# World Animal Health Information System (WAHIS) as a tool to support decision making and research in animal health

P. Cáceres* (1), L. Awada (1), L. Weber-Vintzel (2), R. Morales (3), M. Meske (4) & P. Tizzani (1)

(1) World Animal Health Information and Analysis Department, World Organisation for Animal Health, 12 rue de Prony, 75017 Paris, France

(2) Data Integration Department, World Organisation for Animal Health, 12 rue de Prony, 75017 Paris, France

(3) Science Department, World Organisation for Animal Health, 12 rue de Prony, 75017 Paris, France

(4) Status Department, World Organisation for Animal Health, 12 rue de Prony, 75017 Paris, France

*Corresponding author: information.dept@woah.org



**Summary**

The World Animal Health Information System (WAHIS) collects and publishes a wealth of information gathered by individual countries' Veterinary Services, including detailed country-specific information on outbreaks of diseases listed by the World Organisation for Animal Health (WOAH, founded as OIE), including emerging diseases, in domestic animals and wildlife, and non-listed diseases in wildlife. The dataset is one of the most comprehensive in the world as 182 Members are obliged to report this information to the WOAH in a timely manner. As such, the data provides invaluable inputs for veterinary services, animal health researchers and stakeholders to gain insight into risk from infectious diseases, for example through the development of predictive models, risk assessments to address the risk from trade of animal products, globalisation or movement of wildlife or vectors across country borders. This paper reviews previous analyses that have been

conducted using this data and outlines ways in which it can be used for preparedness and risk assessment.

**Keywords**

Animal disease notification – Early detection – Early response – Information dissemination – International trade of animals – Risk analysis – Transparency – WAHIS – WOAH – World Animal Health Information System –World Organisation for Animal Health – Self-declarations – WOAH official status.

## Introduction to WOAH and its mission

The World Organisation for Animal Health (WOAH, founded as OIE) is the international organisation in charge of animal health and welfare. Since its creation in 1924, one of its main missions has been to ensure the transparency of the global animal health situation and improve knowledge of animal diseases. To enable the WOAH to fulfil this mission, its Members are required to notify all relevant information on their animal health situation, in compliance with the provisions of their Organic Statutes and WOAH Standards [1, 2, 3]. The information submitted by Veterinary Authorities to the WOAH on events involving diseases listed by the WOAH and emerging diseases is then verified, translated into the WOAH's official languages and made publicly available through an online worldwide reference information system, better known as the World Animal Health Information System (WAHIS). The verification process consists of (a) checking the scientific consistency of the data and its alignment with WOAH standards, (b) checking consistency with previously submitted information, and (c) checking consistency with what is known about the regional and global context of the disease. If inconsistencies are detected, clarifications are requested from the reporting Member. Information is validated by WOAH only after all inconsistencies have been clarified. This information is subsequently shared publicly through the WAHIS public interface [2, 3, 4, 5].

WOAH Members have the obligation to report on their situation for a list of selected diseases. This WOAH list of diseases evolves each year,

following a robust process involving WOAH Specialist Commissions and Members. In 2022, WOAH Members were to report on a total of 120 diseases. In addition, as part of their mandate to also notify emerging diseases, WOAH Members have reported a total of 15 emerging diseases between 2005 and 2021. Finally, countries may report on a voluntary basis, information on around 50 diseases non-listed by the WOAH in wildlife, which will complement the information compulsorily provided on diseases listed by the WOAH in wildlife. As a result, the WAHIS system contains information collected as of 2005 on approximately 230 terrestrial and aquatic animal diseases affecting domestic and wild species, including zoonoses.

How is the information from this data source used for preparedness and risk assessment? Who is using the data? This article seeks to answer these questions by briefly summarising the legally binding mechanisms for disease notification to the WOAH, and the implications of disease notification for international trade, risk analysis and preparedness against disease spread from a national or country-to-country perspective and at the regional and international levels. It also outlines ways in which this information can be used in the future, as well as, the use for research and impact assessments. Examples of the use of WOAH data are provided by means of a non-systematic review of papers published in international journals, which have analysed and used WAHIS data.

## The World Animal Health Information System: a comprehensive, sensitive and modern system to collect information on animal diseases

### WAHIS system overview

The World Animal Health Information System (WAHIS) is an internet-based information and early warning system that processes data on animal diseases in real time (https://wahis.woah.org). In 2022, WAHIS data reflects the information gathered by the Veterinary Authority of WOAH Members and non-Members on 120 diseases listed by the WOAH in domestic animals and wildlife, including zoonotic diseases, in addition to emerging diseases. Access to this secure reporting site is

only available to WOAH Delegates – oftentimes the Chief Veterinary Officers – and their nominees (Focal Points). This limited access under the Delegate's supervision leads to the fact that WAHIS data are both official and confirmed animal health data [6, 7].

Following the notification of a disease event by a country's Veterinary Authority, the WOAH has a duty to disclose and disseminate this information among its Members and the international community. This essential information will allow them to take appropriate action to prevent the transboundary spread of diseases listed by the WOAH and emerging diseases. In practice, the WOAH disseminates this information through WAHIS, which is composed of two complementary information systems:

a) **An early warning system**: to collect and inform the international community, by means of immediate notifications and follow-up reports, of relevant epidemiological events as notified by WOAH Members and non-Members; and

b) **A monitoring system**: to keep track of the animal health situation for diseases listed by the WOAH in terrestrial and aquatic animals (presence or absence) over time, by means of six-monthly reports.

For both situations, the information submitted by WOAH Members (and non-Members) is verified, translated into the three WOAH's official languages as needed and then made publicly available. While this dissemination always includes a publication on the WAHIS public interface, the early warning system also involves an email alert message to all Delegates (Veterinary Authorities), as well as to a large list of subscribers (around 17,000 people worldwide) [2, 3, 4, 5].

## WAHIS and epidemic intelligence activity

With the aim of minimising the number of unreported events warranting an *immediate notification report*, and improving the transparency and timeliness of the notifications, the WOAH actively searches for non-official information, rumours and signals relating to animal health and veterinary public health events around the world since 2002. This

information is subsequently checked with their Members. Since 2018, advanced software applications have also been used to perform epidemiological intelligence activities. Currently, the WOAH retrieves information from a variety of sources, using two platforms for automatic search (the International Biosecurity Intelligence System [IBIS – Managed by the government of Australia] and Epidemic Intelligence from Open Sources [EIOS – Managed by the World Health Organization [WHO]]). Thanks to this activity, the verification output rose from 10,000 manually verified news items per year until 2017 to 120,000 items verified through automation in 2021 alone, thus further increasing the capacity of WAHIS to detect disease events [8, 9]. As a direct consequence, around 14% of *immediate notification reports* on average were annually submitted, thanks to active search and subsequent confirmation with WOAH Members (minimum 3% – maximum 28%), with large variability across the period. This percentage has stabilised to around 10% in the last few years. In other words, this value represents the increased capacity of WAHIS to report disease events due to epidemic intelligence activity.

## WAHIS sensitivity

Moreover, one of the unique features of the WAHIS system is its high sensitivity[1] to report numerous diseases events of high commercial impact (e.g. avian influenza). More specifically, the sensitivity of the system, or the capacity of WAHIS to identify the reporting countries that have tested positive for the presence of a specific disease, has increased. Several studies have demonstrated the high sensitivity of WAHIS. In addition, the number of Members and non-Members notifying their animal disease situation to the WOAH has increased considerably over the years. A study conducted in 2016 showed that the sensitivity of the system to collect disease events information through spontaneous notification from Members was very high for diseases like bluetongue, low pathogenic avian influenza, foot and mouth disease, and African swine fever [10]. For emerging diseases, such as SARS-CoV-2 in animals, WAHIS is considered one of the most complete and relevant sources for registering animal diseases and chronicling their

[1] Sensitivity: the capacity of WAHIS to detect disease events

distribution [11, 12]. A recent study using the capture-recapture technique evaluated the sensitivity of the system for Tularemia events in lagomorphs among selected North American and European countries between 70 to 90%, depending on the source used [13]. Another study using a similar approach highlighted a very high global sensitivity of WAHIS for exceptional epidemiological events as defined by WOAH standards (sensitivity higher than 90%) [14].

In summary, the WAHIS data represent: confirmed and official data, specific and sensitive, and quite comprehensive as they cover endemic situations and exceptional events for more than 120 diseases in more than 200 countries and territories.

## Use of global animal health information systems to regulate international movement, support risk analysis and improve preparedness against disease spread

### Animal disease information to regulate trade

The notification of animal diseases to the WOAH by its Members plays an important role in limiting the spread of pathogenic agents to other countries and territories, facilitating the safe trade of animals and animal products. Accurate and timely communication of animal disease information by WOAH Members is an indication of their national capacity for disease surveillance. When this information is transferred to the WOAH for dissemination, it allows countries at risk to take appropriate action in a timely manner, to prevent or prepare for the transboundary spread of diseases and trade partners to adjust their import conditions and thereby mitigate, in a timely manner, the associated animal and public health risks [7].

Early warning reporting, by means of immediate notifications and follow-up reports alerts, is the most widely used dissemination mechanism for Members and stakeholders to take rapid preventive measures to prevent a disease. Moreover, these alerts are often used for risk analysis for different purposes (e.g., to assess the risk of introduction of a disease through the importation of animal products or

the risk of exposure and spread of a disease into new areas). According to Chapter 1.1. of the WOAH *Terrestrial* and *Aquatic Animal Health Codes*, and under specific circumstances, WOAH Delegates have 24 hours after confirmation of a disease to send an immediate notification report through WAHIS. The update of an event and all its epidemiologically associated outbreaks is provided by countries on a weekly basis through follow-up reports [2, 3]. The information in these follow-up reports is essential to understand and assess the risk of disease spread and to describe the actions taken to mitigate the risk.

Another important mandate of the WOAH is to ensure safe international trade of live animals and their products. International standards are developed since 1968 and regularly revised based on the latest scientific evidence to provide recommendations to trade and move animals and products without spreading diseases and pathogens. Since 1995, the standards established by the WOAH are recognised by the World Trade Organization (WTO) and its Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) as science-based reference standards for international trade to prevent and control animal diseases, including zoonoses [15]. These standards, which allow the worldwide harmonisation of sanitary measures, enable WOAH Members to protect themselves from the introduction of animal diseases and pathogens, while avoiding the implementation of unjustified barriers to the international trade of animals, their products and by-products. While the importation of animals and their products, it is critically important to know the animal health status of the exporting (and importing) country prior to trade transactions, in order to adjust the potential mitigation measures to be taken.

## Animal disease information and risk assessment

In this context, WAHIS information on the absence of a disease available in the six-monthly reports, is highly useful and complementary to the alert messages from the early warning system. Both pieces of information should be used to inform risk analysis at global, regional and national levels, especially when combined with data such as control measures applied, including specific active or

passive surveillance in place, thus reinforcing the value of the reported absence of a disease and the data collected [16, 17]. From a quantitative point of view, in WAHIS, control measures such as targeted surveillance or vaccination (official vaccination or ring vaccination in response to an outbreak), allows Members to add the total number of animals tested/vaccinated, which makes the analysis more robust, and provides additional information to be used in qualitative and quantitative risk assessments. The information on targeted surveillance and vaccination can be provided at country level and by animal categories for domestic animals (e.g. cattle, sheep, goat, horses, etc.) and for wildlife in general.

From a risk assessment perspective, with the exception of disease absence data, the quantitative data on number of outbreaks, cases, susceptible animals and culled animals can also be used for risk assessment purposes. All the information provided in WAHIS is spatially localised (at country, administrative division, or outbreak level), thus providing additional relevant and useful information for decision makers, experts, researchers and other stakeholders

## Animal disease information to identify disease patterns and improve preparedness

Animal health information systems are indispensable not only for animal health surveillance and early warning, but also allow to identify disease patterns and their evolution. These systems also inform risk assessments and preparedness on the origin and spread of animal diseases. Following a recent study, the most sought after features in risk analysis tools were pathways of introduction and spread assessment [18]. While this information can be reported in the immediate notification reports, it should be noted that this information is often not available at the time when these immediate notification reports are submitted to the WOAH. Between 2005 and March 2021, only 27% of immediate notification reports contained this information. It is usually after an epidemiological investigation, which can take several months, that the introduction of the disease is identified, or it can sometimes remain unknown. Therefore, the monitoring of these events through

follow-up reports is essential to understand the overall situation of the disease dynamics.

An online questionnaire administered in 2020 for the purpose of assessing the use of animal health platforms, surveyed 213 respondents from 132 countries and concluded that there was a large variability among the different types of information available in animal health systems and their degree of usefulness. According to the experts surveyed, the most useful information extracted from these systems related to disease preventive and control measures. In this study, respondents from government, research and university institutions used the WAHIS system as their main platform, followed by EMPRES Global Animal Disease Information System (EMPRES-i), the Program for Monitoring Emerging Diseases (ProMED) and the Animal Disease Notification System (ADNS) of the European Union (EU) [18].

A large number of enquiries are also sent to the WOAH by people who are looking to find out whether their country is free of certain animal diseases, especially before travelling with their pets to other countries. Typically, the Veterinary Authorities of the destination country ask for different diagnostic tests, vaccinations or animal health certificates as part of the import requirements. While all animal health certificates are issued by the Veterinary Authority of the country of origin, and based on our internal statistics on the basis of requests received by the WOAH, destination countries usually refer to the sanitary information declared by the Veterinary Authority in WAHIS through six-monthly reports, to confirm the sanitary status of the country of origin and proceed, if appropriate, with quarantine measures upon entry of the animals. In this context, a major challenge is the international movements of equids throughout the world, which have increased significantly in the past 15 years as a result of the participation of competition horses in international equestrian and racing events [19]. As a consequence, the introduction of pathogens in previously disease-free areas is very well documented [20, 21, 22].

Furthermore, since 1996, WOAH (at that time OIE) officially recognises its Members' animal health status for six selected diseases;

which has been recognised by the WTO for trade purposes. In accordance with the relevant Standard Operating Procedures (SOPs), the consistency of information reported through WAHIS is systematically assessed when applications are received for official recognition of free status, as well as for the endorsement of a national official control programme [23].

In addition, WOAH Delegates have the possibility to self-declare their country, or a zone or compartment within their territory, to be free from diseases, except the ones included in the official procedure mentioned above. Should Delegates request it, the WOAH offers to publish their self-declaration(s) on its website. The SOPs for self-declarations of freedom and the publication of the establishment of an Equine Disease-Free Zone, involve a screening process by the WOAH to ensure the quality of the self-declaration to be published, the compliance with the provisions of the *Terrestrial* and *Aquatic Animal Health Codes*, and the consistency with data reported through WAHIS [2, 3, 24, 25].

Finally, WAHIS has become one of the tools used to demonstrate the impact of certain diseases, especially transboundary diseases, on wildlife conservation. Many examples have shown how several diseases can threaten the survival of endangered species. Among other examples, it is worthy to cite the haemorrhagic septicaemia epidemic that occurred in Kazakhstan in 2015 [26] and the peste des petits ruminants epidemic in Mongolia in 2016 [27], threatening the Saiga antelope, or the African swine fever epidemics in Asia that threaten endemic wild pig species in Southeast Asia [28]. Epidemics reported in WAHIS can also be used to indirectly monitor potential effects on threatened predator species like the Amur tigers through the reduction of the populations of their main prey [29]. The collection of information is also important to prevent the spread of diseases impacting biodiversity through international trade, like chytridiomycosis (*Batrachochytrium dendrobatidis* and *Batrachochytrium salamandrivorans*) that are among the most important pathogens causing a population crash worldwide in amphibians [30, 31].

In all these cases, the collection and sharing of animal health information through WAHIS represents another relevant example of the importance of the availability of disease information, not only for risk assessment but also for biodiversity conservation purposes.

## Use of global animal health information systems at regional and global levels: role and impact of WAHIS

At present, there are multiple ways of communicating information on animal diseases. However, global public platforms that alert on exceptional events/outbreaks are scarce. As mentioned above, one of the specificities of WAHIS is that all information is confirmed before it is published by the competent Sanitary Authority of the notifying country. Although it is possible to report a suspected disease, very few countries use this option due to the trade implications this may have. This could be considered a limitation when trying to assess the capacity of the system to collect information on and report disease events. Nevertheless, official information published in WAHIS is particularly useful for trade purposes and to alert other international organisations to support countries affected.

The WOAH contributes to the Global Early Warning System (GLEWS) set up by the Tripartite members (Food and Agriculture Organization of the United Nations [FAO], WOAH and WHO); its principal goal is to facilitate the rapid detection and risk assessment of health threats at the human-animal-ecosystems interface to inform and orient prevention and control measures among its Members. Each organisation collects unofficial information (rumours/signals) through different sources. If the disease has not officially been reported to WHO or WOAH, it is considered an event that can be treated through the GLEWS confidential platform. The WOAH and WHO confirm these signals among their Members. Once the signals have been confirmed by Members, the information is disseminated through the early warning mechanisms that each Organization has in place (i.e. WAHIS, FAO Empres-i+, WHO IHR Event Information Site [EIS]) (Figure 1).

WAHIS is a major source of information in the interconnected world of animal health information systems. As mentioned above, the WOAH screens on a daily basis different sources in the context of its epidemic intelligence activity to track non-official information. These activities allow the WOAH to increase the sensitivity of its information system. Reciprocally, WAHIS official data are used as a primary source of data in other systems, and thus its publications are 'amplified'.

To measure the dissemination of WAHIS information through other information systems, the percentage of outbreaks published on FAO's Empres-i+ with the 'OIE' mentioned as source of reference was assessed, for the period between 2005 and 2020 and for diseases in the common scope. As a result, 65% of outbreaks published in FAO Empres-i+ were based on WAHIS data. A similar analysis was made for ProMed, the percentage of posts published on ProMed with the "OIE" mentioned as source of reference in the title was assessed. This analysis was done for the same period and for all diseases listed by the WOAH. As a result, 18% of ProMed posts were based on WAHIS data. This shows that the dissemination of WAHIS information goes beyond the direct users of the system.

In addition to alert messages following the immediate notification reports, global animal health information systems such as WAHIS, allow visualisation of disease spread across regions and globally. Both the WOAH and FAO prepare global disease situation reports with different frequency (biweekly to monthly) for diseases that have a high global impact (such as AI, ASF, SARS-CoV-2). Moreover, the WOAH uses the reported data to produce aggregated analyses of the animal health situation for selected diseases. These reports are usually presented and discussed during the WOAH General Session or during the WOAH Regional Conferences, and recommendations are provided by the WOAH to its Members based on these reports [8].

## Use of global animal health information systems for research purposes, evaluation of the efficacy of WOAH standards and assessment of socio-economic impact of animal diseases

One of the other advantages of large amounts of standardised data is that predictive models can be developed. Many studies have used data collected in WAHIS for predictive modelling. Among many examples, we can quote the work of Madin (2011) that used data on disease outbreaks, livestock movements and prices to predict where new outbreaks may occur, or the work of Choi and collaborators (2011) on modelling and predicting the occurrence of foot and mouth disease [32, 33]. Considering the WOAH makes available to researchers, institutions, decision makers and other stakeholders data on more than 200 diseases collected in a consistent way since 1996, from around 200 countries at global level, it is clear that these data represent an important source of information for disease modelling and prediction.

Measuring the real implementation and impact of WOAH standards, including international disease reporting according to the *Aquatic* and *Terrestrial Animal Health Codes*, forms part of the main activities of the WOAH and its Observatory. From this perspective, data collected through WAHIS are seen as a proxy to describe how WOAH Members understand and implement WOAH Standards. Several publications have been developed on this topic [34, 35, 36].

In addition, the WOAH is working with the Global Burden of Animal Diseases (GBADs) programme which will assess the burden of terrestrial and aquatic animal diseases and will help to quantify the positive and negative impacts of animal production systems. A diverse team of researchers will develop a detailed methodology to collect data and produce standardised and comparable information on the economic impact of animal diseases, using information systems such as WAHIS, WOAH PVS Pathway, FAOSTAT, and FAO Empress-i [37].

## Data exchange and interoperability between systems to enhance collaborative efforts

In the framework of 'One Health', globalisation, increased international trade and due to technological advances in data storage and visualisation, animal health information systems have become essential tools for the management and surveillance of animal diseases.

To facilitate the management and surveillance of diseases, interoperability between animal health information systems should be prioritised as a future improvement. In its 7th Strategic Plan, the WOAH has launched an action plan to interconnect WAHIS with the EU platform Animal Diseases Information System (ADIS) by 2022 to 2023. In addition, a project has been developed to generate electronic codes to some elements to facilitate the exchange of data (such as disease names, pathogens and hosts). The elaboration of a codification system and its communication and implementation into animal health systems around the world will allow for a much faster, comprehensive and transparent communication of animal health information. Countries around the world will benefit from this initiative as the interoperability of WAHIS and the use of the codification system will facilitate the submission of information, as well as the download of worldwide data for specific purposes (i.e. development of risk analysis, simulation spread models, etc.) which will help countries to prevent and/or control foreign animal diseases.

## Conclusions

Since its foundation in 1924, the role of WOAH has been to disseminate, as widely as possible, information on animal health from the national Veterinary Services of its Members as well as some non-Members. Prior to the publication of this information, WOAH verifies the data to ensure their consistency and quality. The nature of the notification ensures that published data are validated, official and therefore guarantee the specificity of the system. More recently, epidemic intelligence activity and the use of intelligence systems have increased the sensitivity of WAHIS to detect disease events. Finally, WAHIS making publicly available all the information collected by the

Veterinary Services or Competent Authorities of each country, allows WAHIS to be one of the most comprehensive animal health databases in the world.

The information available in WAHIS is paramount for establishing the animal health status of each country. The accurate and timely reporting by WOAH Members through WAHIS enables early warning and preparedness, and mitigates the associated animal and public health risks.

Furthermore, information in WAHIS is used for different purposes, for example, to take preventive measures against disease outbreaks, for risk assessment of importation of animal products, to establish official status or self-declarations of country freedom, for export certification of animals (e.g. pets or horses), for risk assessment of diseases impacting wildlife conservation and for the development of predictive models, among others.

Since its conception, WAHIS remains a reference for other global animal health information systems. Thanks to technological advancements and the efforts made by the WOAH in developing new information technologies, WAHIS is expected to remain a key source of animal health information and to become a source of metadata that will allow interoperability with multiple systems in the near future.

## Acknowledgements

The authors are particularly grateful for the assistance given by Dr M. Arroyo Kuribreña during the revision of this article. The authors would like to thank WHO (Dr Dubravka Selenic Minet) and FAO (Drs Madhur Dhingra and Fairouz Larfaoui), GLEWS focal points, for their support and their authorisation on the use of GLEWS diagram in this article. The authors are particularly grateful for the assistance given by Kevin Kawi during the revision of this article.

## References

[1] World Organisation for Animal Health (OIE) (1924). – Organic Statutes of the Office International des Epizooties. OIE, Paris, France. Available at: https://www.woah.org/en/who-we-are/structure/framework/basic-texts/organic-statutes (accessed on 30 May 2022).

[2] World Organisation for Animal Health (WOAH) (2021). – Terrestrial Animal Health Code. 30th Ed. WOAH, Paris, France. Available at: https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access (accessed on 31 May 2022).

[3] World Organisation for Animal Health (WOAH) (2022). – Aquatic Animal Health Code. 30th Ed. WOAH, Paris, France. Available at: https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access (accessed on 31 May 2022).

[4] Cáceres P., Awada L., Barboza P., Lopez-Gatell H. & Tizzani P. (2017). – The World Organisation for Animal Health and the World Health Organization: intergovernmental disease information and reporting systems and their role in early warning. *In* Biological threat reduction (T. Beckham, ed.). *Rev Sci Tech*, **36** (2), 539–548. https://doi.org/10.20506/rst.36.2.2672

[5] Vallat B. & Wilson D.W. (2003). – The obligations of Member Countries of the OIE (World Organisation for Animal Health) in the organisation of Veterinary Services. *In* Veterinary Services: organisation, quality assurance and evaluation (E. Correa Melo & F. Gerster, eds). *Rev Sci Tech*, **22** (2), 547–552. https://doi.org/10.20506/rst.22.2.1416

[6] Cáceres P., Tizzani P., Ntsama F. & Mora R. (2020). – The World Organisation for Animal Health: notification of animal diseases. *In* Ensuring safe trade in animals and animal products (C. Wolff & A. Hamilton, eds). *Rev Sci Tech*, **39** (1), 289–297. https://doi.org/10.20506/rst.39.1.3082

[7] Cáceres P., Mapitse N., Vergara P., Meske M. & Tizzani P. (2017). – Notification of animal disease information to the OIE. *In* WAHIS is modernising: be a partner in the project. *Bull. OIE*, **2017** (2), 4–12. https://doi.org/10.20506/bull.2017.2.2637

[8] Awada L., Cáceres P., Tizzani P., Lambergeon N. & Melens P. (2022). – Current animal health situation worldwide: analysis of events and trends. OIE General Session final report.

[9] Cáceres P. & Tizzani P. (2020). – Inside the OIE's rumour tracking service. OIE, Paris, France. Available at: https://www.report2020oie.fr/en/inside-the-oie-rumour-tracking-service (accessed on 9 May 2022).

[10] Cáceres P. (2016). – Tracking activity to improve the sensitivity of the OIE's monitoring and early warning systems for human and animal diseases. *Int. J. Infect. Dis.*, **53**, 11. https://doi.org/10.1016/j.ijid.2016.11.032

[11] Bonilla-Aldana D.K., García-Barco A., Jimenez-Diaz S.D., Bonilla-Aldana J.L., Cardona-Trujillo M.C., Muñoz-Lara F., Zambrano L.I., Salas-Matta L.A. & Rodriguez-Morales A.J. (2021). – SARS-CoV-2 natural infection in animals: a systematic review of studies and case reports and series. *Vet. Q.*, **41** (1), 250–267. https://doi.org/10.1080/01652176.2021.1970280

[12] Hobbs E.C. & Reid T.J. (2021). – Animals and SARS-CoV-2: species susceptibility and viral transmission in experimental and natural conditions, and the potential implications for community transmission. *Transbound. Emerg. Dis.*, **68** (4), 1850–1867. https://doi.org/10.1111/tbed.13885

[13] Fanelli A., Awada L. […] & Tizzani P. (2022). – Sensitivity of an international notification system for wildlife diseases: a case study using the OIE-WAHIS data on tularemia. *Zoonoses Public Health*, **69** (4), 286–294. https://doi.org/10.1111/zph.12916

[14] Awada L. (2012). – Évaluation de l'exhaustivité du système d'alerte précoce de l'OIE par la méthode « capture-recapture » à trois sources. Doctoral dissertation, École Nationale Vétérinaire d'Alfort, Maisons-Alfort, France, 94 pp.

[15] Thiermann A.B. (2005). – Globalization, international trade and animal health: the new roles of OIE. *Prev. Vet. Med.*, **67** (2–3), 101–108. https://doi.org/10.1016/j.prevetmed.2004.11.009

[16] Fanelli A., Buonavoglia D., Martinez C., Carrasco P. & Tizzani P. (2020). – Paratuberculosis at European scale: an overview from 2010 to 2017. *Vet. Ital.*, **56** (1), 13–21. https://doi.org/10.12834/VetIt.1829.9692.3

[17] Cárdenas L., Awada L., Tizzani P., Cáceres P. & Casal J. (2019). – Characterization and evolution of countries affected by bovine brucellosis (1996–2014). *Transbound. Emerg. Dis.*, **66** (3), 1280–1290. https://doi.org/10.1111/tbed.13144

[18] Bianchini J., Simons X., Faes C., Nicolas G., Vilain A., Hendrickx G. & Saegerman C. (2022). − Assessing the use of animal health platforms: user's needs, preferences and constraints. *Transbound. Emerg. Dis.*, **69** (2), 501–515. https://doi.org/10.1111/tbed.14008

[19] Herholz C., Fussel A.E., Timoney P., Schwermer H., Bruckner L. & Leadon D. (2008). – Equine travellers to the Olympic Games in Hong Kong 2008: a review of worldwide challenges to equine health, with particular reference to vector-borne diseases. *Equine Vet. J.*, **40** (1), 87–95. https://doi.org/10.2746/042516408X253136

[20] Dominguez M., Münstermann S., De Guindos I. & Timoney P. (2016). – Equine disease events resulting from international horse movements: systematic review and lessons learned. *Equine Vet. J.*, **48** (5), 641–653. https://doi.org/10.1111/evj.12523

[21] Leadon D.P. & Herholz C. (2009). – Globalisation of trade and the spread of infectious disease. *Equine Vet. Educ. Manual*, **8**. Available at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.477.1552&rep=rep1&type=pdf (accessed 15 April 2022).

[22] King S., Rajko-Nenow P., Ashby M., Frost L., Carpenter S. & Batten C. (2020). – Outbreak of African horse sickness in Thailand, 2020. *Transbound. Emerg. Dis.*, **67** (5), 1764–1767. https://doi.org/10.1111/tbed.13701

[23] World Organisation for Animal Health (WOAH) (2022). – Official recognition of animal health status. WOAH, Paris, France. Available at: https://www.woah.org/en/what-we-do/animal-health-and-welfare/official-disease-status (accessed on 31 May 2022).

[24] World Organisation for Animal Health (WOAH) (2022). – Self-declared disease status. WOAH, Paris, France. Available at: https://www.woah.org/en/what-we-offer/self-declared-disease-status (accessed on 31 May 2022).

[25] Kettle A. (2019). – Guidelines on the establishment, management, and self-declaration to the OIE of an equine disease free zone. OIE, Paris, France, 27 pp. Available at https://www.woah.org/en/document/edfz_guidelines (accessed on 31 May 2022).

[26] Fereidouni S., Freimanis G.L., Orynbayev M., Ribeca P., Flannery J., King D.P., Zuther S., Beer M., Höper D., Kydyrmanov A. & Karamendin K. (2019). – Mass die-off of saiga antelopes, Kazakhstan, 2015. *Emerg. Infect. Dis.*, **25** (6), 1169. https://doi.org/10.3201/eid2506.180990

[27] Pruvot M., Fine A.E., Hollinger C., Strindberg S., Damdinjav B., Buuveibaatar B., Chimeddorj B., Bayandonoi G., Khishgee B., Sandag B. & Narmandakh J. (2020). – Outbreak of peste des petits ruminants among critically endangered Mongolian Saiga and other wild ungulates, Mongolia, 2016–2017. *Emerg. Infect. Dis.*, **26** (1), 51. https://doi.org/10.3201/eid2601.181998

[28] Luskin M.S., Meijaard E., Surya S., Walzer C. & Linkie M. (2021). – African swine fever threatens Southeast Asia's 11 endemic wild pig species. *Conserv. Lett.*, **14** (3), e12784. https://doi.org/10.1111/conl.12784

[29] Zakharova O.I., Titov I.A., Gogin A.E., Sevskikh T.A., Korennoy F.I., Kolbasov D.V., Abrahamyan L. & Blokhin A.A. (2021). – African swine fever in the Russian Far East (2019–2020): spatio-temporal analysis and implications for wild ungulates. *Front. Vet. Sci.*, **8**, 723081. https://doi.org/10.3389/fvets.2021.723081

[30] Martel A., Spitzen-van der Sluijs A., Blooi M., Bert W., Ducatelle R., Fisher M.C., Woeltjes A., Bosman W., Chiers K., Bossuyt F. & Pasmans F. (2013). – Batrachochytrium salamandrivorans sp. nov. causes lethal chytridiomycosis in amphibians. *Proc. Nat. Acad. Sci. USA*, **110** (38), 15325–15329. https://doi.org/10.1073/pnas.1307356110

[31] Olson D.H., Aanensen D.M., Ronnenberg K.L., Powell C.I., Walker S.F., Bielby J., Garner T.W., Weaver G., Bd Mapping Group & Fisher M.C. (2013). – Mapping the global emergence of *Batrachochytrium dendrobatidis*, the amphibian chytrid fungus. *PLoS One*, **8** (2), e56802. https://doi.org/10.1371/journal.pone.0056802

[32] Madin B. (2011). – Understanding and predicting the influence of animal movement on the spread of transboundary animal diseases. Doctoral dissertation, Murdoch University, Murdoch, Australia, 300 pp.

[33] Choi Y.K., Johnson W.O., Jones G., Perez A. & Thurmond M.C. (2012). – Modelling and predicting temporal frequency of foot-and-mouth disease cases in countries with endemic foot-and-mouth disease. *J. R. Stat. Soc. Ser. A Stat. Soc.*, **175** (2), 619–636. https://doi.org/10.1111/j.1467-985X.2011.01004.x

[34] Awada L., Tizzani P. & Cabezas A. (2021). – Implementation of the OIE standards on FMD in the Americas. *Panorama*, **2021** (2), 3 pp. https://doi.org/10.20506/bull.2021.2.3285

[35] Bucher K. (2021). – OIE Observatory: pathway from vision to reality. *Panorama*, **2021** (2), 4 pp. https://doi.org/10.20506/bull.2021.2.3278

[36] World Organisation for Animal Health (OIE) (2021). – OIE Observatory: prototype on African swine fever. OIE, Paris, France. Available at: https://www.woah.org/app/uploads/2022/05/oie-asf-prototype-final.pdf (accessed on 30 May 2022).

[37] World Organisation for Animal Health (WOAH) (2022). – GBADs: the Global Burden of Animal Diseases. WOAH, Paris, France. Available at: https://gbads.woah.org (accessed on 30 May 2022).


**Figure 1**

**Global early warning mechanism among GLEWS Tripartite Members**