring countries and interregional organizations such as PANAFTOSA, or the WOAH health statutes. At the national level, governance among different actors has influenced the PPP. Indeed, the implementation of this PPP results from arbitrations and social choices involving various actors, both public and private. The role that the producers' association has played in this PPP is very important. It should be noted that it was the most powerful livestock producers who had a commercial interest in the country's FMD-free status and who were able to influence the program. The non-export-oriented smallholders' farmers did not have any influence on the evolution of the program, but they are directly involved, as they are now obliged to vaccinate their herds. In addition, it can be mentioned that the country's political system was a source of motivation for the establishment of a PPP able to manage its own funds for the implementation of vaccination.

The environmental context was rarely mentioned in the interviews conducted during this study. It was mentioned particularly in the southern region of Ñeembucú, which is a wetland area, partly flooded. This region suffers from increasingly regular flooding, which makes it difficult to access the farms during vaccination campaigns and therefore has an impact on the organization of the PPP (for example, actors are forced to travel on horseback rather than on foot or by car). Little information was available in the grey literature consulted that was related to livestock or PPP. However, given the interaction between livestock and land use, land availability, deforestation and environmental legislation, it would have been interesting to look at other sources of grey literature. We encourage people who want to analyse the influence of the context on the PPP to consider the environmental dimension.

We have also highlighted the influence of the history of the PPP on its own performance, which leads to an evolution of the context. The networks of actors involved in the PPP have led to indirect governance outcomes: the evolution of legislative governance and regulations, resulting in the current system between FUNDASSA and SENACSA. In 2017, the animal health commissions of the producer's association created a foundation, recognized as a legal entity, for fear of disappearing because of political changes, leading to the current PPP for FMD control. The FMD program in Paraguay, based on the collaboration between the public and private sectors, has resulted in outcomes on the animal health system. It has resulted in the emergence of a structured public veterinary service with a developed network at the local level. Today, the program provides 100% vaccination coverage of the herd. Paraguay has not experienced an outbreak of FMD since 2012. This review also showed that the FMD program allowed to develop the veterinary infrastructures such as offices at local level with computers and connected management system.

The review allowed for an understanding of the interactions between the public and private sectors, the evolution of forms of organization and collaboration, the evolution of the legislative system, and the systems of governance that we believe are necessary to formulate relevant recommendations in a PPP evaluation process. For these reasons, we think that, when evaluating PPPs, it would be interesting to do so from a historical perspective. This will allow for a deeper understanding of the PPP process and the reasons for its current functioning, and thus be able to provide relevant recommendations. From a methodological point of view, the combination of semi-structured interviews with key informants who have been directly or indirectly involved in the PPP for a long time seems interesting. However, we are aware that access to grey literature and archives is sometimes very limited in some countries. In Paraguay, and more broadly in South America, given the importance of the livestock industry in the national economy, data are numerous and accessible. In other contexts, it might be necessary to consider how to overcome this lack of access to data.

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