World Organisation for Animal Health

TECHNICAL ITEM I

Use of epidemiological models to support decision-making in Veterinary Services

Author: María V. Iriarte[1,2]
Co-author: José L. Gonzáles[3]

[1] General Directorate of Livestock Services, Ministry of Livestock, Agriculture and Fisheries, Montevideo, Uruguay.
[2] Faculty of Veterinary Medicine, University of the Republic (Uruguay), Montevideo, Uruguay.
[3] Department of Epidemiology, Bioinformatics & Animal Models, Wageningen Bioveterinary Research, Lelystad, The Netherlands.

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1. Summary

The Americas have achieved substantial progress towards the eradication of foot-and-mouth disease (FMD), with the great majority of the regional cattle population located in countries or zones recognised as FMD-free. In this evolving epidemiological context, maintaining effective capacities for prevention, surveillance, preparedness and rapid response remains essential to sustain these achievements.

Epidemiological and mathematical modelling can complement traditional epidemiological approaches by supporting preparedness and contingency planning, exploring potential outbreak scenarios, identifying areas and populations at risk, evaluating alternative control and vaccination strategies, and anticipating operational resource requirements. Modelling can therefore provide evidence not only for emergency decision-making but also for identifying preparedness needs before an emergency occurs. When combined with economic analyses, modelling can also inform resource allocation and investment decisions.

To assess current experience, capacities and needs, a questionnaire was distributed among the 33 Members of the WOAH Regional Commission for the Americas. A total of 26 Members (79%) responded. Most responding Veterinary Authorities (VAs) reported previous experience with epidemiological modelling, and preparedness emerged as the area in which modelling was considered to provide the greatest value. In the event of an imminent foot-and-mouth disease virus (FMDV) threat, respondents identified practical modelling needs related to risk mapping, resource requirements, the evaluation of stamping out policy versus emergency vaccination, and the identification of emergency vaccination strategies.

The survey also identified important capacity needs. While most responding Veterinary Authorities reported access to personnel capable of interpreting and developing models, responding Members also reported limited familiarity with the criteria for assessing model quality and reliability. Limited capacity to interpret model outputs emerged as a particularly important perceived barrier, while data quality, transparency, appropriate representation of the epidemiological context, and communication of uncertainty and limitations were considered important for confidence in modelling results.

Strengthening modelling capacity in the region should therefore extend beyond technical model development. Veterinary Authorities need the capacity to formulate relevant questions, critically interpret modelling evidence and translate results into operational decisions, supported where appropriate by specialised external expertise. Integrating modelling into preparedness activities and simulation exercises could help identify operational and resource constraints before emergencies occur, while regional cooperation and collaboration with universities, research institutions and international organisations could contribute to building and sustaining these capacities.

2. Introduction

The Americas have made substantial progress towards the eradication of foot-and-mouth disease (FMD), with 99% of the regional cattle population located in FMD-free countries or zones by 2025 (Centro Panamericano de Fiebre Aftosa y Salud Pública Veterinaria (PANAFTOSA-SPV), 2025). Similarly, the vast majority of countries in the region have remained free from African swine fever (ASF). However, the recent spread of highly pathogenic avian influenza (HPAI) across the Americas (Pan American Health Organization (PAO), 2025), together with the evolving global epidemiological dynamics of major transboundary animal diseases, highlights the continuous threats to animal health and livestock production in the region. These threats are further illustrated by recent shifts in global FMD virus (FMDV) distribution, notably the unexpected expansion of serotypes such as SAT1 beyond their traditional endemic regions in Africa (WOAH/FAO FMD Reference Laboratory Network, 2026; World Organisation for Animal Health (WOAH), 2026). In this context of evolving global animal health risk, maintaining effective capacities for prevention, surveillance, preparedness and emergency response remains essential. Epidemiological modelling can support Veterinary Authorities in anticipating potential outbreak scenarios, evaluating alternative control strategies and estimating the resources required for an effective response.

Preparedness for an animal health emergency requires decisions to be made under uncertainty and often within limited timeframes. Veterinary Services may need to anticipate where and how rapidly disease could spread, identify populations or areas at greatest risk, assess the potential consequences of delayed detection, compare alternative control strategies, determine vaccination approaches and estimate the human, logistical and financial resources required for an effective response.

Epidemiological and mathematical models provide a means of exploring such questions in a structured and quantitative manner (Hagenaars et al., 2011). By integrating epidemiological knowledge with available data, models can be used to simulate alternative scenarios and explore the potential consequences of different assumptions and interventions. They can therefore complement surveillance, risk assessment and field epidemiology by providing additional evidence to support preparedness, contingency planning and emergency decision-making (Backer, Engel, et al., 2012; Backer, Hagenaars, et al., 2012; Boender et al., 2007, 2010; Cardenas et al., 2024; Cardenas, Santos, et al., 2025; Harvey et al., 2007; Iriarte Barbosa, 2026). When combined with economic analyses, modelling outputs can also support the assessment of the costs and economic consequences of alternative control strategies, providing additional evidence for decision-making (Cardenas, de Menezes, et al., 2025; Rich & Winter-Nelson, 2007).

Modelling can also support resource planning by estimating the personnel, vaccination capacity and other operational resources required under different outbreak scenarios and control strategies (Garner et al., 2016; Sanson et al., 2022). This application is particularly relevant in the context of the broader challenge of ensuring adequate and sustainable investment in Veterinary Services. The Technical Item presented at the 93rd General Session of WOAH highlighted the importance of strengthening the evidence base to support investment decisions and improve resource allocation in animal health (Berthe et al., 2026). Epidemiological modelling can contribute to this evidence base by anticipating resource requirements under alternative outbreak scenarios and control strategies, thereby supporting investment and preparedness decisions before an emergency occurs.

However, the usefulness of modelling does not depend solely on the availability of advanced modelling approaches. Their effective application within Veterinary Services requires appropriate and sufficiently reliable data, the ability to formulate relevant operational questions, access to modelling expertise, and the capacity to understand model assumptions, uncertainty and limitations. Equally important is the ability to translate modelling outputs into information that can be used by decision-makers (Kao et al., 2023).

This Technical Item is also aligned with WOAH's 8th Strategic Plan (2027-2031), in particular with Strategic Orientation Two, which aims to strengthen Members' animal health systems and their capacity to prevent, detect and respond to animal health emergencies. By supporting evidence-based decision-making, preparedness and emergency management, strengthening capacity and cooperation across the region, epidemiological modelling can contribute to the implementation of those objectives (World Organisation for Animal Health (WOAH), 2026).

In this context, this Technical Item explores the role of epidemiological and mathematical modelling as a complementary tool for Veterinary Services in the Americas, using FMD as a practical example to illustrate how modelling can support preparedness and decision-making. Its overall objective is to explore the value of modelling in supporting preparedness, emergency response and strategic planning, thereby contributing to evidence-based decision-making and more informed investment in animal health systems.

Specifically, the Technical Item aims to assess current capacities, limitations and needs of Veterinary Services in the Americas regarding the use of modelling tools, and to explore how modelling approaches could be better integrated into preparedness plans, surveillance systems, emergency response frameworks, resource planning and investment decisions.

3. Approach

A structured questionnaire was distributed to the 33 WOAH Members of the Regional Commission for the Americas in 2026 to collect information on the current use of epidemiological models within Veterinary Authorities (VAs) and to identify existing capacities, limitations and priority needs for strengthening their application in animal health decision-making.

The questionnaire explored the use and frequency of epidemiological modelling, the purposes for which models have been applied, and the institutions providing modelling expertise. It also assessed Members' perceptions of the relevance and potential applications of modelling. Members were asked to report on their capacity to develop and interpret models, their familiarity with criteria for assessing model quality and reliability, as well as the factors influencing confidence in modelling results. Particular attention was given to the potential use of modelling for preparedness and response to an imminent FMDV incursion. Finally, Members were asked to identify barriers to the use of modelling and priority areas for capacity building.

Responses were analysed descriptively to identify regional trends, existing technical and institutional capacities, perceived barriers, and priority areas for regional cooperation and capacity building. For questions allowing multiple selections, each response option was analysed separately.

4. Findings

A total of 26 of the 33 Members (79%) of the Regional Commission for the Americas responded to the questionnaire. The list of responding Members is provided in Annex 1.

The findings of this questionnaire should be interpreted in light of the following limitations: firstly, the questionnaire relied on self-reported information; secondly, seven of the 33 Members of the Regional Commission did not respond. Furthermore, respondents may have interpreted the concept of epidemiological modelling differently depending on their institutional context and previous experience. Therefore, the results should be understood as indicating regional patterns, reported practices, and perceived capacity-building needs rather than as an objective assessment of national modelling capacities.

4.1. Current use of epidemiological modelling

Epidemiological modelling is already used by most responding VAs in the Americas. Twenty-two of the 26 respondents (85%) reported that their VA had used epidemiological models to support animal health decision-making. Modelling had been used within the VA, through external institutions, or through a combination of both, with the latter being the most frequently reported arrangement (9/26; 35%) (Figure 1, panel A). Four respondents (15%) indicated that their VA had never used epidemiological models for decision-making.

Among respondents reporting previous use of epidemiological models (n=22), preparedness and contingency planning was the most frequently reported application (73%). Models were also used to support outbreak response, resource planning and economic impact assessment, although less frequently (Figure 1, panel B).

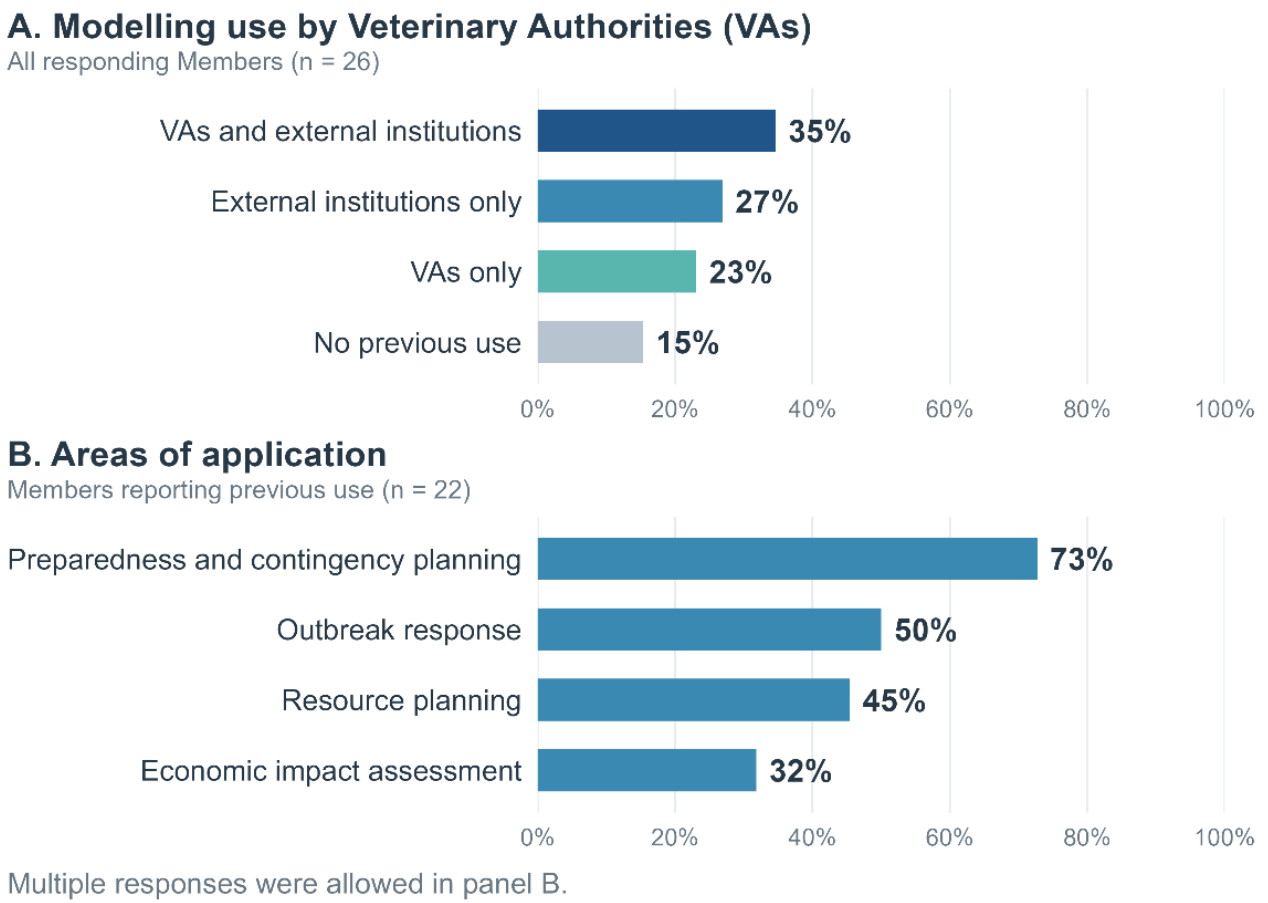


Figure 1 Current use of epidemiological modelling among responding Veterinary Authorities in the Americas. (A) Use of epidemiological models by Veterinary Authorities (VAs), external institutions, or both (n=26). (B) Reported areas of application among respondents with previous experience using epidemiological models (n=22). Multiple responses were allowed in panel B.

The frequency of use varied among respondents. During the previous five years, 10 respondents (38%) reported using epidemiological models one or two times, seven (27%) three to five times, and three (12%) more than five times. Six respondents (23%) did not know how frequently models had been used.

Respondents identified several institutions as sources of modelling expertise, most frequently the VA itself (15/26; 58%), followed by international organisations (12/26; 46%), universities (11/26; 42%) and external consultants (5/26; 19%). Other government agencies, research institutes and national laboratories were also mentioned.

4.2. Perceived relevance and potential applications of modelling

All respondents considered epidemiological modelling relevant to the current work of VAs. Thirteen (50%) considered models highly relevant and a core part of their decision-making or planning, while 13 (50%) considered them potentially relevant, primarily relying on other tools or established protocols.

There was broad agreement regarding the types of questions that epidemiological models could help address. Twenty-five respondents (96%) identified both understanding how disease might spread within or between holdings and identifying geographical areas, production systems or animal populations at greatest risk of disease introduction or spread. Twenty-one respondents (81%) considered models useful for assessing the potential impact of delayed disease detection.

Models were also considered useful for assessing the expected impact of vaccination strategies (20/26; 77%), estimating the likely size and duration of an outbreak under different control strategies (20/26; 77%), and evaluating the costs and benefits of different intervention strategies (20/26; 77%). Nineteen respondents (73%) identified the estimation of operational resources required to control an outbreak as a potential application.

When respondents were asked in which areas epidemiological modelling could add the greatest value to their work, preparedness was selected by all 26 respondents (100%). Outbreak response was selected by 20 respondents (77%), post-outbreak assessment, referring to demonstrating that the measures taken were appropriate and that the outbreak was fully resolved, by 17 (65%), and post-outbreak evaluation, referring to assessing the overall effectiveness and economic impact of the implemented control measures, by 15 (58%).

4.2.1. Modelling needs in the event of an imminent FMDV threat

As a small case study within the questionnaire, respondents were asked what they would request from a modelling team if an FMDV incursion represented an imminent risk to their country. Risk maps identifying areas at highest risk of introduction and spread were the most frequently selected output (23/26; 88%).

Other frequently identified needs were estimates of the resources required to control an outbreak and evaluation of stamping out policy versus emergency vaccination (21/26; 81% each), as well as identification of an optimal emergency vaccination strategy (19/26; 73%) (Figure 2).

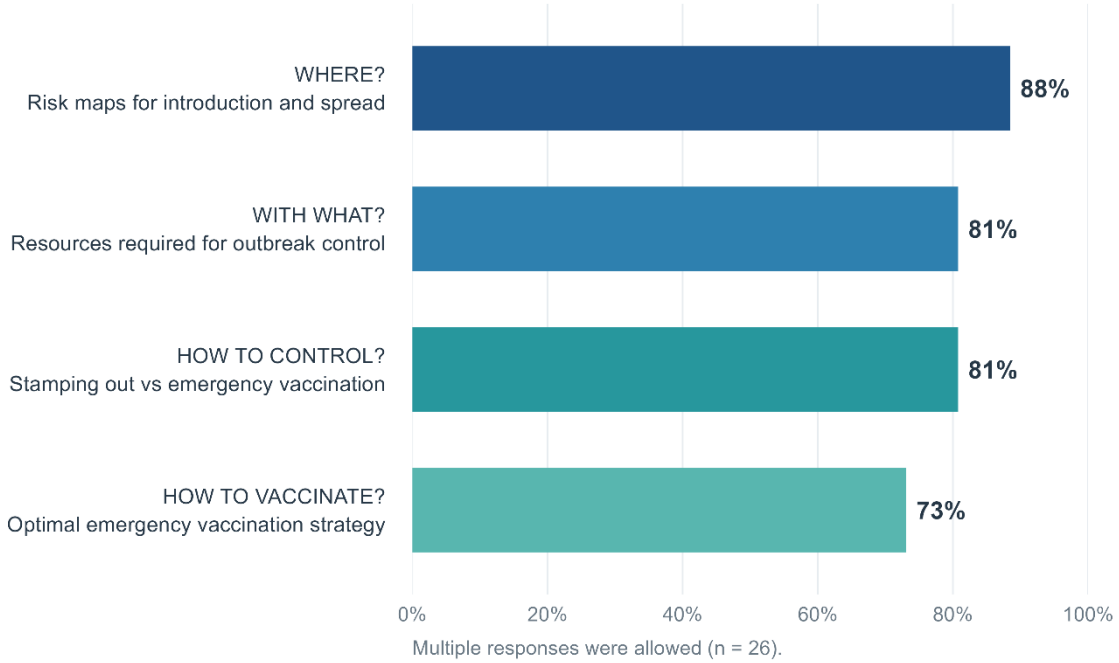


Figure 2 Modelling outputs that Veterinary Authorities would request in the event of an imminent FMDV threat. Multiple responses were allowed (n=26)

4.3. Capacity to interpret, develop and assess epidemiological models

Access to personnel capable of interpreting epidemiological model outputs was reported by 22 of 26 respondents (85%), compared with 19 respondents (73%) reporting access to personnel capable of developing epidemiological models. In both cases, expertise could be available within the VA, through external institutions, or through a combination of both (Figure 3).

Responding Members reported limited familiarity with the criteria used to assess the quality and reliability of epidemiological models. Most respondents (19/26; 73%) reported being only partially familiar with these criteria, while five (19%) reported not being familiar and only two (8%) reported being familiar with them (Figure 3).

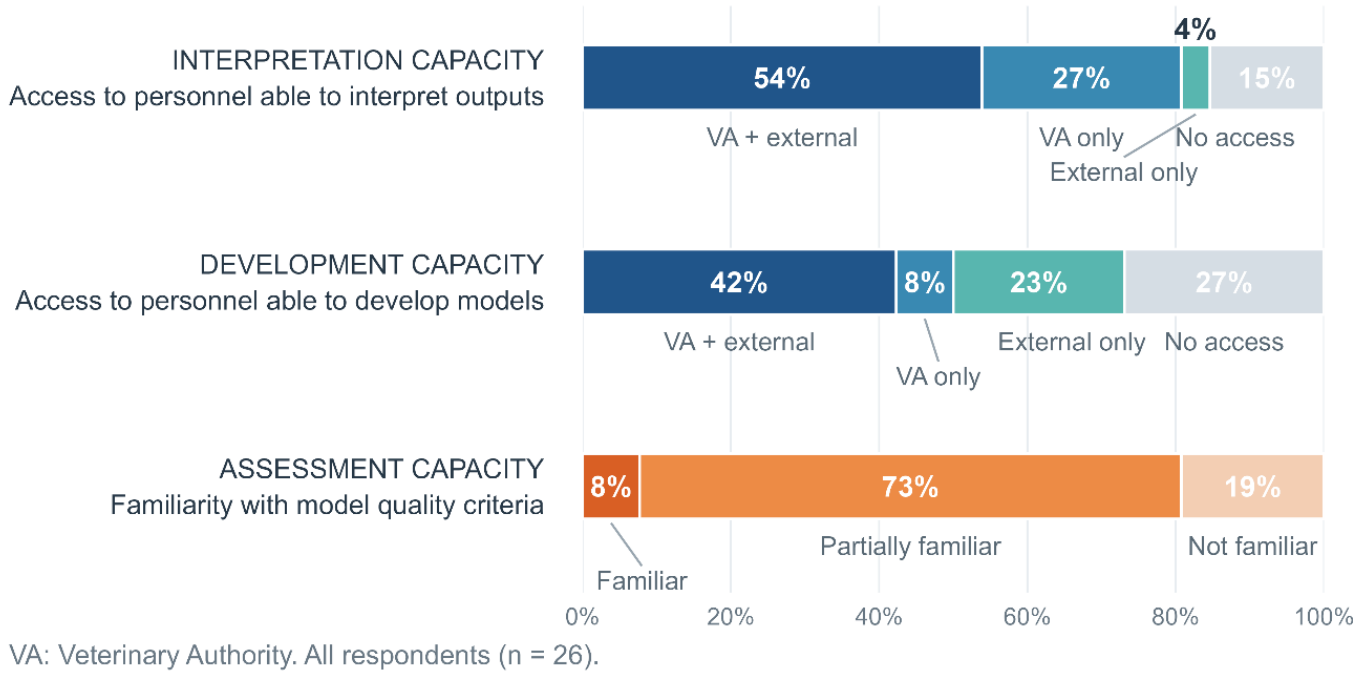


Figure 3 Reported access to personnel capable of interpreting and developing epidemiological models, and familiarity with criteria for assessing model quality and reliability (n=26).

4.4. Factors influencing trust in modelling results

Data quality was identified as the most important factor for trusting model results, being selected by all 26 respondents (100%). Transparency of model structure, assumptions and methods, the use of country-specific or real-world epidemiological data, and clear communication of uncertainty in model results were each selected by 19 respondents (73%).

Other factors identified as important for trusting model results included clear explanation of model limitations (18/26; 69%), expert involvement in model development and interpretation (14/26; 54%), and validation against historical outbreaks or independent data (12/26; 46%).

4.5. Barriers and capacity-building needs

Several perceived barriers to the successful implementation of epidemiological models within the VA were considered important by a large proportion of respondents. Limited staff capacity to interpret model outputs was the most frequently identified barrier (24/26; 92%), while funding, capacity to develop models, data limitations and access to modelling tools were also frequently considered important (Figure 4). In contrast, limited confidence or trust in the reliability and usefulness of model outputs showed a more mixed pattern, with 10 respondents (38%) considering it important, 12 (46%) neutral and four (15%) not important.

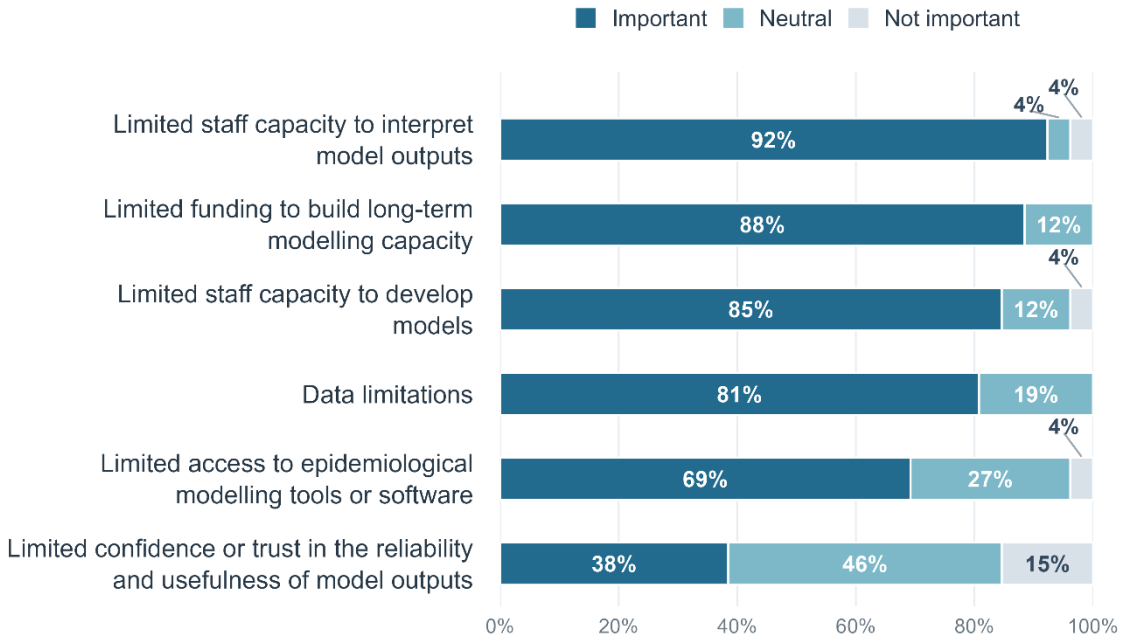


Figure 4 Perceived importance of potential barriers to the successful implementation of epidemiological models within Veterinary Authorities (n=26).

All 26 respondents (100%) indicated that their VA would be interested in strengthening its capacities in epidemiological modelling. Training in the development, use and interpretation of epidemiological models was the most frequently identified form of support (22/26; 85%), followed by access to user-friendly modelling tools (21/26; 81%) and guidance on integrating model results into decision-making (19/26; 73%). A range of additional needs related to data access, expert support, region-specific models and institutional collaboration were also identified (Figure 5).

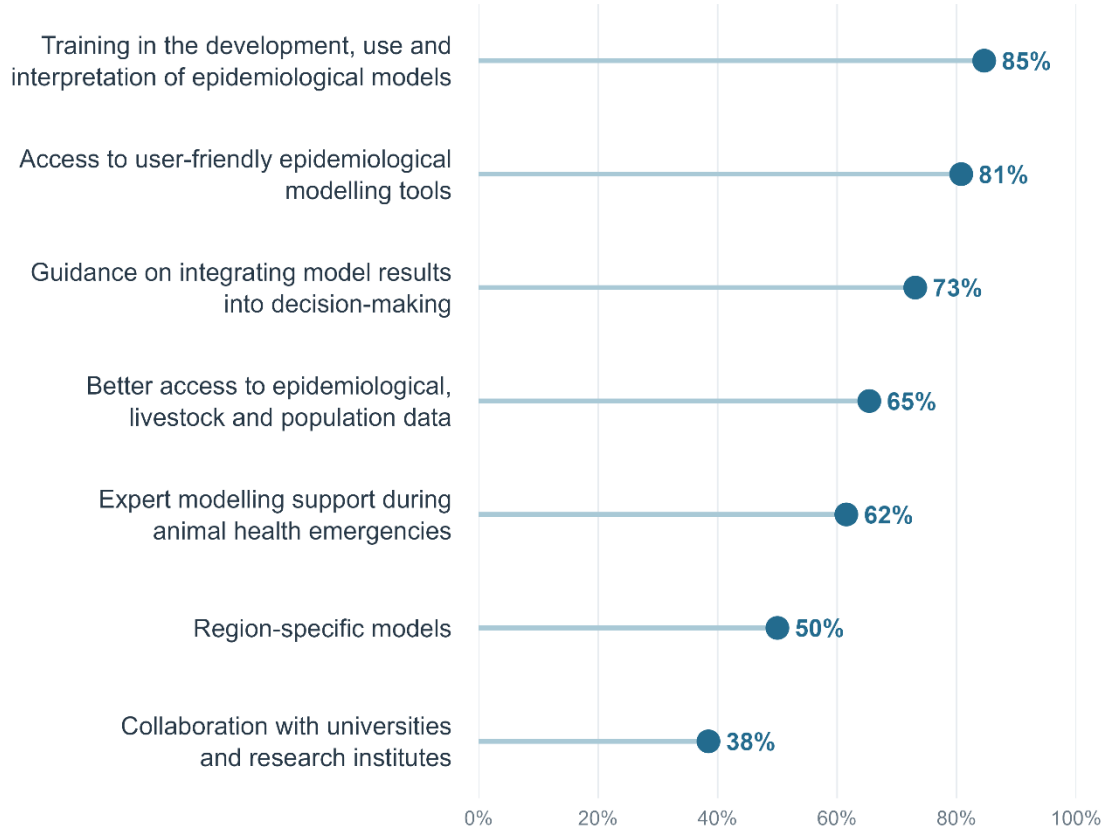


Figure 5 Forms of support identified by Veterinary Authorities for strengthening capacities in epidemiological modelling (n=26). Multiple responses were allowed.

5. Discussion

The widespread reported use of epidemiological modelling across the region provides an important foundation for its further integration into Veterinary Services. The involvement of both internal and external expertise also suggests that assessment of the modelling capacity of Members should be considered beyond the boundaries of the VA itself, recognising the potential contribution of universities, research institutes, international organisations and other technical partners. Building on these existing capacities may provide a more feasible approach to strengthening the systematic use of modelling for animal health decision-making.

However, the survey also indicates that modelling is not yet used systematically across Veterinary Services. While 22 out of 26 respondents (85%) reported previous use of epidemiological models, half of all respondents considered modelling to be potentially relevant rather than a core component of their decision-making or planning. This suggests that it is important to support conditions that enable models to become more routinely integrated into animal health decision-making.

Preparedness emerges as a particularly relevant area for the application of epidemiological modelling. This is especially important in the current HPAI and FMD context in the Americas, where maintaining preparedness and rapid response capacities is essential to sustain the sanitary situation and achievements of the region. Before an emergency occurs, modelling can be used to explore potential outbreak scenarios, identify areas or populations at higher risk, assess the consequences of delayed detection, compare the cost-effectiveness of alternative control strategies, evaluate emergency vaccination options, and estimate the resources (e.g. requirements for vaccine stocks, personnel, humane killing/disposal, laboratory capacity, etc) that may be required for an effective response (Backer, Engel, et al., 2012; Backer, Hagenaars, et al., 2012; Boender et al., 2010; Cardenas et al., 2021, 2026; Cardenas, Santos, et al., 2025; Iriarte Barbosa, 2026; Prosser et al., 2024; Rawson et al., 2025). Incorporating these modelling applications into simulation exercises provides an opportunity to test response strategies and operational capacities before an emergency occurs.

The importance given to resource estimation in the questionnaire is particularly relevant from a preparedness perspective. When faced with a hypothetical imminent FMDV threat, 21 of 26 respondents (81%) indicated that they would request estimates of the resources required to control an outbreak. Resource availability is not only a logistical consideration but can also influence epidemic outcomes (Sanson et al., 2022). By estimating resource requirements under different outbreak scenarios and control strategies, modelling can help VAs identify critical capacity gaps and assess how available resources could be allocated most effectively. This may inform decisions on staffing, vaccine stocks, diagnostic capacity and other operational needs, as well as help prioritise investments to strengthen preparedness and response capacity (Boklund et al., 2017; Seitzinger et al., 2022). When combined with economic analyses, these estimates can also contribute to selecting cost-effective control strategies (Cardenas, de Menezes, et al., 2025) and assessing the potential benefits of investing in preparedness before an emergency occurs (Gilbert et al., 2023). Together, these applications can strengthen the evidence base for resource allocation and investment decisions, as highlighted by Berthe et al. (2026).

While preparedness was identified as the area where modelling could add the greatest value, respondents also identified important applications during outbreak response and post-outbreak assessment and evaluation. For modelling to effectively support preparedness and emergency response, it should be driven by the decisions that VAs need to make rather than by the availability of particular modelling techniques. Questions related to where disease is most likely to spread, which populations should be prioritised, whether and how emergency vaccination should be implemented, or what resources may be required have direct operational implications. Defining these questions in advance can help determine the appropriate modelling approach, identify the data required and ensure that outputs are produced at the level and within the timeframe needed for decision-making. This is particularly important during animal health emergencies, when decisions must often be made rapidly and under considerable uncertainty.

This decision-oriented perspective also has implications for how modelling capacity is defined. Developing models represents only one component of that capacity. While limited staff capacity to develop or build models was considered an important barrier by 22 of 26 respondents (85%), limited capacity to interpret model outputs was identified even more frequently (24/26; 92%). Consistent with this, two of the most frequently requested forms of support were training in the development, use and interpretation of models (22/26; 85%) and guidance on integrating model results into decision-making (19/26; 73%).

This need is also reflected in the relatively limited familiarity with criteria for assessing model quality and reliability: 19 of 26 respondents (73%) reported being only partially familiar with these criteria, while five (19%) were not familiar with them. VAs would benefit from strengthening competencies beyond model development. They need to be able to formulate relevant epidemiological and operational questions, understand the assumptions and limitations underlying a model, critically interpret its outputs, and assess whether those outputs are appropriate for the decision under consideration. Strengthening these competencies may therefore be as

important as increasing technical capacity to build models. In particular, strengthening the capacity of epidemiologists and decision-makers to understand and critically assess modelling approaches and outputs could facilitate more effective interaction with modelling specialists and help bridge the gap between model development and operational application.

Not every VA necessarily needs to have the capacity to develop complex epidemiological models in-house. In this survey, 17 of 26 respondents (65%) reported access to model development capacity through external institutions, either alone or in combination with capacity within the VA. Specialised modelling expertise requires technical skills, appropriate software, data infrastructure and sustained investment that may be difficult to maintain in every institution. A collaborative model may therefore be more realistic, combining specialised expertise available in universities, research institutes, government agencies or regional and international organisations with the epidemiological knowledge and decision-making responsibilities of VAs. Within such an arrangement, VAs retain a central role in defining the problem, providing and interpreting the epidemiological context, assessing the operational feasibility of potential interventions and ultimately translating modelling evidence into action.

The usefulness of such collaborations will depend not only on technical expertise but also on the credibility and relevance of the evidence produced. Data quality was identified by all respondents (26/26; 100%) as an important factor for trusting model results, making it the most frequently selected factor influencing confidence in modelling outputs. This highlights the importance of using appropriate and reliable data to parameterise and validate epidemiological models. Similarly, transparency regarding model structure and assumptions, explicit consideration of uncertainty and limitations, and the use of data that adequately represent the population and production systems under consideration are important for interpreting results appropriately. Models should therefore be assessed not only in terms of technical performance, but also in terms of whether they are fit for purpose for the specific decision they are intended to support.

Capacity building should therefore extend beyond technical training in model development. A more comprehensive approach should combine the capacity to interpret and critically assess models with access to appropriate tools, reliable data and technical support, as well as guidance on how modelling evidence can inform decision-making. User-friendly tools can facilitate access to modelling, but their effective use requires an understanding of their assumptions, data requirements, uncertainty and limitations. Ultimately, capacity-building efforts should aim to connect technical modelling capabilities with their practical application in preparedness and emergency response.

This is particularly relevant for FMD in South America, where livestock production systems may differ from those in which many existing transmission parameters were estimated. Differences in population structure, farm density and contact patterns can influence disease transmission and the effectiveness of control strategies (Keeling et al., 2001; Perez et al., 2004). Recent studies in Uruguay, Brazil and Bolivia highlight the importance of generating epidemiological evidence that reflects regional production systems and adapting modelling approaches to local conditions (Cardenas et al., 2022; Cardenas, Santos, et al., 2025; Iriarte Barbosa, 2026).

Long-term sustainability is another important consideration. Maintaining modelling capacity requires sustained investment in personnel, data systems, tools and institutional collaboration, as well as opportunities to apply and maintain skills between emergencies. Integrating modelling into contingency planning and simulation exercises could provide a practical mechanism for this, allowing VAs and modelling teams (internal or external) to work together under non-emergency conditions, test alternative strategies, assess data availability and identify capacity gaps before they become critical during an outbreak.

Regional cooperation could further strengthen and sustain modelling capacity. Rather than requiring each Member to independently develop the full range of specialised expertise, regional networks could facilitate the sharing of knowledge, methodological approaches, tools and experience, while providing access to specialised support when needed. WOAH Collaborating Centres, together with academic institutions and other technical partners, could play an important role in facilitating regional cooperation, providing technical expertise and supporting capacity-building activities. Establishing and exercising these collaborations during preparedness activities would be particularly important, as developing partnerships, accessing data and defining decision questions only after an outbreak has begun may limit the timeliness and usefulness of modelling support.

The potential role of modelling therefore extends across the emergency management cycle, from preparedness and planning through outbreak response and post-outbreak assessment and evaluation. In this context, epidemiological modelling should be considered as one of the tools available to support evidence-based animal health decision-making. When combined with economic analyses, epidemiological modelling can also inform the assessment of alternative control strategies, resource allocation and investment decisions. It should complement surveillance, field epidemiology, risk assessment, expert knowledge and operational experience. Its value will depend on asking relevant questions, using appropriate data and methods, understanding assumptions and uncertainty, and translating results into timely and actionable information. The challenge for

the region is therefore to strengthen the capacities and institutional conditions needed to translate modelling evidence into informed decisions and practical action.

6. Conclusions

The findings of the regional survey highlight the potential of epidemiological modelling to support animal health decision-making across the Americas. They show that modelling is already being used by Veterinary Authorities in the region, while also identifying opportunities to strengthen its integration into preparedness, contingency planning and emergency response.

The main challenge is not only to ensure access to specialised modelling expertise, but also to translate modelling outputs into relevant and actionable information for decision-making. Building on existing capacities and fostering regional cooperation could help strengthen the practical application of modelling and support more informed decisions on animal health prevention, preparedness and emergency response throughout the Americas.

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Annex 1 Members of the WOAH Regional Commission for the Americas that responded to the questionnaire

A total of 26 of the 33 Members of the WOAH Regional Commission for the Americas (79%) responded to the questionnaire on the use of epidemiological modelling in Veterinary Services.

The responding Members are listed below in alphabetical order:

1. Argentina
2. Bahamas
3. Belize
4. Bolivia
5. Brazil
6. Canada
7. Chile
8. Colombia
9. Costa Rica
10. Curaçao
11. Dominican Republic
12. Ecuador
13. El Salvador
14. France
15. Guatemala
16. Honduras
17. Jamaica
18. Mexico
19. Panama
20. Paraguay
21. Peru
22. Saint Lucia
23. Saint Vincent and the Grenadines
24. Trinidad and Tobago
25. United States of America
26. Uruguay

Note: This list acknowledges the participation of Members in the questionnaire. Survey results are presented in aggregate form, without attributing individual responses to specific Members.