Risk-based surveillance for early detection of transboundary animal diseases at the Brazil–Bolivia border in Mato Grosso State

D. Schettino (daniellaschettino@indea.mt.gov.br), A. C. Schmidt, C. Boursheid, J. M. Néspoli

Animal Health Coordination, Instituto de Defesa Agropecuária do Estado de Mato Grosso (INDEA/MT), Cuiabá, Brazil

Summary
The state of Mato Grosso, Brazil, shares an extensive and accessible border with the Republic of Bolivia, creating a continuous risk of introduction of transboundary animal diseases. Mato Grosso is one of the world's largest livestock-producing regions and is officially recognized as free from Foot and Mouth Disease without vaccination, free from Classical Swine Fever, and has never reported High Pathogenic Avian Influenza in commercial poultry. Maintaining this sanitary status requires surveillance strategies capable of early detection, particularly in high-risk border areas. In this context, we developed and implemented a risk-based surveillance approach for the Mato Grosso–Bolivia border region. Farms were ranked according to their probability of disease introduction using epidemiological risk factors and a proxy risk measure derived from expert-based modelling. The top 50% highest-risk farms were selected, and surveillance activities were conducted through structured field operations combined with animal health education. During the initial implementation period (February–March 2026), 384 farms were planned for surveillance, of which 337 were effectively visited. A total of 571 surveillance forms were issued, covering both prioritized farms and additional field activities. During these visits, more than 150,000 cattle and thousands of animals from other species were inspected, and animal health education was delivered to producers and animal caretakers to improve early recognition of clinical signs and timely notification to the Official Veterinary Service. This approach demonstrates that risk-based surveillance, combined with field implementation and farmer engagement, can strengthen early detection capacity in border regions under continuous risk of disease introduction. It represents a practical and scalable strategy to support the protection of the country's sanitary status at its entry point through the state of Mato Grosso.

Methods
The methodology can be found in Schettino et al. (2021) [1]; however, briefly, we used a combination of factorial design and conjoint analysis, the latter being a statistical tool widely used in marketing as an approach to evaluate decision-making preferences and the relative importance of different risk factors. This method allows the assessment of trade-offs between multiple attributes within hypothetical scenarios. Combinations of factors that contribute to the introduction of specific diseases were created, and for the border region, we selected risk factors related to the introduction of the target diseases.
Through the ordinal categorization of these factors, from lowest to highest, four experts from the Official Veterinary Service (OVS) of Mato Grosso ranked, according to their personal perception and knowledge on the subject, ten hypothetical farms, labeled from A to J (from lowest to highest risk), for the possible introduction of each target disease.

The combination of seven risk factors in eight hypothetical scenarios was created using a factorial model in IBM SPSS [2]. In addition, two combinations representing the extremes of risk were included: combination A (score 1) and combination J (score 10), corresponding to the lowest and highest risk, respectively.

After this grading, an ordinal logistic regression was performed to estimate the weight of each risk factor (regression coefficient) on the probability of disease introduction, according to expert knowledge. Using the coefficients of each risk factor in the model, we categorized farms located within 50 km of the Mato Grosso–Bolivia border according to the presence or absence of these factors, applying an additive model. This allowed us to generate a proxy risk for farms in the border region, supporting the implementation of risk-based surveillance based on the highest estimated risks. The farm database was obtained from the computerized system of the Official Veterinary Service (OVS) of the State of Mato Grosso based on data from January 2026.

Risk factors for each target disease:
Foot and Mouth Disease (FMD)
The risk factors considered in the epidemiological risk analysis model were: cattle density; location in relation to the border line (up to 15 km) or within the border region (up to 50 km); high inflow of cattle; presence of multiple species susceptible to FMD; whether the farm is binational; presence of an international gate; and road density, which facilitates animal movement.
Classical and African Swine Fever (CSF and ASF)

The risk factors considered were: pig density; presence of free-ranging feral pigs; subsistence pig production systems; swill feeding; location within the border region (up to 50 km); road density; and human population density, as these factors are related to the movement of people and the transport of potentially infected animals and animal products.

Avian Influenza and Newcastle Disease

The risk factors considered were: domestic poultry density; proximity to migratory bird sites; farms with multiple poultry species (e.g., ducks, also chickens, guinea fowl, turkeys); location within the border region (up to 50 km); proximity to water bodies; road density; and human population density.

The output of this risk analysis was a list of farms for each target disease, from which we selected the top 50% (median) highest-risk farms for Foot and Mouth Disease, Avian Influenza, and swine fevers.

The list of farms to be visited was provided to official veterinarians who work in 10-day shifts in the region, rotating over time. Farm selection has already been randomized through the end of 2026, and for subsequent years, new analyses will be performed, since risks are dynamic and may change over time. As a result, farms may increase or decrease in risk, making this risk analysis model dynamic and more sensitive for detecting disease introduction.

This methodology was implemented starting in February 2026, with four teams (each composed of one official veterinarian and one veterinary assistant) per 10-day shift. Each team received a list of 16 farms where they were required to conduct surveillance activities in four regions along the Mato Grosso–Bolivia border, known as ‘Corixinha’, ‘Las Petas’, ‘Ponta do Aterro’, and ‘Marphil’.

At the farms, official veterinarians perform not only active surveillance but also mainly animal health education for producers and animal caretakers, teaching them how to identify clinical signs and lesions of these transboundary animal diseases and also emphasizing the importance of timely notification to the Official Veterinary Service (OVS) when they notice something unusual in their animals.

Results

Figure 1 shows the farms assigned for surveillance activities during the initial phase of implementation (February–March 2026). The Bolivian departments bordering Mato Grosso (San Ignacio de Velasco, San Rafael, and San Matías) are highlighted in orange. The colored dots represent farms assigned to each region: Marphil is shown in pink, Ponta do Aterro in dark orange, Las Petas in blue, and Corixinha in grey.

After ranking farms according to their risk (using the median to select the top 50% highest-risk farms), a database of 3,134 farms was generated. For the selection of 16 farms per team, per region, through the end of 2026, a proximity-based random selection was performed using the RStudio data analysis software [3]. A maximum distance of 100 km (straight-line distance) was defined between one randomly selected farm (seed) and the remaining fifteen farms. After this process, a total of 2,048 farms were selected. Each list is made available through a dashboard in Microsoft Power BI, facilitating access to farm names and geographic coordinates and optimizing field location. This approach ensured logistical feasibility while maintaining spatial representativeness of high-risk farms.

During the initial implementation period, 384 farms were planned for surveillance activities based on risk prioritization in the four regions along the Mato Grosso–Bolivia border. Of these, 337 farms were effectively visited, while 47 were not completed.

Execution varied across regions, with 81.2% of planned farms visited in Corixinha and Las Petas, 93.8% in Ponta do Aterro, and 94.8% in Marphil.

A total of 571 surveillance forms (FVV) were issued during the study period, covering both risk-based selected farms and additional surveillance activities conducted as part of routine field operations, such as animal movement inspections.

During these activities, 150,244 cattle, 4,350 sheep, 2,464 pigs, 144 poultry, and 47 goats were inspected. Clinical examination was performed on 12,670 poultry, 1,443 cattle, 28 pigs, and 4 sheep.

Animal health education was incorporated into all field activities and was delivered during these surveillance visits, focusing on improving the recognition of clinical signs of transboundary animal diseases and reinforcing timely notification to the Official Veterinary Service.

Discussion

Risk-based surveillance is increasingly used as a strategy to optimize limited resources in animal health systems, especially in large territories with heterogeneous risk profiles. By prioritizing farms with a higher

probability of disease introduction, surveillance efforts can be more efficiently allocated without compromising coverage.

The integration of passive surveillance through farmer engagement is a key component of early detection systems. In remote and border areas, where continuous official presence is limited, the ability of farmers to recognize and report suspicious events becomes essential for a timely response. The combination of targeted active surveillance and strengthened passive surveillance contributes to a more sensitive and responsive system, particularly in regions under constant risk of disease introduction.

The implementation of this approach in the Mato Grosso–Bolivia border region showed that it is feasible under field conditions. The prioritization of farms based on epidemiological risk factors allowed a structured allocation of surveillance activities, which is particularly important in extensive and logistically challenging regions.

Mato Grosso has a long and accessible international border with Bolivia. Although Bolivia has a similar sanitary status to Brazil regarding Foot and Mouth Disease (free without vaccination), it is not free from Classical Swine Fever. In addition, as this involves two different national veterinary services, it is not possible to ensure that a disease outbreak would be detected and contained on the Bolivian side before spreading into Mato Grosso. Therefore, the border region should be considered an area of increased risk for disease introduction.

The proportion of planned farms effectively visited (337 out of 384) indicates a high level of operational execution, although differences among regions were observed. Lower execution in some areas was mainly associated with logistical constraints, such as long travel distances, poor road conditions, and limited accessibility. These factors highlight the importance of considering operational feasibility when designing surveillance strategies in border regions.

The number of surveillance forms issued (571 FVV) exceeded the number of farms selected through the risk-based approach, reflecting the integration of targeted surveillance with routine field activities. Although these additional activities were not part of the initial prioritization, they contributed to strengthening the overall surveillance system and increasing the likelihood of detecting unusual events.

An important aspect of this approach was the incorporation of animal health education into surveillance activities. By engaging producers and animal caretakers during farm visits, the strategy aimed to improve recognition of clinical signs and reinforce timely notification to the Official Veterinary Service. This is particularly relevant in areas where access is limited and continuous monitoring is challenging.

The large number of animals inspected during the study period demonstrates the capacity of the system to achieve substantial epidemiological coverage, particularly for diseases of major economic importance such as Foot-and-Mouth Disease, Classical and African Swine Fever, and Avian Influenza.

Overall, this experience shows that combining risk-based surveillance with field implementation and farmer engagement can be a practical and scalable strategy for strengthening animal health systems in border regions. Continuous updating of risk factors and periodic reassessment of prioritized farms will be essential to maintain system sensitivity over time.

Conclusion

This epidemiological model focuses on the introduction of diseases rather than their spread. Identifying farms with a higher probability of infection based on the presence of risk factors, and directing surveillance efforts accordingly, contributes to increasing the sensitivity of the surveillance system by strengthening passive surveillance. This approach represents an important advance for the surveillance of transboundary animal diseases and enhances protection of the country's sanitary status at its 'entry point' through the state of Mato Grosso.

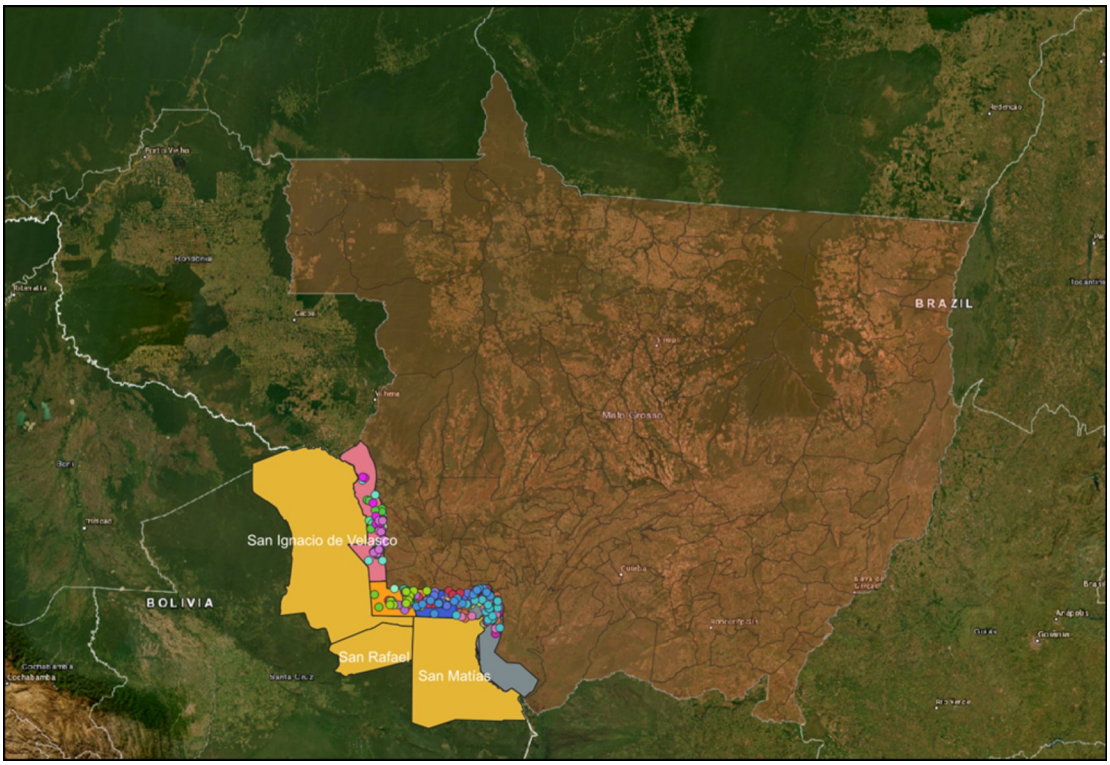


Figure 1. Map of the Mato Grosso–Bolivia border showing farms assigned from shift 1 (02/01/2026–02/10/2026) to shift 6 (03/20/2026–03/31/2026), and the regional divisions used to optimize field surveillance activities.

Keywords: Risk Assessment, Risk-based Surveillance, Transboundary Animal Diseases, Ordinal Logistic Regression, Official Veterinary Service.

References:

1. [1] D. N. Schettino et al., “Risk for African Swine Fever Introduction Into Kazakhstan,” Front. Vet. Sci., vol. 8, no. February, pp. 1–11, 2021, doi: 10.3389/fvets.2021.605910.
2. [2] IBM Corp., “IBM SPSS Statistics for Windows (Version 26.0).” Armonk, NY.
3. [3] RStudio Team, “RStudio: Integrated Development for R. RStudio, Inc.” Boston, MA, 2024. [Online]. Available: http://www.rstudio.com/