Scientific Papers. Series D. Animal Science. Vol. LXVII, No. 1, 2024
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

HARMONIZING GLOBAL HEALTH - EXPLORING THE ROLES OF WAHIS, EMPRES-i AND ADIS IN ANIMAL HEALTH SURVEILLANCE AND RESEARCH

Dimitar TANCHEV, Gergana BALIEVA

Trakia University, Students campus, 6015, Stara Zagora, Bulgaria

Corresponding author email: dimitar.tanchev@trakia-uni.bg

Abstract

In an era where timely and reliable animal disease reporting is more critical than ever before, this research paper meticulously examines the pivotal global animal disease reporting systems-World Animal Health Information System (WAHIS), Global Animal Disease Information System (EMPRES-i), and European Union Animal Disease Information System (ADIS). The study provides a systematic analysis of their distinct features, data management strategies, and visualization approaches, exploring their interconnectedness with national and international legislative frameworks. Amidst the evolving landscape of emerging zoonotic diseases with pandemic potential, this research sheds light on the roles of WAHIS, EMPRES-i, and ADIS in global animal health surveillance and research. The findings helps to understand transboundary disease monitoring mechanisms within regulatory landscapes, fostering a harmonized approach to advancing global animal health.

Key words*: animal health, disease surveillance, information database, transboundary diseases.*

INTRODUCTION

In order to successfully and effectively fight contagious animal diseases and reduce economic losses from morbidity and mortality, it is extremely important each country to have in place measures for disease prevention and control, including early detection of outbreaks (Kshirsagar et al., 2013). Many regional local and worldwide systems are established with the overarching goal of bolstering global capacity for animal disease surveillance, monitoring, and reporting. These initiatives emerged from a recognition of the critical need for centralized platforms capable of efficiently collecting, analyzing, and disseminating comprehensive information on animal diseases on a worldwide scale. By facilitating early detection and swift response mechanisms, these systems aim to not only safeguard the health of animals but also protect public health and preserve the integrity of international trade. Furthermore, they play a vital role in supporting informed decision-making processes, enabling risk assessment, and fostering the development of effective policies pertaining to animal health and veterinary public health. In addressing transboundary disease outbreaks, these initiatives seek to mitigate the socio-economic repercussions, ensuring the resilience and sustainability of agricultural practices while safeguarding livelihoods and food security.

In this article, we examine three systems established to address specific needs in global animal health surveillance and management.

WAHIS

Being recognized as the referral organisation for animal health by WTO (World Trade Organisation) and a standard-setting intergovernmental worldwide presented structure, WOAH (World Organisation for Animal Health) ensures freedom of trade in live animals and animal products internationally thorough maintaining rigorous and transparent information system on animal health status. For this purpose, WOAH publishes annually a list of notifiable animal diseases and zoonoses, with a great health impact and economic importance, for which all member states have to provide data on timely manner regarding occurrence, reoccurrence and emergence of new diseases. All data provided by the WOAH members are entered, recorded, processed, analyzed and used through WAHIS (World Animal Health Information System) for disease prevention and control. Due to the constantly changing environment, climate change, human activities

and many others, the challenges for WOAH related to animal health are more complex and there is a need of a continuous improvement and update within the organization, including to WAHIS. At present, the system operates based on three main pillars:

1. A tool for early warning and immediate notification of disease alerts after confirmation of an outbreak of a WOAH-listed disease.
2. A tool for monitoring the development of the WOAH-listed animal disease through six-monthly updates.
3. Mandatory annual reports from the Member states` competent authorities on the status of the notifiable animal diseases and zoonoses, population of susceptible animal species, capacities and resources for disease control and prevention.

Furthermore, as an additional module WOAH had developed WAHIS-Wild which operates with data on wildlife diseases that are not on the notifiable list but still require surveillance (WOAH, 2023b).

EMPRES-i

EMPES-i is also an internet-based system, which operates under the United Nations (FAO) in order to ensure the access and timely management on transboundary and contagious animal diseases with high heath and economic impact on international level, including zoonoses. This Global Animal Disease Information System is aimed at methodologically active assistance to veterinary services in their official control activities, in line with the need of progress and improvement (FAO, 2021).

ADIS

At European level, a secure tool to provide relevant and timely information on animal health situation was established by the European Commission as Animal Disease Information System - ADIS. The system operates as a centralized hub for receiving, processing and circulating precise data on animal disease status among the EU member states and associated countries through notifications. The digital platform of ADIS allows competent authorities to improve data accuracy upon entry, to simplify reporting procedures and reduce administrative burden. As ADIS is functionally in synchronization with the WAHIS, it is a valuable tool for the decision makers when it comes to the need of accurate information on animal health status and contagious diseases outbreaks (European Commission, 2024a).

MATERIALS AND METHODS

Data collection

For the purposes of this study, a comprehensive approach was adopted to collect data from official sources corresponding to each of the three systems under examination. Information pertinent to the World Animal Health Information System (WAHIS) was meticulously sourced from the official website of the World Organization for Animal Health (WOAH). This entailed accessing a plethora of reports, publications, and databases housed within the WOAH platform, all of which were deemed relevant to the realm of disease surveillance within the global animal health landscape (WOAH, 2023).

Similarly, data pertaining to the European Union Animal disease information system (ADIS) were diligently gathered from official publications, reports, and databases sanctioned by the European Union. This encompassed a comprehensive review of EU publications pertaining to animal health and disease surveillance, as well as personal access to specific databases and repositories housing relevant data within the EU.

In the case of the Emergency EMPRES-i a thorough examination of data was conducted through access to the official website of the Food and Agriculture Organization of the United Nations (FAO). This involved targeted retrieval of global information on transboundary animal and plant diseases via EMPRES-i reports, maps, and datasets, ensuring a comprehensive understanding of disease dynamics and surveillance efforts on a global scale.

Data analysis

Comparative analysis

The collected data underwent rigorous comparative analysis aimed at identifying not only similarities but also differences in the characteristics, data management approaches,

and visualization methods employed by each of the three systems under investigation - WAHIS, ADIS, and EMPRES-i. This involved a meticulous examination of various parameters, including but not limited to, the scope of disease surveillance, reporting structures, response mechanisms, and data dissemination protocols. By conducting a detailed comparative assessment, insights were gleaned into the unique strengths and potential limitations of each system, thereby facilitating a nuanced understanding of their respective contributions to global animal health surveillance and management.

Thematic Analysis

In addition to comparative analysis, a thematic analysis approach was adopted to delve into the alignment of WAHIS, ADIS, and EMPRES-i with national and international legislative frameworks governing animal health surveillance and management. This multifaceted examination involved a systematic review and synthesis of relevant policies, regulations, and guidelines enacted at both the national and international levels. These legislative frameworks were meticulously mapped to the functionalities and operational conditions of each system, allowing for an in-depth exploration of their compliance with regulatory requirements and their capacity to effectively address emerging challenges in animal health surveillance and management. By juxtaposing the operational modalities of WAHIS, ADIS, and EMPRES-i with established legal frameworks, this thematic analysis shed light on the extent to which these systems are poised to meet the evolving needs of global animal health governance.

RESULTS AND DISCUSSIONS

Legal framework

WAHIS

The legal basis for operation of WAHIS is laid down by Art. 1.1.2. of the WOAH Terrestrial Animal Health Code which stipulates that all member states have to report to the WOAH Headquarters the available information of notifiable animal diseases in order to improve globally their management and control by minimizing the spread of outbreaks and pathogens.

EMPRES-i

The legal framework of EMPRES-i is multifaceted and encompasses a combination of international agreements, national legislation, FAO governance structures, and collaborative partnerships, all aimed at promoting global cooperation and coordination in addressing transboundary animal and plant health threats.

ADIS

Within the European legislation, Regulation (EU) 2016/429 Animal Health Law defines the categories of contagious animal diseases with economic and health importance to the EU, for which occurrence, reoccurrence and development of outbreaks have to be registered by the member states through the ADIS. Regulation (EU) 2020/2002 additionally lays down the uniform rules for procedures and notifications of listed animal diseases to the EU which are applied with the computerized information system.

Data collection

WAHIS

In compliance to the rules set in the WOAH Terrestrial Animal Health Code by Article 1.1.3., all member states shall provide the WOAH Headquarters through their competent veterinary authorities with on-time notifications within 24 hours of the laboratory confirmed diagnose accurate information through WAHIS platform on first occurrence on a WOAH listed disease or pathogen on the territory of the country or part of it (zone, compartment). The same information shall be provided for recurrence of an eradicated listed disease or a pathogen in one of the member states or a part of it, as well as a change in increase of virulence/morbidity/mortality of any of the diseases from the WOAH list, including the pathogens causing animal diseases and zoonoses in an unusual animal host species.

To ensure the quality and relevance of the information, training and support services are provided. Since 2006, annual training sessions have been conducted focusing on the practical utilization of the reporting system (WAHIS) and key aspects of disease notification. These sessions primarily target WOAH Focal Points for Animal Disease Notification, who serve as the WOAH's national contact points for disease reporting.

In terms of support services, the WOAH directly assists the Veterinary Services of its Member States. This assistance encompasses clarifying notification requirements and enhancing Members' awareness of their obligations for disease notification to the WOAH. Additionally, the WOAH's regional and sub-regional Representations are available to provide support in utilizing the reporting system (Caceres et al., 2020).

The quality and relevance of the information are significantly influenced by the quality of veterinary services, emphasizing their importance in ensuring accurate and pertinent data. Like unique intergovernmental organisation WOAH has established a number of international standards, some of which regulate and enforce a framework for ensuring the quality of Veterinary Services worldwide (WOAH, 2023a).

As developed and improved constantly, the OIE PVS Tool for the evaluation of performance of Veterinary Services - encompasses four fundamental components (WOAH, 2019). The aim of the PVS Tool is to ensure all necessary factors for the effective performance of Veterinary services are in place, up-to date and efficient in order to maintain high level of protection of animal health and public health and food safety:

1) adequate human, physical and financial resources under proper coordination and allocation, with staff excelled in technical and leadership competences;

2) technical authority and capability which include veterinary laboratory capacities and aim at control, surveillance, emergency preparedness and response to animal diseases, food and feed safety, antimicrobial resistance and animal welfare as well;

3) interaction with stakeholders expressed through regulation, communication and consultation with interested parties at various scales with the goal to enhance joint collaboration and up-to date performance;

4) sustainable access to markets ensuring safe trade in animals, animal products, food and feed through introduction of international veterinary legislation, certification, sanitary agreements and harmonization of standards and defining of zones and compartments with disease free-status (WOAH, 2019).

It's evident that the ability of veterinary services to substantiate claims regarding the health status of animals through disease surveillance data, monitoring program results, and detailed disease history is highly relevant (Vallat & Wilson, 2003).

In order to enhance the effectiveness of its animal health information system and acquire a comprehensive understanding of the global animal health situation, WOAH initiated an active search for non-official information related to animal health and public health starting from 2002. The acquired information is subjected to assessment with regard to the predominant animal health status within the respective zone, region or country. If the information is confirmed, it is verified by the member state with official confirmation and potential publication (Caceres et al., 2017).

For this purpose, Member states have granted WOAH Headquarters the authority to directly contact their national Delegate for all cases of reported through media or other non-official channels news on animal health incidents and outbreaks which may require legally action of immediate disease notification to WOAH system. However, before being officially confirmed by the competent authority of the member state this information is not to be announced and published.

As certain procedures have been set regarding reporting events with importance to animal health, the prerequisite of receiving official confirmation on notifiable animal disease by the member states is invaluable and mandatory to have the reported information disseminated afterwards through official forms (WOAH, 2023c). Percentage of this notification vary by the years (Figure 1).

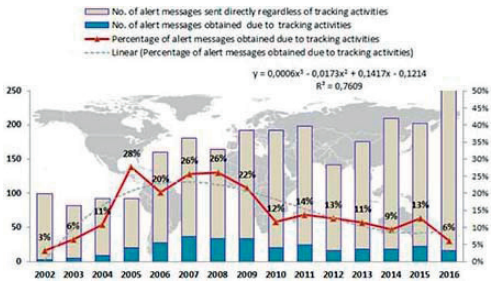

Figure 1. Percentage of alert messages obtained due the tracking activities (Source: WOAH website)

EMPRES-i

This platform is designed to provide joint information on notifiable animal diseases at global level through consolidation of data from various sources shared on a regular basis between collaborative partners and FAO. Besides the official information fed to EMPRES-i from the global networks, the platform also uses non-official channels.

Informal information on animal health situation enters EMPRES-i through media reports from the countries or networks like ProMED (Program for Monitoring Emerging Diseases, managed by the International Society for Infectious Diseases) (ISID, 2023) and GPHIN - Global Public Health Intelligence Network (developed by Canada`s Public Health Agency, also part of WHO alert system) (Government of Canada, 2023).

Sources of formal information to EPMRES-i are provided by WOAH, WHO, FAO, European Commission and partnering Non-Governmental Organizations.

However, the unconfirmed information on animal diseases events has to be verified through a coordinated process with the relevant organisations - WOAH and WHO. The process includes disease-tracking in order to confirm or deny the information. When necessary veterinary officers from national competent authorities are contacted to verify data provided within official reports on the location and time of animal disease outbreaks, and is further detailed through mapping tools like Google Earth. The same verification process and contacts are used for confirmation of data coming from informal channels (Farnsworth et al., 2010).

ADIS

The process of reporting data to ADIS (Animal Disease Information System) is governed and standardized according to the legal framework established by the European Union. This regulatory framework is detailed in Article 3 of the Commission Implementing Regulation (EU) 2020/2002 with regard to reporting listed disease to the EU with the List of diseases of terrestrial animals provided in Annex I of the Regulation.

The legislation implies that in case a primary outbreak of a notifiable animal disease is registered within the territory of a member state, it is mandatory to alert the European Commission (EC) within 24 hours after the laboratory confirmation of the diagnosis. Regarding secondary outbreaks, a rigorous reporting procedure requires Member states to notify the EC on the events on the first working day of the week at the latest with information covering the previous week.

Upon receipt of a report, WOAH verifies, processes, translates and subsequently displays the information in the WAHIS, publicly available. Information is sent promptly to all WOAH members by email (Lin et al., 2023).

The alert procedure on listed diseases is defined by Article 1.1.5 of the OIE Terrestrial code which assigns the Headquarters the duty to communicate all relevant information on animal disease outbreaks to the member states` competent authorities through electronic means - email or WAHIS interface (WOAH, 2023).

EMPRES-i

EMPRES-i disseminates scientific data by presenting it on its publicly accessible profile. Users have the ability to explore “Disease Events”, which are visually represented on a map interface. Further analysis is facilitated through the selection of various optional layers available for examination. This dissemination strategy ensures that stakeholders have prompt access to pertinent information concerning animal health situation and emerging threats worldwide.

ADIS

Based on the mode of operation, ADIS requires the information on a primary animal disease outbreak to be entered into the platform. After receiving the initial report, the system generates timely notifications on automated mode which are emailed to all member states-users of the application.

Additionally, to ensure comprehensive communication, a detailed weekly email bulletin is circulated to all ADIS members every Friday. This bulletin serves to summarize and provide insights into both primary and secondary outbreaks that have been documented throughout the week. For the purpose of effective and efficient management on information regarding listed animal diseases, ADIS works in a close joint collaboration with WAHIS. Figure 2 explain ADIS dissemination of data and connection with WAHIS.

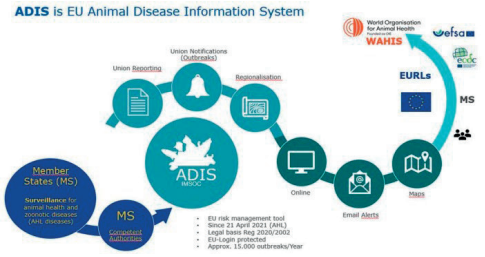

Figure 2. ADIS dissemination of data
(Source: An official website of the European Union https://food.ec.europa.eu/animals/animal-diseases/animal-disease-information-system-adis/unveiling-adis_en)

Both databases function at international level and manage the crucial task to provide its members with precise and timely information on current animal health events, thus allowing the interested parties to implement measures to prevent and stop contagious animal diseases to spread across state boundaries (Lin et al., 2023). Despite that they contribute to global animal health surveillance, they serve distinct purposes and user bases.

WAHIS functions as an extensive official global repository for data on animal health events, facilitating standardized reporting and analysis to support disease monitoring and control efforts on a global scale. It focuses on promoting transparency, collaboration, and data exchange among member countries and international organizations to enhance global animal health governance. According to the OIE Manual 6: Animal health information system: "An animal health information system is only as good as the data it contains" (WOAH, 2018). With the aim to provide information with integrity and reliability, the WOAH not only furnishes a comprehensive database but also disseminates standardized laboratory manuals tailored for disease diagnosis. Additionally, WOAH undertakes the evaluation of veterinary services, aiming to synchronize their capacities and bolster their preparedness in effectively managing outbreaks of emerging diseases.

The data within WAHIS are verified and official, featuring sensitive and specific information on more than 120 animal diseases. They characterize the endemic situations for over 200 territories, including all current 183 members and other interested parties who willingly provide information to WOAH. Because of these features, there exists a significant diversity in the utilization of data from WAHIS (Caceres et al., 2023).

WAHIS offers a suite of tools and features for data submission, validation and visualization, including standardized reporting formats, interactive maps, and data analysis tools. It emphasizes the importance of official reporting channels and data quality assurance mechanisms to ensure the reliability and comparability of reported information. Because of these features, there exists a significant diversity in the utilization of data from WAHIS (Mur et al., 2019).

The valuable resource of WAHIS could be interpreted in two ways: first, to discover an occurrence/reoccurrence of listed animal diseases through alert messages and follow-up reports, and second, to observe an absence of a disease within the mandatory reports each six months. Combined at regional, national and global level, the information from both datasets is further analyzed and used for risk assessment which in combination with data on control measures could enhance disease management in terms of the noted absent listed diseases (Caceres et al., 2023).

Furthermore, data from animal health platforms could be used to improve members` preparedness based on the analysis of disease patterns. By tracing the changes in disease development, the animal health experts could use the platform to identify the evolution and spread of diseases (Bianchini et al., 2022).

And not least, WAHIS is a part of WOAH role in international trade regulation. The information system is used to ensure safe trade in live animals and animal products with the help of the notifications disseminated to the member states that allow them to impose timely measures to limit the spread of pathogens from the infected country to other territories (Cardoen et al., 2017).

In the other hand EMPRES-i is specifically designed as an early warning system for animal diseases, emphasizing real-time monitoring, rapid detection, and response to disease outbreaks and emerging threats. It prioritizes the timely dissemination of actionable information to stakeholders to mitigate the impact of diseases on animal health, livelihoods, and food security. Data on animal disease events are

entered in EMPRES-i based on formal and informal reports. The information is provided through various sources among which reports from FAO and some partnering organizations and national authorities on field missions and regional projects, media and computerized health monitoring systems (Perez et al., 2011).
By harnessing data from numerous and varied sources, EMPRES-i can capture a comprehensive snapshot of the global animal health landscape in real-time. This multifaceted approach to data aggregation ensures that the system remains responsive to emerging disease threats, rapidly detecting and disseminating information on new outbreaks or disease patterns. Furthermore, the diversity of data sources allows for cross-validation and triangulation of information, enhancing the reliability and accuracy of the insights provided by EMPRES-i.
In essence, the wealth of sources available to EMPRES-i empowers the system to maintain a state of heightened situational awareness regarding animal health events worldwide. This dynamic and expansive information ecosystem positions EMPRES-i as an indispensable means for early warning, decision support, and strategic planning in the realm of animal disease prevention and control. It accelerates the dissemination of disease information at regional and international scales. At the meantime, it is also used for risk assessment of the current animal health situation with present and emerging diseases. The platform is a valuable tool for planning and implementation of surveillance measures and detailed epidemiological analysis on a particular listed disease (FAO, 2015).
The utilization of EMPRES-i not only facilitates the examination of the geographic dispersion of diseases but also enables the visualization of human or animal populations within a given area (Figure 3). This capability extends beyond mere mapping to include the activation of topographic features, thereby providing a comprehensive understanding of natural barriers that may influence disease spread dynamics. Moreover, EMPRES-i offers the flexibility to identify the source of information, regardless of its official or unofficial nature, thereby contributing to a nuanced assessment of disease events. The integration of a vast repository of disease data and the capacity to generate diverse graphical models further augment EMPRES-i effectiveness as a tool for rapidly comprehending infectious disease processes in animal populations.

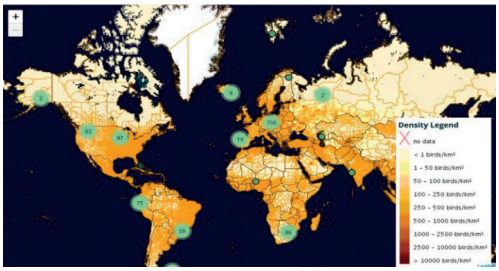

Figure 3. Map with visualized livestock density (personal access)

Another unique opportunity offered by EMPRES-i is the genetic module within the platform which encompasses data from real health events on registered influenza outbreaks and data on the characteristics of the virus itself. By integrating the specific viral features within the information system it could be possible to trace the distribution of the viruses, track their strains with molecular markers, analyze the effects on viral distribution after vaccination for control and prevention purposes. In the case of influenza outbreaks an algorithm is developed that automatically computes the probability of related disease outbreaks and viral sequences, using information provided by EMPRES-i on animal health events and virus characteristics available in OpenfluDB (OpenFluDB, 2024) . The suggested links between the outbreak event and particular viral strain as a cause has to be mandatory validated by experts (Claes et al., 2014).
Based on the current legislative framework and the categorization of contagious animal diseases with significance to the EU, as defined by the Animal Health Law (Regulation (EU) 2016/429), ADIS operates as a tool for disease management and control of epidemiological situation among the member states connected to the application. The system provides immediate access to the EU countries and the partnering organisations on the current status of animal health (occurrence, reoccurrence of outbreaks, emerging threats) and through the early warning mechanism enables the countries to undertake

urgent measures and response to ensure the safety and health of their animal populations and the public as well (European Commission, 2024). Based on its automated mode that requires only one-time reporting on a disease event by the member states, ADIS operation leads to less administrative workload. By the dissemination of information via email to a large number of veterinary specialists at various levels ADIS works as a valuable tool for decision-makers to allow them use the latest and most consistent data on animal health situation and thus develop and implement reasonable and efficient decisions and policies on animal health management (WOAH, 2023).

On one hand, the system enables more specific data retrieval not only by country but also by region within the EU. This allows for obtaining information regarding disease zoning. On the other hand, the automatic linkage with WAHIS facilitates reporting of diseases by member states.

CONCLUSIONS

Despite sharing certain superficial resemblances, such as geographical data visualization and data exchange functionalities, the examined systems occupy distinct niches within the realm of global animal health surveillance and research. This necessitates a comprehensive understanding of the nuanced disparities between them, encompassing aspects such as legislative frameworks, methods of data acquisition, export functionalities, and approaches to data visualization. This nuanced understanding facilitates the judicious selection of the most suitable system for conducting specific analyses, thereby ensuring the acquisition of precise and reliable data. Conversely, in the context of global analysis and varied dissemination needs, it is common practice to leverage multiple or all of these systems, as they often complement one another, synergistically enhancing the comprehensiveness and depth of insights garnered, and contributing to a more holistic understanding of the prevailing circumstances.

ACKNOWLEDGEMENTS

The authors received no financial support for the research, authorship and/or publication of this article.

REFERENCES

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.

Caceres, 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. *Revue scientifique et technique (International Office of Epizootics), 36*(2), 539–548.

Caceres, P., Awada, L., Weber-Vintzel, L., Morales, R., Meske, M., & Tizzani, P. (2023). The World Animal Health Information System as a tool to support decision-making and research in animal health. *Revue scientifique et technique (International Office of Epizootics),* 42, 242–251.

Caceres, P., Tizzani, P., Ntsama, F., & Mora, R. (2020). The World Organisation for Animal Health: notification of animal diseases. *Revue scientifique et technique (International Office of Epizootics), 39*(1), 289–297.

Cardoen, S., De Clercq, K., Vanholme, L., De Winter, P., Thiry, E., & Van Huffei, X. (2017). Preparedness activities and research needs in addressing emerging infectious animal and zoonotic diseases. Revue Scientifique et Technique. *Office International des Epizooties, 36* (2), 557-568.

Claes, F., Kuznetsov, D., Liechti, R., Von Dobschuetz, S., Truong, B.D., Gleizes, A., Conversa, D., Colonna, A., Demaio, E., Ramazzotto, S., Larfaoui, F., Pinto, J., Le Mercier, P., Xenarios, I., & Dauphin, G. (2014). The EMPRES-i genetic module: a novel tool linking epidemiological outbreak information and genetic characteristics of influenza viruses. *Database (Oxford),* 2014, bau008. doi: 10.1093/ database/bau008.

European Commission (2024). *Food Safety. ADIS*. https://food.ec.europa.eu/animals/animal-diseases/animal-disease-information-system-adis_en

European Commission (2024a). *Unveiling ADIS. Food Safety.* https://food.ec.europa.eu/animals/animal-diseases/animal-disease-information-system-adis/unveiling-adis_en

FAO (2015). *EMPRES-i: a powerful global tool for controlling major animal diseases*. https://www.fao.org/3/i4386e/i4386e.pdf

FAO (2021). *EMPRES-i - about*. https://data.apps.fao.org/static/sites/empres-i/about.html

Farnsworth, M. L., Hamilton-West, C., Fitchett, S., Newman, S. H., de La Rocque, S., De Simone, L., Lubroth, J., & Pinto, J. (2010). Comparing national and global data collection systems for reporting, outbreaks of H5N1 HPAI. *Preventive veterinary medicine, 95*(3-4), 175–185.

Government of Canada (2023). *About - GPHIN - Canada*. https://gphin.canada.ca/cepr/aboutgphin-rmispenbref.jsp?language=en_CA

ISID (2023). *About ProMED - ProMED-mail*. https://promedmail.org/about-promed/

Kshirsagar, D.P., Savalia, C.V., Kalyani, I.H., Kumar, R. & Nayak, D.N. (2013). Disease alerts and forecasting of zoonotic diseases: an overview. *Veterinary World, 6 (*11), 889-896.

Lin, S., Beltrán-Alcrudo, D., Awada, L., Hamilton-West, C., Schettini, A. L., Cáceres, P., Tizzani, P., Allepuz, A., & Casal, J. D. (2023). Analysing WAHIS Animal Health immediate notifications to understand global reporting trends and measure early warning capacities (2005–2021). *Transboundary and Emerging Diseases*, 1-10. https://doi.org/10.1155/2023/6666672

Mur, L., Tizzani, P., Awada, L., Lambergeon, N., Braham, I., Masse, C., Caceres, P., Melens, P., & Arroyo, M. (2019). WAHIS, the unique source of official worldwide animal health information, is becoming OIE-WAHIS, a new digital platform. *Front. Vet. Sci.,* 6.

OpenFluDB website. (2024). https://openflu.vital-it.ch/browse.php

Perez, A., Alkhamis, M. A., Carlsson, U., Brito, B., Carrasco-Medanic, R., Whedbee, Z., & Willeberg, P. (2011). Global animal disease surveillance. Spatial and Spatio-temporal *Epidemiology, 2*(3), 135–145.

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. *Revue scientifique et technique (International Office of Epizootics), 22*(2), 547–559.

WOAH (2018). *Manual 6 : Animal Health Information Systems.* https://doi.org/10.20506/standz.2797

WOAH (2019). *OIE Tool for the Evaluation of Performance of Veterinary Services,* Seventh Edition. https://www.woah.org/app/uploads/2021/03/2019-pvs-tool-final.pdf

World Organisation for Animal Health (2023). *Terrestrial Code Online Access - WOAH - World Organisation for Animal Health.* WOAH - World Organisation for Animal Health. https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=1&htmfile=chapitre_notification.htm

World Organisation for Animal Health (2023a). *Improving veterinary services - World Organisation* for Animal Health. WOAH - World Organisation for *Animal Health*. https://www.woah.org/en/what-we-offer/improving-veterinary-services/

World Organisation for Animal Health (2023b). *World Animal Health Information System WAHIS. WOAH - World Organisation for Animal Health*. https://www.woah.org/en/what-we-do/animal-health-and-welfare/disease-data-collection/world-animal-health-information-system

World Organisation for Animal Health (2023c). *Active Search - WOAH - World Organisation for Animal Health.* https://www.woah.org/en/what-we-do/animal-health-and-welfare/disease-data-collection/active-search/