Food and Agriculture Organization of the United Nations

Global consultation on highly pathogenic avian influenza (HPAI)

Rome, Italy
2–4 May 2023

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Abbreviations and acronyms

AI	avian influenza
AMR	antimicrobial resistance
AMU	antimicrobial use
CMS	Convention on the Conservation of Migratory Species of Wild Animals
ECTAD	Emergency Center for Transboundary Animal Diseases
ECOWAS	Economic Community of West African States
ENVT	Ecole nationale vétérinaire de Toulouse
FAO	Food and Agriculture Organization of the United Nations
HPAI	highly pathogenic avian influenza
INRAE	Institut national de la recherche agronomique
LBM	live bird markets
LNU	Linneaus University
LPAI	low pathogenic avian influenzaa
ND	Newcastle disease
NNU	Nanjing Normal University
OFFLU	WOAH/FAO Network of Expertise on Animal Influenza
PMP-TAB	progressive management pathway for terrestrial animal biosecurity
PCR	polymerase chain reaction
UCD	University of California
UGA	University of Georgia
USDA	United States Department of Agriculture
WHO	World Health Organization
WOAH	World Organization for Animal Health

Executive summary

Highly pathogenic avian influenza (HPAI) is a highly contagious disease that has severe impacts on animal and human health, livelihoods, and the economy. Since its emergence in Asia over 20 years ago, avian influenza (AI) caused by A(H5Nx) subtype viruses in the goose/Guangdong/1/96 lineage (gsGD) has affected poultry, wild birds, humans, and other mammals. These viruses have spread across Eurasia and western Africa since 2005, leading to multiple waves of intercontinental transmission. Presently, they have spread to nearly all parts of the world except Oceania and Antarctica. Some countries have managed to eliminate the virus from poultry, while others have implemented measures to mitigate its impact. Wild birds and cross-border trade, particularly informal poultry trade, have played significant roles in the transmission of AI.

The ongoing H5 HPAI wave, which started in 2020, has affected more than 70 countries and territories, resulting in over 11,000 disease events in domestic and wild bird populations. It is the first wave to reach Central and South America. While human cases associated with gsGD viruses have occurred, there is no sustained human-to-human transmission reported. Nevertheless, these viruses are considered a potential pandemic threat. The virus has also spilled over to various mammalian species, such as farmed mink in Spain and pinnipeds in the Americas. Endangered species have experienced significant mortality, contributing to the loss of biodiversity. Genetic analysis reveals multiple genotypes resulting from reassortment with other avian influenza viruses in both wild birds and poultry.

The current panzootic of HPAI is unprecedented in terms of its extensive spread and the number of wild birds and mammals affected. Whether the current clade 2.3.4.4b virus will persist in wild birds as an ongoing source of infection for poultry remains unclear. The devastation caused by this virus underscores the need to prevent new strains from establishing in wild birds and causing further waves of infection. This requires improved control measures in places where the virus persists and evolves in poultry, as well as stronger engagement of the wildlife and environmental sectors using a One Health approach.

Recognizing the global spread of AI and the evolution of avian influenza viruses in wild birds, FAO and World Organization for Animal Health (WOAH) Network of Expertise on Animal Influenza (OFFLU) organized a global scientific community consultation meeting to review the latest science and evidence on the disease. The objective was to support the development and implementation of disease prevention and control strategies, as well as contribute to global efforts in reducing pandemic risk.

The global consultation on HPAI involved plenary sessions, break-out groups, expert-led presentations, and discussions on the current epidemiology of avian influenza. The participants discussed gaps, challenges, and new approaches in AI surveillance and diagnosis, prevention and control, the human-wild/domestic animal interface, wild bird ecology, and pandemic preparedness. At the conclusion of the meeting, the participants formulated several recommendations to address identified challenges and gaps, aiming to minimize the impact of HPAI worldwide.

Key recommendations include assessing ways to enhance prevention and control

in countries where the viruses persist. This may involve implementing socially acceptable changes in poultry rearing and sales practices to improve biosecurity throughout the value chain. Vaccination should be considered and improved to protect both poultry and potentially wild birds. Empowering the private sector and communities involved in poultry management, strengthening collaboration with the wildlife and environmental sectors, and adopting a One Health approach are also crucial steps in combating this disease.

Key recommendations and conclusions

These recommendations were formulated to address short and mid-term needs in the coming five years. Per session, they are ranked in order from most to least important per session, as identified by the experts present at the global consultation on HPAI (in-person and online). Rankings for each recommendation, including importance, perceived feasibility within the given time and novelty, can be viewed here.

SESSION 2: UPDATED AI EPIDEMIOLOGY

Recommendations

- Evaluate the use of vaccination at national/subnational level, including solutions for vaccine matching and post-vaccination monitoring.
- Conduct or update value chain analysis, trade network analysis, transmission studies and observational field studies to support appropriate national and regional implementation of holistic prevention and control measures related to AI introduction (including from wild birds) and lateral transmission along poultry value chains.
- Identify and evaluate social, economic, cultural and other structural factors that drive AI introduction, establishment and spread along national and international poultry value chains and develop mitigation strategies to reduce transmission risk along poultry value chains.
- Build sustainable national and regional capacity for early warning surveillance, and regularly conduct risk assessments and evaluate risk management and risk governance along poultry value chains.
- Identify drivers, risk factors and any key components of the value chain that can influence endemnicity.

Conclusions:

- The epidemiology of the current clade 2.3.4.4 virus has shown increasing expansion of host range, and several countries/regions are becoming endemic.
- Appropriate biosecurity remains necessary to prevent and control HPAI even when vaccination is/will be used. Clandestine vaccination is a challenge in many countries.
- The private sector, local competent authorities and communities who own/manage poultry should be empowered to participate in the implementation of biosecurity and control measures as co-equal partners to prevent and control AI.

SESSION 3: SURVEILLANCE AND DIAGNOSTICS FOR AI: NEW APPROACHES AND CHALLENGES

Recommendations

- Tailor and target AI surveillance for different country contexts and purposes. Surveillance data from all sectors needs to be shared rapidly and integrated for decision-making support and communication with all stakeholders.
- Validate novel approaches for AI surveillance and diagnostics for different objectives in the next year. Identify the context(s) to apply novel approaches in surveillance systems and evaluate key performance indicators including added value with respect to existing approaches and systems, cost effectiveness, sustainability, feasibility, as well as confidentiality, curation and integration based on ethical/legal context including vaccination. Ensure validated data is appropriately disseminated/communicated.
- Assess the legal and governance frameworks needed to apply different surveillance approaches at national level for disease control and in line with WOAH standards when applied to trade and market access, as well as access and benefit sharing arising from the use of genetic resources.
- Encourage multi-pathogen/multi-species approaches where it aligns with national surveillance objectives and ethical and legal frameworks.
- Engage stakeholders in surveillance system design and implementation and develop educational and awareness materials and other means of communication.

Conclusions

- It is important to validate and apply novel surveillance and diagnostic methods within the context of existing technical, operational, legal and governance elements at the national and regional levels.
- The application of these methods is subject to WOAH guidelines and standards.

SESSION 4: AI PREVENTION AND CONTROL

Recommendations

- Apply AI vaccination stewardship in countries where used to prevent and control AI introduction and subsequent transmission along poultry value chains.
- Where appropriate, rapidly intensify efforts to integrate behavioral science and adult learning principles into HPAI prevention and control work to better inform, design, test and scale behaviour change interventions, through for example, farmer field schools or other modalities of community engagement, and by increasing regional applied/adaptive research capacity.
- Share relevant experiences on biosecurity, build a community of practice and use the information to enhance progressive biosecurity management along value chains and at national level (via Progressive Management Pathway for Terrestrial Animal Biosecurity).
- (Re)build trust and engage local communities to participate in risk assessment and management to establish realistic, practical and sustainable long-term solutions for biosecurity management.

- In the short term, undertake a critical review in every country with or at high risk of HPAI, assessing what has been done, by bird type and production sector, at production level and post-farm gate, to enhance prevention of HPAI. Use the results of the critical review to develop and implement enhanced programmes for HPAI prevention, adopting a broad One Health approach and ensuring drivers for behavioural changes and gender effects are considered.
- Ensure emergency response plans and responses to HPAI outbreaks match capacity, community needs, disease status, willingness to report disease, carcass management capacity and the availability of compensation, and revise to match reality.
- At regional and sub-regional levels, work with private sector and other partners to establish information-sharing platforms and deliver data-sharing trainings. More and better data will contribute to better inform policy development for prevention and control.

Conclusions

- Biosecurity measures in farms and markets and along value chains remain the primary defence against HPAI but can be difficult to implement in low input systems in countries where HPAI persists. Changes to the way birds are reared and sold have reduced the likelihood of infection with HPAI viruses, but many high-risk practices persist.
- Vaccination has been used to reduce the spread of AI in multiple countries, especially those where the virus was entrenched and stamping out coupled with biosecurity and movement controls could not eliminate the virus from poultry. Vaccination practices, including decisions not to use vaccination, warrant regular review and modification when deemed necessary.

SESSION 5: HUMAN-ANIMAL-INTERFACE AND PANDEMIC PREPAREDNESS

Recommendations

- Ensure coordinated surveillance, data and sample sharing and risk assessments under a One Health approach between the animal (domestic and wildlife), environmental and human health sectors with public health pandemic planning and response at national, regional and global levels.
- Establish data/information sharing platforms to integrate information for epidemiological analyses and decision-making using a One Health approach at national, regional and global levels. This includes addressing issues relating to impacts of data sharing on scientific publications, data ownership and implications of access and benefit-sharing legislation.
- Identify the related drivers and risks posed to human health, livelihoods and food security and biodiversity at the human-animal-wildlife/environment interface at national, regional and global levels.
- Identify risk hotspots and develop contingency plans collaboratively and in coordination with all quadripartite partners at national, regional and global levels.

Conclusions

- The need to develop and strengthen ties with wildlife and environment sectors is of critical importance to the effective prevention and control of AI viruses at the interface.
- Surveillance in humans, wild and domestic animals and the environment needs to be strengthened, targeted and adapted to objectives appropriate to local and regional context to inform decision-making, risk assessment, pandemic preparedness and response planning. Funding for improvement of data quality, timeliness and use of surveillance data should be prioritized.
- Use a multi-sectoral approach, including (but not limited to) communication, behavioural science, workplace safety, sociology and economics. Build trust with all stakeholders and establish a One Health collaboration in peacetime.
- Systems should be created in such a way that they can rapidly adapt to emerging needs, including new data types, new systems/tools (e.g., wastewater) and inclusion of new stakeholders.

SESSION 6: ECOLOGY OF AI IN WILD BIRDS AND THE WILDLIFE-LIVESTOCK INTERFACE

Recommendations

- Following the One Health approach, recognize HPAI not only as a concern for poultry production and public health but also as a concern for wildlife conservation, and change goals, methods and implementation of AI surveillance, research and response in wild birds accordingly at national, regional and global levels. Competent government authorities for livestock production, nature conservation and public health should take joint responsibility for these actions.
- Make international funds, laboratory support, and capacity building available to low- and middle-income countries to improve geographical and species coverage of AI surveillance in wild birds sustainably at the global level.
- Support international cooperation to obtain and improve flyway-based AI surveillance in wild birds (including waterfowl/aquatic birds) at regional levels.
- Prepare and fund multi-agency and multi-sector contingency planning responses for HPAI outbreaks, including mass mortality events, in wildlife to mitigate and monitor the impact of HPAI on wild bird and wild mammal populations at national and regional levels. Competent government authorities for livestock production, nature conservation and public health should take joint responsibility for implementation of these contingency plans.
- Support and collaborate in research—including hotspot mapping, ecological studies at the environment/wildlife/poultry/human interface, population immunity, and virus phylodynamic—to improve understanding of the epidemiology and impacts of HPAI in wild bird and wild mammal populations at national and regional levels. This will require funding and support for long-term research.
- Review regulatory issues that impede domestic and international transfer of wildlife samples for AI diagnosis and research at the global level.

Conclusions

- The current HPAI outbreak is causing unparalleled high mortality in many species of wild birds and wild mammals, with population level threats to species already threatened or endangered by other anthropogenic pressures. It is also recognized that any mitigation of impacts of HPAI in wild birds reduces risks to poultry and human health.
- Current AI surveillance in wild birds shows large geographical gaps, is country-based rather than flyway-based, and does not provide an estimate of the immediate and long-term impacts of the current HPAI outbreak on wild bird populations.
- Monitoring, reporting and responding to wild bird and wild mammal die offs from HPAI in most countries are poorly planned, poorly funded, and in many areas rely on non-governmental organizations (NGOs) and volunteers.
- Passive AI surveillance in wild birds–while cost-effective for early warning and detection of outbreaks–does not provide adequate information to understand the epidemiology and impact of HPAI in wildlife populations.

Background

HPAI is a highly contagious transboundary disease with zoonotic potential that affects both animal and human health. The disease causes variable clinical signs in birds and can lead to high mortality rates in both wild and domestic bird populations. AI also poses a great strain on poultry-related businesses, as culling and movement restrictions are required to stop its spread, which may also affect the trade of poultry products. The current epizootic of H5 AI has affected more than 70 countries across Africa, the Americas, and Eurasia. This has led to a great loss of rare and important wild bird species, indirect social and economic costs, and impacts ranging from livelihood losses to egg shortages.

To improve evidence-based risk management and multi-sectoral collaboration, FAO and OFFLU have brought together public health and animal health experts from affected and at-risk countries, academic scientists, and subject matter experts to review the latest scientific evidence.

The meeting was held over two and half days and was attended by over 200 participants in-person and online. The subsequent sections summarize the meeting discussions, the key recommendations, and next steps.

Consultation sessions

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SESSION 1: OPENING AND THE GLOBAL OVERVIEW
Chair: Madhur Dhingra, FAO

Welcome and opening remarks
Maria Helena Semedo, FAO Deputy Director-General; Thanawat Tiensin, Director of FAO's Animal Production and Health Division; Montserrat Arroyo Kuribreña, WOAH Deputy Director-General of International Standards and Science

The AI outbreak in Asia almost 20 years ago brought together global experts to discuss AI for the first time and this meeting is following that precedent. The current outbreak, however, is without precedent. It began in 2020, and has now spread to the Americas, a previously unaffected region, and has infected wild birds and mammals with a significant negative impact on the conservation of these species.

The aim of this global consultation is to incorporate the recommendations and conclusions into the global strategy for AI. In order to achieve a scientifically sound and practical strategy, the involvement of OFFLU is critical. Likewise, the long-standing partnership with United States Agency for International Development (USAID), which has supported ECTAD, enables this important work.

Given the extent and severity of the current AI panzootic, several expert meetings, including this consultation, are planned to share knowledge and solutions. The most important work will follow the meetings, when the recommendations and outcomes will be incorporated in future work and actions, including the global strategy.

Meeting objectives and expected outputs and outcomes
Madhur Dhingra, FAO

The aim of the meeting was to bring together the global community to share the latest scientific findings and knowledge to support the development and implementation of disease prevention and control strategies and policies and contribute to global efforts towards reducing pandemic risk.

The objectives of the consultation meeting and the expected outputs were to:

- Summarize the latest scientific evidence and knowledge gaps in terms of epidemiology, ecology, virus evolution and pandemic risk.
- Draft recommendations for prevention and control in poultry production systems and value chains and at the human-animal-environment interface.
- Capture recommendations to support the review of the joint FAO-WOAH Global Control Strategy for AI.

Global overview of AI situation and key updates on global initiatives
Baba Soumare, FAO

FAO has been involved in global initiatives against AI since 2004. Through various mechanisms, different resources have been, and continue to be, utilized for AI response. The organization has emphasized the importance of biosecurity and worked to raise awareness and promote good practices along the poultry value chain, and two decades of capacity building has greatly increased laboratory diagnostic capabilities, biosecurity and biosafety. FAO has long understood the importance of the One Health approach, and has facilitated the establishment of national platforms, formed partnerships and joint initiatives with organizations like WOAH and OFFLU, and advocated for a One Health approach for prevention and control of AI.

SESSION 2: UPDATED AI EPIDEMIOLOGY
Chair: David Swayne, FAO and OFFLU

New gaps and challenges of the global HPAI situation
David Swayne, FAO and OFFLU

Some of the primary challenges of the current HPAI panzootic relate to the transmission and maintenance of HPAI in bird populations. An important research gap is understanding the impact of year-round transmission of the H5Nx virus in wild bird populations (both migratory and sedentary) on the spread to farming systems. Furthermore, the specific mechanisms through which the virus is transferred from wild bird reservoirs to poultry barns remain unknown, which hinders the improvement of biosecurity measures. There are numerous knowledge gaps related to virus transmission within domestic poultry systems. Investigations into the dynamics of local spread between farms, particularly in densely populated poultry areas, are necessary, and the role of airborne transmission, mechanical vectors, and human activities in this process needs to be explored. Clarification is required regarding the contribution of different farming and marketing systems to the maintenance of HPAI virus in poultry populations.

Understanding the transmission dynamics of different strains is important for implementing evidence-based and effective control measures. The factors that influence the dynamics of multiple virus strains, cross-protective immunity and viral fitness in different host species and farming systems need to be explored. Also essential for effective control of virus spread is determining the appropriate density of poultry and poultry farms, taking into account species, control measures, and production systems.

Biosecurity along poultry value chains presents multiple challenges. Emphasizing the importance of biosecurity is necessary, even for farms that have implemented improvements but continue to experience infected bird cases. It is understood that improving biosecurity measures in village poultry, small and medium poultry flocks, live poultry markets, and along value chains is of utmost importance; the challenge lies in how to achieve it. To this end, identifying structural factors that influence value chain configurations and promote the adoption of protective or risky behaviors among stakeholders is crucial.

Several cross-cutting issues were identified, including the lack of risk communication and community engagement action plans; the need for effective public private partnerships to enhance prevention and control programs; poor coordination in implementing the One Health approach; and in many countries, insufficient funding for surveillance, emergency response, indemnity, and compensation for AI. Reliable data on outbreak occurrence, infection prevalence across diverse farming systems, and genetic sequences are lacking. Additionally, there is a need for associated metadata and detailed sampling processes to improve understanding.

These challenges highlight the need for collaboration, increased funding, and improved data sharing. Addressing these gaps and strengthening surveillance and control strategies for AI requires the collective effort of all stakeholders involved.

Transmission dynamics in different poultry systems

Transmission dynamics of HPAI in intensive poultry production systems

Arjan Stegeman, University of Utrecht

Historically, outbreaks of HPAI in intensive systems were rare, and low pathogenic AI viruses of certain subtypes would often fade out without mutating to HPAI. However, major epidemics occasionally occurred in poultry-dense regions, as demonstrated by outbreaks in Pennsylvania, United States of America (1983-1984), Italy (1999-2000), and the Netherlands (2003). The transmission of HPAI between farms in intensive systems is influenced by various factors, including poultry movement, occupational visitors, feed and egg transport, rendering trucks, and farm density in the region. Outbreaks that could not be traced to a source were observed, with the likelihood of virus introduction depending on the distance to previously infected farms, and the risk of continued spread depending on farm density. Strategies to control between-farm transmission include depopulating infected farms, pre-emptive depopulation of neighbour or epidemiologically linked farms, movement restrictions, surveillance, and stringent biosecurity measures. Currently, most HPAI outbreaks in intensive systems result from introductions from wild bird reservoirs. The presence of windborne particles of wild bird origin in poultry barns can be identified using eDNA quantification and annotation. However, farm-to-farm spread remains significant in high-density farm regions and systems

with limited biosecurity. Developing farm-specific biosecurity plans that focus on preventing virus introduction and considering the potential use of vaccination can enhance the effectiveness of biosecurity measures.

Transmission dynamics of HPAI epidemics in mixed poultry production systems
Sébastien Lambert, Ecole nationale vétérinaire de Toulouse (ENVT)

The diversity of poultry production systems in France includes chicken layers and broilers, duck broilers and for foie gras, and various indoor/outdoor, intensive/extensive, integrated/independent systems. Poultry density and species distribution exhibit significant geographic heterogeneity. The epidemic in France in 2006 began with the introduction of H5N1 HPAI by migratory birds and affected wild birds and a single turkey flock. In contrast, the 2015-2016 epidemic was due to a mutation LPAI into HPAI, primarily impacting duck farms. Recurrent epidemics of HPAI H5Nx clade 2.3.4.4b occurred after 2016, although the 2016-2017 epidemic has been studied extensively. Phylogenetic analyses indicated a single primary introduction from wild birds into domestic poultry, followed by between-farm spread with limited long-distance transmission. The role of live bird transportation, wind, and vehicles in transmission remains unclear. While backyard farms had a limited role in transmission, densely populated areas and duck farms played a significant role. Despite biosecurity improvements, breaks in measures were observed in commercial farms.

HPAI transmission dynamics in endemic settings
Guillaume Fournié, INRAE

Transaction dynamics in poultry value chains are influenced by factors such as limited access to financial capital, leading to potential adoption of risky practices (e.g. in Bangladesh). The degree to which HPAI transmission and endemicity is influenced by multiple practices across farming and trading systems, including density, connectivity, stakeholder movements, batch and species mixing, hygiene practices, clinical severity, reporting, vaccination coverage and matching, and poultry turnover is unclear, undermining our understanding of transmission dynamics. These gaps can be partly addressed by collecting reliable data on outbreaks, system configurations and contact patterns, population dynamics (including wild birds), and detailed genetic sequences and associated metadata. Structural constraints can lead to practices such as mixing along trading networks that facilitate viral amplification. While the impact of viral endemicity in wild birds and vaccine use on transmission dynamics is uncertain, the possibility of repeated viral incursion into poultry leading to viral endemicity in previously unaffected farming systems is acknowledged.

Overview of updates from FAO regional experts
Africa
Abebe Wolde, FAO Regional Office for Africa

HPAI outbreaks have occurred in multiple West and Central African (WCA) countries, with at least ten of fifteen countries of the Economic Community of West African States (ECOWAS) affected. Active outbreaks are currently ongoing in five countries: Senegal, Gambia, Guinea, Nigeria, and Niger. Nigeria is a regional HPAI

hotspot and the most affected country in sub-Saharan Africa, with multiple outbreaks since 2006. Known risk factors for transmission within the region include wild birds, uncontrolled movement of poultry and poultry products, poor border control, and inadequate biosecurity measures. Challenges to effective control include a lack of skilled human resources and infrastructure, poor biosecurity awareness, insufficient resources for response, lack of coordination among stakeholders, and uncontrolled movement of poultry and products. Knowledge gaps include understanding the species of wild migratory birds that spread the virus, monitoring and tracking of LPAI, factors that influence sustained spread and introduction of new virus clades, and the role of clandestine vaccination. Lessons learned from previous outbreaks to reduce HPAI transmission include strengthening early detection and response capacities, including targeting surveillance around wetlands, enhancing biosecurity in farms and live bird markets, improving disease surveillance and outbreak containment, and enhancing cross-border surveillance of poultry and product trade. Successes in the region include the commitment of ECOWAS towards control of HPAI, availability of emergency stockpiles and support from FAO, capacity building efforts, and intersectoral collaboration.

Asia

Filip Claes, FAO Regional Office for Asia and the Pacific

In the Asia region, eleven countries have reported outbreaks of HPAI. H5 virus clade 2.3.4.4.b is predominant with co-circulation of endemic subclades H5 2.3.2.1e/a/c. The private sector is exploring options for vaccines, and Indonesia is considering vaccine production. Researchers are studying migration trajectories of wild birds. Known risk factors for transmission include virus introduction through migrating birds and poultry trade at the local level. Key knowledge gaps include limited understanding of poultry value chains, and epidemiological patterns, information on susceptible species, and migration patterns in wild birds. Proposed actions to improve control of HPAI include enabling data sharing and partnerships, improving risk evaluation and prediction, enhancing traceability and use of AI, and promoting novel approaches in surveillance. Successes included improved international coordination, better understanding of disease risks, increased outreach, development of tools and guidance, improved surveillance efficiency, and the piloting of new technology. Challenges to HPAI control have been faced when trying to enhance One Health coordination, address information-sharing gaps, prioritize government resources, increase public/private partnerships, improve data and surveillance in wild birds, and promote technical skills.

Latin America

Larissa Zanette, FAO Regional Office for Latin America and the Caribbean

HPAI has so far affected 14 countries, possibly due to birds migrating from North America to Latin America, infecting poultry. Several countries are facing events of this nature for the first time and face several challenges in controlling the transmission of HPAI. These include movement control, biosecurity gaps, difficulties in surveillance, and the absence of a compensation system for poultry farmers affected by the disease. It is crucial to improve surveillance to identify the source of

the virus in domestic poultry in order to control its spread effectively. The HPAI outbreaks in wild mammals in South America is a major challenge for surveillance. A new structure for surveillance of HPAI in wild mammals has been developed as a result, in which vet services coordinate with other institutions, such as organizations in protected areas. Knowledge and training on how to sample sea lions and other marine mammals for HPAI is needed, then questions related to HPAI virus in mammals can be elucidated. More information is needed regarding which bird species act as reservoirs and transmit the disease to native birds and marine mammals. Investigations into the time lag in disease reporting are ongoing, as the delay may be due to the different levels of surveillance structures for mammals and birds, and the lack of reporting habits, making it difficult for protected areas to report.

Panel discussion
Facilitator: David Swayne

Panel members: Charles Bebay, FAO Kenya; Abebe Wolde, FAO Regional Office for Africa; Filip Claes, FAO Regional Office for Asia and the Pacific; Guillaume Fournié, INRAE; Arjan Stegeman, UU; Larissa Zanette, FAO Regional Office for Latin America and the Caribbean; Eran Raizman, FAO Regional Office for Europe and Central Asia; David Castellan, Texas A&M University; Sébastien Lambert, Ecole Nationale Vétérinaire de Toulouse; Mia Torchetti, USDA

Impact and feasibility of implementing biosecurity

External verification is necessary as farmers may have an overly optimistic view of their biosecurity practices. This was supported by the observation that, in the United States of America, the number of wild animals affected by disease has increased while the number of cases in domestic poultry has remained constant, indicating an improvement in biosecurity, but with potential shortcomings still present.

In developed countries such as Europe and the United States of America, where there are resources and good infrastructure, many biosecurity measures are properly implemented. However, developing countries often lack the necessary resources and infrastructure, and even when available, their implementation depends on projects. The FAO Regional Office for Asia and the Pacific has implemented programmes to engage farmers, teach them basic biosecurity measures, and encourage them to commit to these measures, which has shown positive results with participating farmers receiving more money than non-participating farmers.
It was also suggested that vaccine composition meetings for the animal health sector should be considered, like those held for the public health sector. China has already organized such meetings.

Role of systems
There are significant blind spots regarding the role of poultry farming systems and there is little evidence to identify the role of each system in the spread of the disease. Better understanding of the structure of systems in countries and regions is necessary to have a clearer picture of their role in the spread of avian influenza.

An observed shift in the distribution of cases, with more cases being reported in broiler farms than in the past, whereas in previous epidemics, more cases were seen in layer farms. The virus is difficult to assess without considering different systems and call for further research to better understand the spread of avian influenza.

Carcass management
Some countries have limited resources for carcass management.

Data sharing and transparency
In Pakistan and India, for example, where H5N1 has been reported in scavenging crows, there is limited reporting data.
In East Africa, there have been no reports of HPAI for years. However, it is unclear whether this is due to a lack of data or a problem of under-reporting. There may be an under-reporting of the disease, but most East Africa countries are transparent. To know whether the risk of spread, the context (i.e. the high number of birds in Uganda), the dynamic trade movement (political will to become a dynamic trading point) and the transparency of the countries need to be considered. Currently, there is little monitoring in East Africa. However, further research and support from the private sector is recommended.

There is a general lack of specimen sharing/transport and material transfer agreements for further analysis and characterization.

Role of wild birds and mammals
In Latin America and the Caribbean, it is estimated that cases of HPAI originated from wild birds and were transmitted to smallholder and commercial poultry farms. Most farmers in the region have small and medium-sized farms with poor levels of biosecurity, which poses a significant challenge for preventing virus introduction.
The lack of movement control, biosecurity programs, and surveillance systems for early detection also contribute to the spread of the virus. To prevent transmission, countries need to improve their identification of the epidemiological links between outbreaks and understand the routes of transmission. The role of marine mammals

in virus transmission is unknown and needs to be studied further. Additionally, it is not clear whether the virus affecting mammals is the same as that affecting wild birds. The European Union has confirmed a new type of virus affecting mink.

Risk factors

The factors related to the observed increase in the number of AI outbreaks are not clear, and it is unknown if it is due to new or existing strains. It is also unclear whether the spread is due to wild birds or a cycle of transmission between farms and wild birds. It is likely that both factors are at play as farms can be exposed to wild birds, and farm connectivity seems to be strongly linked to the spread of AI.

The decline in surveillance of domestic ducks and geese is concerning, and surveillance strategies need to be reassessed. It is challenging to detect the virus through serological testing, and it is usually found in markets. The virus's persistence in duck flocks is still unknown, and repeated cycles of infection are uncertain. Environmental sampling can complement surveillance efforts and should be considered as a useful addition.

SESSION 3: SURVEILLANCE AND DIAGNOSTICS FOR AI: NEW APPROACHES AND CHALLENGES

Chair: Nicola Lewis, Royal Veterinary College

The aim of this session was to identify opportunities and feasibility of novel approaches to HPAI surveillance and diagnostics in specific regions. Some of the topics covered in this session included:

- Geospatial risk modelling to inform HPAI surveillance in poultry.
- Pirate Science in Asia - FAO Regional Office for Asia and the Pacific.

Geospatial risk modelling to inform HPAI surveillance in poultry

Marius Gilbert, ULB

The presentation highlighted the use of geospatial risk modelling to inform HPAI surveillance in poultry.

- The objective of this modelling is to improve the targeting and adaptation of surveillance and control.
- The process involves mapping suitability by using spatial predictors in the location of observed cases and then using absence data to predict variables in absence points.
- This allows for the prediction of the probability of being positive or negative and then projecting the predicted variable space into the geographical space.
- This technique has been applied in Thailand for HPAI H5N1 duck and helped in identifying the geographical distribution of free-grazing ducks in rice fields.
- The spatial model predictions were also used to map the distribution of infection risk at the market level for H7N9 in China and live bird poultry markets.
- The H5N1 global suitability model has also been used to predict H5N8 domestic cases in Europe.
- The benefits of geospatial suitability modelling include high predictive performance and the ability to easily integrate complex dependencies and interactions to provide a reliable contribution of predictor variables.

Pirate Science in Asia - FAO Regional Office for Asia and the Pacific
An overview of novel sampling and diagnostic tools
Erik Karlsson, FAO

The presentation focused on novel sampling and diagnostic tools for anticipating, detecting, and preventing endemic and emerging diseases such as HPAI.

- HPAI virus is endemic in Cambodia, with 30 percent of chickens testing positive. To stay ahead of endemic and emerging diseases, it is important to improve sampling and diagnostic tools to anticipate, detect, and prevent outbreaks.
- Improving sampling can include sampling environmental samples such as air and surfaces, as well as animals at risk and wild animals.
- Additionally, new sampling techniques such as using drones in bat caves, slaughterhouses, LBM, and wastewater from LBM can also be employed. To improve diagnostics, sensitivity, specificity, speed, and versatility need to be increased. This can be done through multiplex sampling, advanced sequencing, and collaboration for rapid HPAI sequencing. Additionally, the use of bioinformatics can help decrease turnaround times and provide real-time subtype information.
- By using these innovative technologies, we can increase surveillance capacity and contribute to our understanding of new or emerging pathogens at high-risk interfaces. These innovative technologies can also help measure the butterfly effect, such as changes in human behavior impacting HPAI spread.
- The possibility of combining environmental sampling with metagenomics for even more rapid information was also mentioned. These novel technologies could use environmental samples for in-field diagnostic surveillance and discovery, increasing surveillance capacity and contributing to our understanding of new or emerging pathogens at high-risk interfaces.
- Field-forward technologies such as field-forward Reverse Transcription Polymerase Chain Reaction (RT-PCR) and real-time bioinformatics, which enable fast response timelines and reduce analysis bottlenecks were introduced. The use of metagenomics and environmental sampling for rapid information detection and discovery are also relevant.
- Additionally, theCOVID-19 has impacted poultry farming and AIV risk, resulting in changes such as the transition of tour guides to poultry farming during the pandemic. The need for incorporating novel technologies and field-based sequencing to prevent and respond to outbreaks effectively was highlighted.
- The presentation also highlighted considering the socio-economic factors related to emerging and endemic diseases and explores how innovations can contribute to response and control strategies.
- Overall, the importance of surveillance, early warning systems, and innovative technologies in the context of disease surveillance and response in Asia, particularly focusing on avian influenza, was emphasized. Innovative technologies increase comprehensiveness, biosafety, animal welfare, and reduce cost, making them a valuable tool in anticipating, detecting, and preventing endemic and emerging diseases.

Barriers to implementation - Expert opinions

If it works, why are we not doing it yet?

Timm Harder from the Friedrich-Loeffler-Institut (FLI); Nicola Lewis (CRICK); Ron Fouchier, Erasmus Medical Center Rotterdam; Gwenaelle Dauphin, Health for Animals and Ceva Santé Animale (Ceva); and Giovanni Cattoli, Joint FAO/IAEA Centre for Nuclear Applications in Food and Agriculture

- Giovanni Cattoli emphasized the relevance of cost-effective environmental sampling strategies and technologies and the need to collect validation data in the field. He also talked about how environmental sampling can have a positive impact on farm biosafety and biosecurity, while on-site testing can contribute to reducing turn-around-time and issues with sample transportation. A legal framework for both (environmental sampling and on-site testing) needs to be developed.
- Nicola Lewis stressed the importance of multidisciplinary expertise, communication, and policies being in place before anything happens.
- Ron Fouchier highlighted the need for rapid testing and serological testing and emphasized the limitations of these new tools.
- Timm Harder also emphasized the need for validation and the key point of getting the right number (statistical backup) of samples.
- Gwenaelle Dauphin talked about the importance of new sampling techniques and the need for farmers' willingness to have bugs detected and surveillance to support vaccine development. She also mentioned the use of cameras and audios and the transportation of samples.

COMMENTS FROM EXPERTS IN THE CONFERENCE ROOM

During this session, various experts provided insights on using surveillance approaches to detect avian influenza in live bird markets. They emphasized the significance of analyzing the environmental conditions and their impact on the spread of AI. It was also discussed that demonstrating the impact of AI detection is important in convincing public health officials. Stakeholder involvement, such as industry, Chief Veterinary Officers (CVOs), and Chief Medical Officer (CMO), is vital in developing effective policies. The use of technologies for AI detection was emphasized, which can also be utilized for other diseases and AMR. The importance of monitoring vaccinated flocks and verification for legal purposes was highlighted. Collaborative surveillance was deemed important to link AI detection in live bird markets to humans working in the market. Finally, experts discussed conducting longitudinal cohort studies to collect serum for serology testing to understand AI protection levels in humans.

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Group work

Utility, acceptance, implementation of new thinking

- The working groups discussed recommended actions for the utility, acceptance, and implementation of novel approaches for better surveillance and control of AI.
- The first question addressed how these novel techniques and approaches can be optimally used for prevention and control, including demonstrating their added value, developing clear guidance on how to use these tools, and understanding how to apply them in different situations. It was recommended to optimize the prevention and control, it is necessary to demonstrate the added value of these novel approaches, include them in a global package, ensure clear guidance, and develop sustainable tools.

- The second question discussed how to ensure acceptance, such as by validating data and promoting these techniques as part of the national animal diseases prevention and control/biosecurity programme and collaborating with stakeholders to share information and benefits. It was recommended that acceptance can be achieved by validating data and promoting these techniques as part of national animal disease prevention and control programs.
- Finally, the third question addressed how to ensure implementation by looking beyond disease specifics limits, demonstrating proof of concept, integrating new ways of thinking into policy and international levels, and involving academia to support these new approaches. It was recommended that the implementation can be ensured by demonstrating proof of concept, integrating new ways of thinking into policies at national and international levels, and involving academia.

SESSION 4: AI PREVENTION AND CONTROL

Chair: Les Sims, OFFLU

This session aimed to identify regionally adapted HPAI prevention and control recommendations leading to better realization at the country-level. Prior to the meeting, two background papers were circulated to participants on issues relevant to prevention and control of HPAI. One focused primarily on biosecurity measures along the value chain and the other on vaccination against HPAI.

As a result, these issues were not discussed in depth in this session which featured two panels of experts who shared their insights on specific questions within the following areas:

Panel discussion: Prevention and control in low and low-middle income countries

Eric Brum, FAO Bangladesh; Robyn Alders the Australian National University (ANU); Damian Tago-Pacheco, FAO Mexico; Nguyen Thi Diep, Epidemiologist Department of Animal Health – Ministry of Agriculture and Rural Development of Viet Nam; Columba Teru Vakuru, Department of Veterinary ad Pest Control Services – Federal Ministry of Agriculture and Rural Development of Nigeria; Ahmed Saad, FAO Egypt

- Eric Brum shared his views on the realistic options for enhancing prevention and control of HPAI in Bangladesh and the necessary steps to implement them. For example, at the production level the following have proven to be of value: locally specific biosecurity solutions; vaccination using vaccines matched against field strains and combining ND and AI vaccination programmes; participatory surveillance to increase communication and trust between farmers and vet services; human-centric, co-creation processes to working closely with and empowering farmers and stakeholders in the process of designing and delivering solutions.
- Robyn Alders shared her experiences in applying lessons learned from ND and other diseases at the community level to HPAI, with a particular focus on how gender plays into poultry biosecurity.
- Damian Tago-Pacheco provided insights into the incentives that producers and others in the value chain need to change production, transport, and

selling practices. He also discussed how to get around the problem of no or inadequate compensation.

- Robyn Alders highlighted the three key important points. Firstly, family poultry producers are usually accustomed to their chickens dying as endemic diseases such as ND are inadequately controlled, making it difficult to detect HPAI outbreaks. Secondly, national veterinary services tend to focus on large and small ruminants, resulting in inadequate vaccination coverage for indigenous chickens or hybrid chickens raised by independent producers. Thirdly, there is a reluctance to report disease events to authorities due to the mass stamping out of birds without compensation in resource-limited settings. She also highlighted the importance of adopting gender-sensitive methodologies to identify additional issues and opportunities to improve the health of people and poultry within communities.
- Damian Tago-Pacheco emphasized the need for more community engagement and a flexible approach that allows countries to adapt to their own context. He also highlighted the challenges of achieving systematic improvements at the national level due to decentralization. He suggested that leveraging crises to drive behavioural changes, exploring behavioural insights and nudging to support interventions, and creating an enabling environment where peer pressure and peer-to-peer learning can increase the effectiveness of interventions are some options that have worked in the field with HPAI or other diseases.
- Nguyen Thi Diep stressed the need to continue advancing HPAI research and control measures despite the progress made in the past 20 years. Diep suggested enhancing control of poultry, ongoing surveillance and investigation using new technologies, and mapping cartography to determine the best vaccine for new viruses. Diep also recommended the creation of a free zone for HPAI in the future and addressing the role of wet markets in the spread of AI. Overall, Diep's recommendations underscore the importance of continued investment in HPAI research and control measures to prevent future outbreaks and protect public health in Vietnam.
- Teru Vakuru suggested that improving governance of HPAI prevention and control programs requires a good understanding of the entire poultry value chain, local production systems, and associated risk factors. This can be achieved through proper regulation of the poultry industry, holistic implementation of biosecurity measures, capacity building, promotion of ownership of biosecurity measures, disease surveillance, political will, movement control of poultry and poultry products, restructuring of live bird markets, collaboration with partners, and reasonable and timely compensation.
- The question of whether vaccination will be added formally to the suite of preventive measures was also discussed. Ahmed Saad focused on positive steps taken in Egypt to prevent and control HPAI, changes in the poultry industry in terms of biosecurity, and improvements to vaccination.

Overall, the panelists shared valuable insights on enhancing prevention and control of HPAI, including the need for increased community engagement, flexible approaches that consider local contexts, and gender-sensitive methodologies that address barriers to participation.

Panel discussion: Prevention and control in high income countries

Jean-Pierre Vaillancourt, Université de Montréal (UdeM); Jean-Luc, Guerin, ENVT; Sjaak DeWit, University of Utrecht (UU), Gary Flory, Virginia Department of Environmental Quality (DEQ); Francesco Bonfante, Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe); and Gwenaelle Dauphin, CEVA

Jean-Pierre Vaillancourt highlighted the compliance issue with on-farm biosecurity and proposes solutions such as employee training, development of simple technologies like sensors, and low-cost incentives to make biosecurity an investment rather than an expense.

He suggested that regional biosecurity and proper regulation of outside production as a way forward. He also talks about the need for public-private partnerships, where the private sector leads, and the government sets guidelines.

- Jean-Luc Guerin stressed the importance of biosecurity as a basis for controlling HPAI and the need for positive perspectives to maintain farmer involvement. He recommended investigating alternative systems of production, such as free-range, and the regulation of flocks density in specific zones to control the risk. Guerin also emphasized the importance of vaccination as a precious tool for a new model of sustainability, particularly in France where vaccination of ducks is considered a priority. He suggested that surveillance of vaccinated flocks will represent a major challenge in Europe due to its severe regulation.
- Sjaak DeWit discussed the benefits and challenges of vaccination for HPAI and the need for a risk-based approach to control the disease. He also underlined the importance of appropriate surveillance and monitoring of HPAI outbreaks and the need for a global response to the disease.
- Francesco Bonfante discussed the challenges and opportunities for the poultry industry in adapting to changing consumer preferences and demands for better welfare and sustainability. He highlighted the need for innovative solutions and technologies in poultry production, such as precision farming, and the importance of partnerships between industry, academia, and government.
- Gary Flory drew the attention to the strengths and pitfalls of above ground burial and composting techniques for disposal of poultry carcasses. He emphasized the importance of animal mortality management as a crucial component of transboundary animal disease response. Traditional deep burial may be useful in specific settings but can result in significant risks to people, animals, and the environment when implemented in the wrong setting. On the other hand, composting has been extensively used in the United States during recent HPAI outbreaks, and with additional training and outreach, it has the potential to be a helpful disease management tool globally. Above ground burial is a hybrid technique that can potentially be a valuable carcass management tool, especially in resource-limited countries. Flory encouraged countries to enhance their disease response plans to include robust carcass disposal plans.
- Gwen Dauphin inquired about new directions in biosecurity in the poultry industry. Dauphin noted progress in HPAI and salmonella prevention, particularly in passive biosecurity measures such as protecting farms from virus entries and limiting external visitors' traceability. She noted that active

biosecurity measures have also improved, with better-respected disinfection processes and improved sewage management.

Overall, this panel highlighted the need to improve biosecurity measures by training and educating farmers and stakeholders and implementing reliable and realistic surveillance programs. The panel indicated that vaccination will be utilised more frequently as an additional preventive measure.

Progressive management pathway for terrestrial animal biosecurity (PMP-TAB)

Melissa McLaws, FAO

- Biosecurity should be approached strategically and in an integrated manner, considering the relevant risks to human, animal, and plant health, as well as the environment.
- The PMP is a stepwise approach that focuses on improving biosecurity measures and has core components that are considered in each step. Actions are needed on two fronts: The first action is to improve biosecurity along animal value chains, and while the second action is to strengthen national capacities to implement and monitor these improvements PMP-TAB.
- A community of practice has been created on the FAO Virtual Learning Centers (VLC) platform, which promotes collaboration among members and experts and co-creates and shares knowledge about terrestrial animal biosecurity.
- It was also noted that the PMP-TAB is not a scoring process, but rather a stepwise farmework for progress.
- The PMP-TAB includes planned activities such as developing guidelines and toolkits, piloting the approach in different sectors and environments, and establishing the CoP for terrestrial animal biosecurity.

AI Vaccination Stewardship

Les Sims, OFFLU

Les Sims briefly presented on the new concept of AI Vaccination Stewardship aimed at improving usage of vaccinations against HPAI. This covers 12 aspects that anyone or any country using vaccination should consider and implement. This includes not just relying on vaccination, ensuring only vaccines from reputable suppliers that provide appropriate protection are used, that appropriate surveillance systems are needed including systems to detect antigenic variants against which existing vaccines are not working.

Breakout sessions and key recommendations

During the breakout sessions, one group was tasked to discuss "the necessary steps to move towards a lower burden or elimination of endemic diseases", whilst a second group focused on "why biosecurity has broken down in historically-free countries and proposed solutions to address this issue." The results of the group discussions are as follows:

Group A: Endemic countries: What needs to be done to move towards lower burden or elimination?

- Suggestions for necessary steps to move towards a lower burden or elimination of endemic diseases included:
- For enhancing prevention and control of HPAI in Bangladesh:
  - Swift detection of outbreaks is crucial due to the difficulty in differentiating between HPAI and other vaccine-preventable diseases like ND and fowl cholera.
  - National veterinary services should establish direct connections with family poultry farmers, including those raising indigenous or hybrid chickens, to ensure adequate vaccination coverage.
  - Positive engagement with communities is necessary to build trust and encourage disease reporting to authorities.
- Lessons from community-level disease prevention for HPAI:
  - Gender plays a role in the implementation of biosecurity practices, with differing levels of access to information and training for women and non-binary individuals.
  - Inclusive participation, language accessibility, and childcare facilities can address barriers to gender-inclusive biosecurity practices.
  - Consideration of the value of different poultry types and their contributions to household food security and social cohesion is essential in policy development.
- Incentives and strategies for change in production and practices:
  - Crises can drive behavioral changes, such as improved biosecurity attitudes, and should be utilized to promote positive changes.
  - Community engagement, understanding of local business models, and flexible approaches tailored to specific contexts can increase ownership and sustainable changes.
  - Recognizing the challenges of decentralization and working with local authorities is necessary for systematic improvements at the national level.
- Moving forward with HPAI prevention and control:
  - Improved governance through proper regulation, holistic biosecurity implementation, capacity building, and disease surveillance network development.
  - Political will and resource mobilization, movement control of poultry and products, restructuring of LBM, and collaboration with partners.
  - Reasonable and timely compensation, along with the addition of vaccination to preventive measures.
- Positive steps in Egypt for HPAI prevention and control:
  - Swift detection and response to outbreaks, strengthening of biosecurity practices in the poultry industry.
  - Improvement in vaccination strategies.
  - The potential for eliminating HPAI from Egypt in the next ten years is uncertain and requires continued efforts.

Reasons for biosecurity breakdowns in historically-free countries included:

- Lack of incentives for small farmers to implement biosecurity measures.
- Resistance from farmers to implement biosecurity measures.

- Challenges in poultry carcass disposal due to regulatory and environmental limitations.
- Lack of compensation for farmers leading to underreporting.
- Disparity of knowledge in biosecurity measures for women and non-binary people.

Proposed actions included:

- Recognize and understand different business models to develop context specific interventions.
- Tailor programs to the needs of commercial farms and backyard poultry in each production context.
- Customize messages and communicate with different stakeholders to incentivize biosecurity implementation.
- Engage and empower communities in decision-making processes.
- Encourage behavior changes, co-create solutions, provide incentives, and establish farm field schools.
- Foster private-public partnerships to address compensation issues and share resources.
- Link biosecurity with compensation to obtain resources from the private sector.
- Address small-scale production to improve biosecurity.
- Understand the poultry value chain and identify key transmission points.
- Modify production and selling practices to reduce transmission risks.
- Combine biosecurity measures, surveillance, and vaccines.
- Implement effective solutions for carcass disposal, such as composting and above-ground burial.
- Regularly monitor viruses, update vaccines, and reassess vaccine programs.
- Focus on farms or markets with persistent infection despite appropriate vaccine usage.
- Develop specific vaccines tailored to the context and enable rapid response with virus sequencing.
- Utilize tools like lasers and inflated balloons to prevent wild bird access.
- Strengthen biosecurity measures in critical stopover points for migratory birds.
- Enhance training and outreach on biosecurity, including sensor use and real time feedback.
- Promote regional biosecurity and consider micro-zoning in challenging areas.
- Improve animal mortality management through composting and above-ground burial.
- Encourage private-public partnerships in biosecurity efforts.
- Utilize big data for risk analysis, traceability, health care recording, and environmental alerts.
- Emphasize training, external assessment, big data analysis, and trials in prevention and control efforts.

Recommendations proposed from the discussions included:

- Recognize different business models in the poultry industry for context specific interventions.

- Tailor programs to address biosecurity and disease prevention needs of commercial farms and backyard poultry.
- Customize communication to incentivize implementation of biosecurity measures for small stakeholders.
- Engage communities in decision-making, behavior change, and strategy co-creation through farm field schools.
- Establish private-public partnerships for compensation and link biosecurity with compensation programs, considering potential challenges for early warning systems.

SESSION 5: HUMAN-ANIMAL-INTERFACE AND PANDEMIC PREPAREDNESS

Chair: Cornelia Adlhoch, European Centre for Disease Prevention and Control (ECDC)

The objectives of this session were to:

- Identify gaps in knowledge relating to AI in wild mammal populations and the pandemic risk of avian influenza viruses, and
- Discuss how to bridge these gaps.

The session covered two main topics: spillover to mammalian hosts, both human and non-human, and the latest evidence on the zoonotic risk posed by HPAI viruses. The opening remarks for this session highlighted the increasing proximity of HPAI to humans, to wild and domestic/pet animals.

Keynote: The global zoonotic risk from AI viruses – the latest evidence

Magdi Samaan, WHO

The tool for influenza pandemic risk assessment (TIPRA) since 2014, and updated as TIPRA2 in 2020 was presented:

- TIPRA 1 was launched in 2016 and involved assessing several influenza virus subtypes. It was updated in 2019, and TIPRA 2 was launched in 2020.
- The objectives of TIPRA include conducting reproducible risk assessments, documenting virus and infection characteristics, and identifying knowledge gaps.
- TIPRA aims to facilitate information sharing and decision-making on prevention efforts.
- The risk of sustained human-to-human transmission of an Influenza virus with pandemic potential is a key concern.
- The continuum of a pandemic is considered, and global assessments involve WHO, international experts, member states, and academia.
- TIPRA has conducted risk assessments for various influenza virus subtypes, including H5N6, H7N9, H9N2, H1 TRIG, H5N1, H5Nx, and H3N8.
- Knowledge gaps have been identified in areas such as surveillance, population immunity, cross protection, and antiviral susceptibility.
- TIPRA has limitations and does not predict the next pandemic virus, eliminate the need for technical experts, or provide exact statistical risk quantification.

- TIPRA is a unique resource that promotes sharing experiences among experts, follows a systematic process of risk assessment, generates comparable results, captures confidence in risk assessment, and characterizes risks despite knowledge gaps.
- Collaborative partners in TIPRA include WHO Collaborating Centres, H5 Regional Reference Laboratories, National Influenza Centres, FAO/WOAH/ECDC/OFFLU Reference Laboratories, academia, and Global Influenza Programme (GIP) colleagues.

Keynote: Surveillance options in mammals
Ian Brown, OFFLU

The presentation highlighted the need to understand the change in host range and the approach that should be taken for pandemic preparedness. This included:

- Reports of H5 HPAI in non-avian wildlife species have increased over the years.
- The global distribution of H5N1 HPAI in mammals
- An outbreak of H5N1 HPAI in intensively farmed minks occurred in northwest Spain in October 2022, with an uncommon mutation in the PB2 gene.
- Significant mortalities reported in mammalian species, but mammal-to-mammal transmission is not confirmed, except for one known outbreak on a mink farm.
- It highlighted the need to detect and understand changes in the host range of HPAI, investigate infection consequences within and between populations, and rapidly share data for threat mitigation and pandemic preparedness.
- The need for international tracking and monitoring of knowledge gaps related to AI in mammalian populations and wild birds.
- Diverse and complex ecosystems worldwide need to be recognized, and risk assessments should consider populations exposed to infected wild birds, their behaviors, and possible exposure pathways. Surveillance resources should focus on hosts with opportunities for exposure and deeper investigation in populations with higher contact structure.
- Practicality of sampling, maintaining effective cold chain, sharing specimens for advanced diagnostics, and complementing surveillance in mammals with surveillance in wild birds are important considerations.
- Sampling methods, safe handling of samples, storage, and analysis techniques such as serology, real-time PCR, whole genome sequencing, and rapid data sharing were highlighted.
- The spread of H5 HPAI to mammals is occurring widely, and surveillance is needed to assess the impact on wildlife populations and monitor for host adaptive changes in the virus.

Breakout sessions and key recommendations

During the breakout sessions, four groups were tasked to discuss as follows:

Online groups discussions:

- Group A: Considerations when designing surveillance efforts for mammalian species.
- Group B: Identifying barriers that can hinder effective surveillance.

In-person scenario breakout rooms: Influenza pandemic emergence: what did we miss?

- Breakout room 1: Countries with endemic HPAI infection in poultry.
- Breakout room 2: Countries repeatedly affected by new HPAI incursions.
- Breakout room 3: Countries that are new to HPAI outbreaks and disease.
- Breakout room 4: Countries that are not reporting the presence of highly pathogenic HPAI outbreaks.

Results of the group discussions

Considerations that should be taken into account when designing surveillance efforts for mammalian specie:

When designing surveillance efforts for mammalian species, the following should be considered:

- Define the purpose and objectives of surveillance for mammalian species.
- Identify and prioritize target species based on their potential role in disease transmission or susceptibility.
- Determine the appropriate surveillance methods and techniques for different mammalian species.
- The geographic scope and distribution of the target species.
- Consider the habitats and ecological factors influencing mammalian species' interactions with pathogens.

- Ensure collaboration and coordination between relevant stakeholders, including wildlife authorities, health agencies, and research institutions.
- Establish a network of surveillance sites or monitoring stations to cover different regions or ecosystems.
- The use of both active and passive surveillance approaches to enhance detection and monitoring.

Barriers that can hinder effective surveillance

- Lack of awareness or understanding of the importance of surveillance among stakeholders and the public.
- Competing priorities and lack of resources.
- Inadequate infrastructure and laboratory capacity for timely and accurate testing and analysis.
- Limited collaboration and coordination between different sectors and agencies involved in surveillance.
- Inconsistent policies and regulations related to surveillance, reporting requirements, and sample sharing include material transfer agreements (MTAs).
- Difficulties in accessing remote or hard-to-reach areas for surveillance activities.
- Publication-first approaches and privacy concerns delay effective data and sample sharing.

Influenza pandemic emergence: what did we miss?

- Endemic HPAI infection in poultry:
  - Failure to recognize and address the presence of endemic HPAI infection in poultry populations.
  - Insufficient surveillance and control measures in poultry farms to prevent the transmission and spread of HPAI.
  - Inadequate biosecurity practices and lack of compliance with preventive measures in the poultry industry.
- Countries repeatedly affected by new HPAI incursions:
  - Neglecting to focus on transitional farming practices, which can contribute to the introduction and spread of HPAI.
  - Lack of systemic wild mammal surveillance, leading to a potential gap in understanding the role of wildlife in HPAI transmission.
  - Insufficient training, addressing social needs, education and communication, neglecting importance of behavioural science for individuals working at the human-animal interface, increasing the risk of disease transmission.
- Countries that are new to HPAI outbreaks and disease:
  - Need for a One Health approach and improved connectivity between sectors to effectively respond to HPAI outbreaks.
  - Some countries have structures in place, but they require further testing and evaluation to ensure their effectiveness.
  - Challenges in risk communication and promoting behavioral change to prevent the introduction and spread of HPAI.
  - One Health collaborations/platforms not established ahead of crisis.

- Countries that are not reporting the presence of highly pathogenic HPAI outbreaks:
  - Inadequate awareness among value chain actors about the risks associated with HPAI and their ability to respond to outbreaks.
  - Lack of preparedness plans and cost-effective surveillance systems.
  - Need for models and incentives to encourage reporting and improve timely information sharing on HPAI events.

Recommendations

- During these breakout sessions, participants discussed pandemic influenza emergence in endemic countries and identified the importance of decentralized systems and updated pandemic preparedness and response plans.
- Highlighted the need for adopted and targeted One Health surveillance systems according to the needs and objectives determined by each setting and the overall need for informing assessments and pandemic preparedness planning and response efforts.
- Address inconsistent policies between countries, communication issues, For countries facing repeated incursions, there was a need to focus on transitional farming and systemic wild mammal surveillance, as well as raise awareness and provide resources and benefits for those working at the human-animal interface.
- Countries new to outbreaks require a One Health approach and connectivity between sectors, with some structures in place but untested. Participants identified the need for a preparedness plan, cost-effective surveillance systems, and models for incentivizing reporting in countries not reporting.
- When designing surveillance efforts, focus on potential human interaction risks, engaging traditional and non-traditional partners, including village/smallholder systems, and defining the purpose of surveillance to ensure cost-benefit. Incorporate use of new generic tools like wastewater monitoring or air sampling; assess limitations and objectives of surveillance systems and evaluate usefulness of different systems according to the context; determine the minimum and optimal level for information gathering and decision making.
- Barriers to surveillance included trust penalties, problems with transport, collective surveillance, enhancing passive surveillance, and funding surveillance.

SESSION 6: ECOLOGY OF HPAI IN WILD BIRDS AND THE WILDLIFE-LIVESTOCK INTERFACE

Chair: Thijs Kuiken, Erasmus Medical Center Rotterdam

The session objective was to explore different approaches to and objectives of wild bird surveillance, to discuss challenges and opportunities in understanding the spillover from wild birds within different regions, and to understand the impacts of HPAI on wild birds and subsequent conservation effects.

Overview presentation on changes in HPAI in wildlife during the last two years
Thijs Kuiken, Erasmus Medical Center Rotterdam

- An overview of the changes in HPAI in wildlife over the past two years was presented. Highlights included:
- HPAI (Gs/Gd H5NX) is persisting year-round in wild birds in Europe, and it may cause high mortality in both wild birds and mammals.
- The current HPAI Gs/Gd H5NX outbreak is of particular concern for seabirds in breeding colonies and vulnerable/endangered avian and mammalian species.
- Besides dealing with the current HPAI Gs/Gd H5NX outbreak, an important question is how to reduce the chances of future HPAI viruses spilling over from poultry into wildlife.
- Specific recommendations are being formulated for the current HPAI Gs/Gd H5NX outbreak, including AI surveillance in wildlife, measures to reduce morbidity/mortality of wildlife, and guidelines for wildlife care and outdoor activities during HPAI outbreaks.
- There is a need for comprehensive strategies to address the ecological aspects of AI in wild birds and the interface with livestock.
- Collaboration between various stakeholders and international cooperation are crucial for effective surveillance, mitigation, and management of HPAI in wildlife.

Wild-domestic bird interface modelling
Claudia Pittiglio, FAO

The use of interface modeling and the development of risk maps for different regions was highlighted. FAO collaborated with Wetland International, and Sapienza University to enhance the model by including additional factors such as climate variability, wild bird density, and movement, with the goal of creating a real-time mapping tool for early warning of AI. Details provided included:

- The main objective of the FAO's interface modelling effort is to identify, characterize, and predict interfaces between wild and domestic birds that are at risk of HPAI spillover.
- The analysis utilizes hotspots analysis (LISA) and data on wild bird species distribution, important bird areas (IBAs), HPAI events, and chicken and duck density.
- Maps are presented showing the predicted wild/domestic bird interfaces based on the analysis.
- Current developments include collaboration with various organizations to enhance AI interface mapping and modeling, incorporating climate variability, wild bird density, and movement for real-time risk mapping/forecasting.
- Uses expert knowledge and sensitivity analysis.
- Further developments involve the creation of an early warning and decision support tool for AI, which aims to establish a network of wild bird experts, facilitate real-time data sharing and consultation, and enhance preparedness and response.
- The importance of cost-effectiveness in early warning systems was emphasized. The FAO has previously produced an early warning system for Rift Valley fever and is now attempting to do the same for HPAI virus.

This involves taking into consideration the different ecologies and species in different regions, with the two main proxies for wild birds being wild bird species richness and poultry density (grid livestock of world).

Panel discussion: Surveillance for different objectives and associated challenges
In-person: Julianna Lenoch, USDA; Laura Roberts, UP; Jonas Waldenström, LNU; and Claudia Pittiglio, FAO
Online: Dave Stallknecht, UGA; Michelle Wille, United States of America; Marcela Uhart, UCD; Ruth Cromie, CMS; Alexander Shestopalov, NSU; and Zheng Huang, NNU

A panel discussion on various surveillance objectives and challenges was held with participants present both in-person and online. The key issues raised were:

- Early detection is important for mitigating risks to wild bird populations, and surveillance should include not only presence/absence, but also focus on ecology and understanding species transmissibility and epidemiology.
- The economic impacts of HPAI mortalities in wild bird conservation with implications for income-generating activities like ecotourism were discussed, recognizing that HPAI does not only affect poultry.
- The experts agreed that both active and passive surveillance in wild birds could be conducted simultaneously for different reasons, but that understanding wild bird ecology and movements is crucial for pinpointing areas where surveillance would be most effective for early warning.
- Environmental sampling, such as water or wetland sediment, was suggested as an additional way to detect high-risk novel genotypes of HPAI viruses. However, experts acknowledged that cost-effective and adaptable surveillance strategies are needed, especially in countries with limited capacity, and constantly evaluating what is happening in the field is essential.

Impacts on the population ecology of wild birds
Ruth Cromie, CMS

The presentation focused on the impacts of HPAI on wild birds, particularly waterbirds and seabirds:

- Biodiversity is already under significant pressures. Drivers of population decline for wild birds include climate change, habitat loss, land use change, pollution, non-sustainable killing/trade, invasive species, and disease.
- The 1996(Gs/Gd) lineage outbreak in wild birds at Lake Qinghai in China was a significant event, resulting in the mortality of thousands of migratory and resident wild birds.
- In effect the 'genie was out of the bottle' and although there were subsequent significant mortality events in the following years, we have seen a new phase of the epizootic in wild birds in the last two years with survival of virus over the northern summer months and exceptionally high mortality in seabird breeding colonies in particular.
- The impacts on specific wild bird species such as Hooded cranes, White-napped cranes, African penguins, Cape cormorants, Northern gannets, great skuas, terns, guillemots, Humboldt penguins, Peruvian pelicans, and roseate terns are of concern.

- Mammals, including foxes, seals, sea-lions, dolphins, bears, felids, opossums, and mustelids, have been infected - including likely mammal to mammal transfer in wild sea-lions in South America and in a farmed mink outbreak.
- Population vulnerability is influenced by likelihood of exposure, susceptibility, and life history traits.
- The outlook includes concerns about the spread of a fitter (enzootic) virus, and for the virus reaching remote islands where species such as albatrosses breed.
- Future dynamics of spread is unknown, including the potential for immunity in adults and via eggs.
- Emphasis is given for the need for a One Health approach, national mitigation planning, conservation-focused surveillance and research, and resourcing for responses to HPAI in the wild bird context.
- Prevention of emerging infectious diseases requires a focus on ecosystem approaches to health and rethinking poultry production systems and methods.

Panel discussion: Perspectives on the impacts on wild birds

In-person: Julianna Lenoch, USDA; Laura Roberts, South Africa; Jonas Waldenström, LNU; and Claudia Pittiglio, FAO

Online: Dave Stallknecht, UGA; Michelle Wille, United States of America; Marcela Uhart, UCD; Ruth Cromie, CMS; Alexander Shestopalov, Siberia; and Zheng Huang, NNU

A panel discussion on the impacts on wild bird populations - regional experiences and solutions for mitigating impact was held with participants present both in-person and online. The key issues raised were:

- The importance of understanding the rationale for carcass disposal was highlighted in South Africa, and the need for more hypothesis-driven research to determine whether carcass removal helps reduce virus spread was emphasized.
- Concerns were raised about scavengers acting as bridge species and potentially spreading the virus.
- Preparing research permits in advance of big mortality events was recommended, to allow study of response efforts.
- Additionally, the possibility of surveillance and carcass collection being invasive to bird populations and potentially disrupting breeding season, making them more vulnerable to prey, was mentioned.

In the concluding statements of this session, it was emphasized that building capacity beyond a single epizootic outbreak is critical. Wildlife surveillance, currently designed primarily to understand risks to poultry should be re-designed to include risks to conservation which requires involvement of environment ministries. Stakeholders may have conflicting perspectives, such as utilizing hunter-killed waterfowl for surveillance, versus the need to suspend such activities in the case of HPAI detection. Integrating HPAI surveillance and population management is possible, leveraging existing frameworks and structures. Lastly, the need for sustained funding for both research and surveillance of AI in wildlife was emphasized.

SESSION 7: RECOMMENDATIONS FOR AI PREVENTION AND CONTROL

Chairs: Lidewijj Wiersma, FAO; and Gounalan Pavade, WOAH

This session aimed to identify recommendations for HPAI prevention and control based on outputs from the various technical sessions.

Breakout room: identify key elements and approaches for AI prevention and control to include in the updated HPAI global strategy

During the meeting, breakout room discussions were held to build upon the objectives of each preceding session, with the aim of identifying key elements and approaches for HPAI prevention and control. The breakout rooms were organized based on themes and meeting sessions, and participants were asked to attend the room that most closely aligned with their expertise. To ensure balanced groups, some rooms had a limit on the number of participants. Note takers for each breakout room were decided during the session. Participants discussed questions and recommendations supplied by both meeting participants and FAO staff via email.

The sessions included opinion polling and ranking systems to gather feedback and insights from participants:

- Participants focused on changes in HPAI control over the last 20 years and stressed the importance of communication and collaboration among entities and organizations.
- While progress has been made, there is still a need to improve access to PCR analysis in all countries and overcome knowledge gaps.
- The COVID-19 pandemic has highlighted the importance of prevention and biosecurity measures in advance of outbreaks.
- Regular funding for preventive measures and studies is necessary, and countries that are not vaccinating need to be engaged.
- The high density of poultry farms makes it difficult to halt the spread of the virus, and trade regulations should be reconsidered in light of increasing number of endemic countries.
- It was acknowledged that the virus is now endemic in many areas of the world, and participants emphasized the importance of addressing the impact on wildlife for conservation purposes.
- The questionnaire form distributed to participants did not include important recommendations such as strategies to redefine protocols of countries, guidance for decision-making on vaccination, and the impact on wildlife value chains.

During the online session, participants discussed the changes in the context of the HPAI virus over the last 20 years, including the intensification of production and human population and the resulting changes in transmission dynamics. It was noted that although there has been a decrease in the number of cases at the human-animal interface, the virus has spread geographically. The COVID-19 pandemic has brought about significant changes, including a shift towards social health measures and the recognition that the virus is now endemic in many countries. Participants emphasized the need to live with the virus and prioritize prevention measures, given the limited resources available. They also highlighted the importance of research in influenza and the need to change the Knowledge, Attitudes, Practise (KAP) model to adapt to the changing context.

Round-table discussions

Recommendations and conclusions (final recommendations are presented in SECTION 3)

- David Swayne presented several recommendations for the second session on national and regional prevention and control measures related to HPAI introduction and transmission along poultry value chains in the next five years. These recommendations included conducting value chain mapping and transmission studies, identifying factors that drive HPAI transmission, collecting epidemiological, value chain and genetic data, building sustainable capacity for risk assessments and risk management, and evaluating the use of vaccination.
- In the third session, Nicola Lewis discussed the need for tailored country specific HPAI surveillance and the importance of sharing and integrating surveillance data for decision support. She recommended conducting research on novel approaches for HPAI surveillance and diagnostics, validating these approaches through country pilot studies, assessing legislation to apply to novel surveillance approaches, and engaging stakeholders in surveillance system design and implementation. The session concluded by emphasizing the need for multi-pathogen and multi-species testing and the development of educational and awareness materials.
- The fourth session highlighted the lack of control and preparedness for vaccination campaigns, while David Castellan suggested the need to clearly define the community and include more social sciences.
- During the fifth session, Cornelia Adlhoch identified the related drivers and risks posed to human health, livelihoods, food security, and biodiversity at the human/animal interface. She recommended starting locally, prioritizing interests, and establishing coordinated surveillance, data sharing, and risk assessment under a One Health approach between animal, health, and public sectors. The development and strengthening of ties with the wildlife and environment sector was also emphasized as critical for effective prevention and control of HPAI viruses.
- The sixth session, led by Thijs Kuiken, focused on supporting and collaborating on research to evaluate drivers, risks, and impacts of HPAI on wildlife, preparing appropriate contingency response plans for early detection of wild bird die-offs, defining human drivers of HPAI spillover, and advocating for

greater awareness and understanding of ecosystem services and system-based approaches for the prevention and control of AI. The session concluded that the HPAI clade 2.3.4.4b epidemic has no historical precedent, with severe conservation impacts, emphasizing the need to strengthen engagement and involvement of the wildlife/environment sector under a One Health approach.

SESSION 8: CONCLUSIONS AND WAY FORWARD

Chair: Madhur Dhingra, FAO; Rosanne Marchesich, FAO; Keith Sumption, FAO

- Madhur Dhingra expressed gratitude towards all participants for their contribution. A substantial amount of material was presented, which needs to be collated. The ultimate objective is to transfer the recommendations of the scientific community to the policy recommendations that will enable the global prevention and control of HPAI.
- Rosanne Marchesich assured continued support from the FAO, through ECTAD, Emergency Prevention System for Animal Health (EMPRES-AH), and other programmes, for the expanding risk management in value chain with broader geographical coverage. However, more work is needed to identify knowledge gaps and distinguish surveillance protocols for different production systems. The One Health approach is vital for the human animal interface, and OFFLU and the Quadripartite actions will persist in this regard.
- Keith Sumption reflected on the evolution of HPAI expertise and highlighted the importance of preserving the community of expertise and supporting it through quadripartite actions. He expressed his admiration for the high quality discussions during the meeting and thanked all partners. Keith also stressed the need to integrate the recommendations raised into the FAO-WOAH-WHO global strategy to address and manage the impact of HPAI.

ANNEX 1

List of participants

Name	Institution	Modality of participation
Arjan Stegeman	Utrecht University	In-person
Abebe Wolde	FAO Regional Office for Africa	In-person
Charles Bebay	FAO Regional Office for Africa	In-person
Columba Teru Vakuru	CVO of Nigeria	Online
Jean-Pierre Vaillancourt	Canadian University of Montreal	In-person
Leslie Sims	FAO	In-person
Julianna Lenoch	USDA	In-person
David Castellan	Institute for infectious animal diseases	Online
David Swayne	WOAH/FAO Network of Expertise on Animal Influenza	In-person
Erica Spackman	USDA	Online
Dave Stallknecht	University of Georgia	Online
Richard Webby	St. Jude children's research hospital	Online
Amelia Coggon	FAO	In-person
Ihab El Masry	FAO	Online
Mohammed Shamsuddin	FAO Regional Office for Africa	Online
Erik Karlsson	Institut pasteur du Cambodge	In-person
Scott Newman	FAO Regional Office for Asia and the Pacific	Online
Kachen Wongsathapornchai	FAO Regional Office for Asia and the Pacific	Online
Filip Claes	FAO Regional Office for Asia and the Pacific	In-person
Damian Tago Pacheco	FAO Regional Office for Africa	In-person
Frank Wong	Commonwealth Scientific and Industrial Research Organisation	Online
Thijs Kuiken	Erasmus University	In-person
Ron Fouchier	Erasmus Medical Center	In-person
Eran Raizman	FAO Regional Office for Europe and Central Asia	In-person
Timm Harder	Friedrich-Loeffler-Institut	In-person
Claire Guinat	Ecole nationale vétérinaire de Toulouse	Online
Cornelia Adlhoch	European centre for disease prevention and control	In-person
Larissa Zanette	FAO Regional Office for Latin America and the Caribbean	In-person
Andres Gonzalez Serrano	FAO Regional Office for Latin America and the Caribbean	Online
Dilmara Resichak	Unidade de Sanidade Aviária	Online

Name	Institution	Modality of participation
Nguyen Thi Diep	Department of animal health of Vietnam	In-person
Pawin Padungtod	FAO Viet Nam	In-person
Hendra Wibawa	Ministry of agriculture of Indonesia	In-person
Marcela Uhart	University of California Davis	Online
Rafiqul Islam	Bangladesh Agricultural University	In-person
Eric Brum	FAO	In-person
Ahmed Saad	FAO Egypt	In-person
Yanira Santana Morales	FAO Regional Office for Africa	In-person
Isabella Monne	Istituto zooprofilattico sperimentale delle Venezie	In-person
Francesco Bonfante	Istituto zooprofilattico sperimentale delle Venezie	In-person
Mia K Torchetti	USDA	Online
Tony Joannis	National veterinary research institute - Nigeria	Online
Clement Meseko	National veterinary research institute - Nigeria	Online
Malik Peiris	Hong Kong University	Online
Sarah Hill	Royal veterinary college	In-person
Kyle Horton	Colorado State University	Online
Sowath Ly	Institut Pasteur du Cambodge	Online
Celia Abolnik	University of Pretoria	Online
Timothée Vergne	Ecole nationale vétérinaire de Toulouse	Online
Sébastien Lambert	Ecole nationale vétérinaire de Toulouse	Online
Ian Brown	WOAH/FAO Network of Expertise on Animal Influenza (OFFLU)	Online
Keith Hamilton	WOAH	In-person
Guillaume Fournie	Royal veterinary college/INRAE	In-person
Jack Shere	USDA	Online
Gary Flory	Virginia department of environmental quality	Online
Guillermo Zavala	Private vet Latin America	Online
Sjaak De Wit	Utrecht University	In-person
Cortney Price	FAO	In-person
Robyn Alders	Australian National University	Online
Reina Yamaji	WHO	Online
Wenqing Zhang	WHO	Online
Magdi Samaan	WHO	In-person
Camille Hopkins	United States geological survey	Online
Jonathan Sleeman	United States geological survey	Online
Nichola Hill	University of Massachusetts Boston	Online
Damien Joly	Canadian wildlife health cooperative	Online

Name	Institution	Modality of participation
Gonzalo Pascual	Centro de Investigación en Sanidad Animal (CISA-INIA)	Online
Jose Urdaz	IICA/USDA	In-person
Edgardo Arza	Animal and plant health inspection service	Online
Conrad Estrada	Animal and plant health inspection service	In-person
Cheryle Blakely	Animal and plant health inspection service	Online
Rosemary Sifford	Animal and plant health inspection service	Online
Corina Grigorescu Monagin	Defense Threat Reduction Agency	Online
Gounalan Pavade	WOAH	In-person
Grazina Mirinaviciute	European centre for disease prevention and control	Online
Lorraine Chapot	Ausvet	Online
Daniel Schar	United States Agency for International Development	Online
Andrew Clements	United States Agency for International Development	In-person
Zandra Andre	United States Agency for International Development	Online
Ashna Kibria	United States Agency for International Development	Online
Giovanni Cattoli	International Atomic Energy Agency	In-person
Carla Bravo De Rueda	International Atomic Energy Agency	Online
Gael Lamielle	FAO Regional Office for Asia and the Pacific	Online
Temwanoku Ioakim	FAO Subregional Office for the Pacific Islands	In-person
Ohoukou Marcel Boka	FAO Regional Office for Africa	Online
Fredrick Kivaria	FAO Regional Office for Africa	In-person
Ahmed Garba	FAO Regional Office for Africa	Online
Cheikh Fall	FAO	Online
Laura Roberts	Western Cape Department of Agriculture/University of Pretoria	In-person
Todd Davis	Centers for Disease Control and Prevention	Online
Dave Wentworth	Centers for Disease Control and Prevention	Online
Ruth Cromie	CMS	Online
Nicola Lewis	Francis crick institute	In-person
Barbara Haesler	FAO	Online
Jean-Luc Guérin	École Nationale Vétérinaire de Toulouse	In-person

Name	Institution	Modality of participation
Edward Hill	University of Warwick	In-person
Carel Du Marchie Sarvaas	Health for animals	In-person
Nicolò Cinotti	International Poultry Council	In-person
Alvaro Gonzalez	The Permanent Veterinary Committee of Southern Cone	In-person
Gavin Peters	Caribbean Agricultural Health and Food Safety Agency (CAHFSA)	In-person
Ihab Saber Youssef	General organization for Veterinary Service	
Viktor N. Irza	National Reference Laboratory for Avian Influenza and Newcastle Disease	Online
Samantha Gibbs	U.S. Fish and Wildlife Service	Online
Michelle Wille	U of Sydney	Online
Jonas Waldenström	Linnaeus University	In-person
Jiming Chen	OFFLU	Online
Paul Van Der Merwe	World Veterinary Association	Online
Pinto, Julio	FAO	In-person
Elmoubasher Abu Baker Abd Farag	One Health High-Level Expert Panel (OHHLEP)	In-person
Caseybartonbehravesh	OHHLEP	Online
Sieffert Laetitia	OHHLEP	Online
Corli Pretorius	UNEP World Conservation Monitoring Centre	
Charlotte Hicks	UNEP World Conservation Monitoring Centre	
Inmaculada Aznar Asensio		In-person
Iulia Cohen	European Commission	In-person
Sanna Mesman	European Commission	In-person
Christian Mathieu Benson	Servicio Agrícola y Ganadero (SAG) de Chile	
Gwenaelle Dauphin		In-person
Olivier Espeisse		In-person
Alexander Shestopalov	Novosibirsk State University	Online
Leykun Esayas	FAO	Online
Sophie Von Dobschuetz	WHO	In-person
Zheng Y. X. Huang	Nanjing Normal University	Online
Christine Szablewski	Centers for Disease Control and Prevention	Online
Diann Prosser	Eastern Ecological Science Center - U.S. Geological Survey	Online
Daniel Abreu	FAO	Online
Emmie Wachira	FAO	Online

Name	Institution	Modality of participation
Kasumi Sudo	FAO	Online
Gisela Gioia	FAO	In-person
Anthony Akunzule	FAO	In-person
Hernan CACERES	FAO	Online
Muhammad Athar Abbas	National Reference Laboratory for Poultry Diseases	Online
Naila Siddique	Pakistan Agricultural Research Council	Online
Marion Koopmans	Erasmus MC	Online
Mugyeom Moon	FAO Regional Office for Asia and the Pacific	Online
Joshua Mott	WHO	Online
Robin Thompson	University of Warwick	Online
Shivaprasad Desai		Online
Michael Tildesley	University of Warwick	Online
Elias Walelign Dagnachew	FAO	Online
Ouandaogo Sandaogo Hamidou	FAO	Online
Clarice Lulai Angi		Online
Christopher Chadwick	WHO	Online
Natalia Cediel		Online
Bergeri Isabel	WHO	Online
Sergejs Nikisins	WHO	Online
Ilya Chvala		Online
Andrei Varkentin		Online
Jun-Sik Lim	ENVT	Online
Corina Warfield	USAID	Online
Karoon Chanachai	USAID	Online
Glenn Chalkley	USAID	Online
Jaime Romero		Online
Ericka Calderón		Online
Özge Kara	FAO	Online
Mirela Hasibra	FAO	Online
Ndiaye Elhadji Youssou	FAO	Online
Giuseppina Cinardi	FAO	Online
Chevanne Etienne	FAO	Online
Abraham Zirra	FAO	Online
Ahmad Gozali	FAO	Online
Samuel Mulligan	FAO	Online
Farida Camallia Zenal	FAO	Online
Mohammad Taifur Rahman Rahman		Online

Name	Institution	Modality of participation
Jacqueline Lichoti	FAO	Online
Dea Vazin	FAO	Online
Yu Qiu	FAO	Online
Mikhail Volkov		Online
Weining Zhao	FAO	Online
Kohagne Lisette	FAO	Online
Ibrahim Gashash Ahmed	FAO	Online
Yaghouba Kane	FAO	Online
Folorunso Fasina	FAO	Online
Paolo Motta	FAO	Online
Khadak Bisht	FAO	Online
Muhammad Afzal	FAO	Online
Yin Myo Aye	FAO	Online
Valentine Ekechukwu	FAO	Online
Morou Madougou Amadou	FAO	Online
Joseph Adongo Awuni	FAO	Online
Ryan Aguanno	FAO	Online
Andriy Rozstalnyy	FAO	Online
Artem Metlin	FAO	In-person
Emma Gardner	FAO	In-person
Lorcan Carnegie	FAO	In-person
Sandra Carapeto	FAO	In-person
Muhammad Usman Zaheer	FAO	In-person
Alessandra Falcucci	FAO	In-person
Bruno Minjauw Bruno Minjauw	FAO	In-person
Yushan Li Yushan Li	FAO	In-person
Aashima Auplish	FAO	Online
Ian Dacre	FAO	In-person
Claudia Pittiglio	FAO	In-person
Akiko Kamata	FAO	In-person
Ismaila Seck	FAO	In-person
Caryl Lockhart	FAO	In-person
Lidewij Wiersma	FAO	In-person
Madhur Dhingra	FAO	In-person
Tejan Cham	FAO	Online
Rosanne Marchesich	FAO	In-person
Vinsy Szeto	FAO	In-person
Nir Rudoler	FAO	Online
Alfred Kompudu	FAO	Online
Samuel Muriuki	FAO	Online

Name	Institution	Modality of participation
Issoufou Maikano	FAO	Online
Orr Rozov	FAO	In-person
Gian Mario Cosseddu	FAO	In-person
Zuleca Cassamo	Zuleca Cassamo	Online
Getachew Gari Jimolu	FAO	Online
Austine Bitek Bitek	FAO	Online
Sitawa Rinah	FAO	Online
Khaldoun Kashoush	FAO	In-person
Ricarda Mondry	FAO	Online
Plee Ludovic	FAO	In-person
Ayodele Majekodunmi	FAO	Online
Melissa Mclaws	FAO	In-person
Merab Acham	FAO	Online
Katinka De Balogh	FAO	Online
Joana Pastor-Helfer		Online
Serge Nzietchueng	FAO	Online
Ahnaf Tahmed Faiz	FAO	Online
Ashwini Kumar Singh	CCS national institute of animal health Baghpat	Online
Camilla Benfield	FAO	Online
Stella Michelle Bella A	FAO Cameroon	Online
Gessica Tore	Boehringer Ingelheim AH France	Online
Niang Ahmadou Tidiane	FAO	Online
David Hadrill	FAO	Online
Samia Metwally	FAO	In-person
Ohn Kyaw Mr	FAO	Online
Estelle Kanyala	FAO	Online
Traore Kam Adèle	FAO Burkina Faso	Online
Surendra Karki	FAO Nepal	Online
Xavier ROCHE	Pan American health organization (PAHO)	In-person
Milan Pandurovic	Ministry of Agriculture	Online
Meruzhan Zadayan	Veterinarians Without Borders	Online
Susanne Münstermann Susanne Münstermann	FAO	Online
Leyva Baca Ivan	Thermo fisher scientific	Online
Ali Rizqi Arasyi	FAO	Online
Yusuf Ashemi	World Bank REDISSE	Online
Agatha Ugboma	Recipient epidemiology and donor evaluation study (REDS) Programme / Federal ministry of agriculture and rural development (FMARD)	Online

Name	Institution	Modality of participation
Thomas Nyariki	FAO	Online
Lidiia Moskalenko	Estonian University of life sciences	Online
Noelina Nantima	FAO	Online
Volodymyr Polishchuk	FAO	Online
Morgane Gourlaouen	FAO	Online
Mohamed Elfatih Hamad	United Arab Emirates University	Online
Mohamed Houta	Klybeck	Online
Md Zakiul Hasan Hasan	FAO	Online
Nhu Van Thu Nhu	Nhu Van Thu Nhu	Online
Vanessa Max	FAO Regional Office for Latin America and the Caribbean	Online
Alejandra Montalba	Asociación de veterinarios de fauna silvestre de Chile	Online
Palash Sarker Sarker	Department of Livestock Services	Online
Ahmed Kayed Ahmed Kayed	FAO Egypt	Online
Fairouz Larfaoui	FAO	Online
Владислав Мельников	Департамент Ветеринарии	Online
Violeta Barrera Navarro	University San Sebastian	Online
Ender Mengeş	Istanbul University Cerrahpaşa	Online
Ghram Boutheina	FAO	Online
Adamou Harouna Halimatou	FAO	Online
Andrea Capobianco Dondona	FAO	In-person
Nan Mon	FAO	Online
Nusrat Shahrin	FAO	Online
Kadiat Jean Gustave	FAO	Online
Sohir Hassan Abdelkader Mohamed Sohir Hassan Abdelkader Mohamed	FAO	Online
Anna Irza	ARRIAH	Online
Javiera Constanzo	Chilean asosciation of wildlife veterinarians	Online
Garba Ahmed	FAO	Online
Colin Basler	CDC	Online
Abdelnabi Amira	FAO	Online
Amal Mansour	FAO Regional Office for Near East and North Africa	Online
Francisco Chirrute Chirrute	FAO	Online
Bridget Kamara	FAO	Online
Lassina Doumbia Doumbia	FAO	Online
Elma Zanamwe	FAO	Online

Name	Institution	Modality of participation
N'diaye Racine	FAO	Online
Yilma Makonnen	FAO	Online
Bounmee Maokhamphiou	FAO	Online
Chrisostom Ayebazibwe	FAO	Online
Boli Paolo	FAO	Online
Mboup Penda	FAO Angola	Online
Mohamed Moussa	FAO	Online
Patience Tomoh	FAO	Online
Junxia Song	FAO	Online
Sabenzia Wekesa	FAO	Online
Pato Steed	FAO	Online
Rene Bessin	FAO	Online
Sall Baba	FAO	Online
Gerald Mucheru	FAO	Online
Chenjerai Njagu	FAO	Online
Riana Arief	FAO Indonesia	Online
Andrea Ellis	WOAH	Online
Wali Uz Zaman	FAO Bangladesh	Online
Abdal Monium Osman	FAO	Online
Willington Bessong Ojong	FAO	Online
Gisella Dias	FAO	In-person
Tesfai Tseggai	Freelance Consultant	Online
Sarah Van Dyk	FAO	Online
Sokhim OL	FAO	Online
Nhữ Văn Thụ Nhữ Văn Thụ	FAO Viet Nam	Online
Thi Dung Le	FAO	Online
Carla Baker	FAO Regional Office for Asia and the Pacific	Online
Noutlady Inthavong	FAO	Online
Myat Htoo Razak	USAID	Online
Rajesh Dubey	FAO	Online
Javaria Alam	FAO	Online
Susan Ndyanabo	FAO	Online
Jeff Gilbert	FAO	Online
Djonwe Gaston	FAO	Online
Simba Chan	Japan bird research association	Online
Natalia Cediel	Universidad de La Salle	Online
Chadia Wannous	WOAH	Online
Ahmed Kayed	National research center	Online

Name	Institution	Modality of participation
Riasat Wasee Ullah	Ministry of national food security and research	Online
Vivian Fu	East Asian - Australasian Flyway Partnership	Online
Etienne Bonbon	OMSA/WOAH	Online
Danielle Julien	Public Health Agency of Canada	Online
Elisa Palamara	FAO	In-person
Chaiyan Kasorndorkbua	Kasetsart University	Online
Yanira SANTANA	FAO	In-person
Sajjad Hussain Sajjad	Livestock and dairy development department	Online
Amira Preure	WHO	Online
Tan Loc Huynh	Hokkaido University	Online
Rizza Araceli Salinas	Department of environment and natural resources - Biodiversity management bsureau	Online
Beatrice Mouille	FAO	In-person
Paisin Lekcharoen	Chulalongkorn University	Online
Kirana Noradechanon	Department of national parks, wildlife and plant conservation	Online
Muhammad Akram Munir Akram Munir	Riphah international university RCVetS Raiwind Road Lahore	In-person
Giorgos Catsadorakis	Society for the protectiuon of prespa (SPP)	Online
Olga Alexandrou	SPP	Online
Dop Jean Philippe	WOAH	Online
Roxana Sanchez Ingunza	FAO	Online
Mercedes Flores Cancino	FAO	Online
Wanlaya Tipkantha	Zoological park organization of Thailand	Online
Barry Hartup	International crane foundation	Online
Angelique Angot	FAO	In-person
Keith Sumption	FAO	In-person
Monsterrat Arroyo Kuribrena	WOAH	Online
Alvaro Gonzalo Rubio	Conosur	In-person
Juan Escala	Elanco animal health	In-person
Xavier Roche	Pan-American Health Organization	In-person
Francisco Reviego Gordejo	Directorate-general for health and food safety (DG SANTE) - European Commission	In-person
David John	Animal health Europe	In-person

ANNEX 2
Meeting agenda

DAY 1	02 May 2022	
Time	Topics	Speakers
	Session 1: Opening and the global overview	*Chair: Madhur Dhingra (FAO)*
09.00–09.15	**Welcome**	*Thanawat Tiensin (FAO)*
	Opening remarks	*Maria Helena Semedo (FAO) and Montserrat Arroyo (WOAH)*
09.15–09.20	**Meeting objectives and expected outputs and outcomes**	*Madhur Dhingra (FAO)*
09.20–09.30	**Global overview of AI situation and key updates on global initiatives**	*Baba Soumare (FAO)*
	Session 2: Updated AI epidemiology	*Chair: David Swayne (OFFLU)*
09.30–09.40	**New gaps and challenges of the global HPAI situation**	*David Swayne (OFFLU)*
09.40–10.10	**Transmission dynamics in different poultry systems**	*Aimable Uwizeye, Livestock Policy Officer, FAO*
10.10–10.30	Group Photo and Coffee Break	
10.30–10.50	**Overview of updates from FAO regional experts**	*FAO Regional colleagues (RAF/RAP/RLC/REU)*
10.50–12.00	**Panel discussion** Section 1: Questions from audience (20 minutes) Section 2: Pre-prepared questions (15 minutes) Section 3: Participant recommendations to reduce HPAI transmission (30 minutes) Closing Remarks (5 minutes)	*David Castellan (TAMU), Charles Bebay (FAO), Abebe Wolde (FAO), Filip Claes (FAO), Guillaume Fournié (INRAE), Arjan Stegeman (UU), Larissa Zanette (FAO), Andres Gonzalez Serrano (FAO), Eran Raizman (FAO), Mia Torchetti (USDA), Sébastien Lambert (ENVT)*
12.00–13.45	Lunch Break	
	Session 3: Surveillance and diagnostics for AI: new approaches and challenges	*Chair: Nicola Lewis (Crick)*
13.45–13.55	**Geospatial risk modelling to inform AI surveillance in poultry**	*Marius Gilbert (ULB)*
13.55–14.15	**Pirate Science in Asia - FAO Regional Office for Asia and the Pacific** *An overview of novel sampling and diagnostic tools*	*Erik Karlsson (FAO)*

14.15–14.50	**Barriers to implementation - Expert opinions** *If it works, why are we not doing it yet?*	*Timm Harder (FLI), Nicola Lewis (Crick), Mia Torchetti (USDA), Ron Fouchier (Erasmus), Giovanni Cattoli (IAEA)*
14.50–15.00	**Intro to group work** *Utility, acceptance, and implementation of new thinking*	*Filip Claes (FAO) and Erik Karlsson (FAO)*
15.00–15.15	Coffee Break	
15.15–16.15	**Group work** *Utility, acceptance, and implementation of new thinking*	*In-person and online participants*
16.15–17.00	**Plenary feedback and prioritization**	*Filip Claes (FAO) and Erik Karlsson (FAO)*
17.00–17.30	End of Session and Break	
17.30–19.00	**Meet and Greet on the 8th floor**	
	End of Day 1	

DAY 2	03 May 2023	
Time	**Topics**	**Speakers**
	Session 4: AI prevention and control	*Chair: Leslie Sims (OFFLU)*
09.00–09.40	**Panel Discussion: Prevention and control in low and low-middle income countries**	*Eric Brum (FAO), Robyn Alders (ANU), Damian Tago-Pacheco (FAO), Nguyen Thi Diep (DAH), Ahmed Saad (FAO), Columba Teru Vakuru (CVO Nigeria)*
09.40–10.25	**Panel Discussion: Prevention and control in high income countries**	*Jean-Pierre Vaillancourt (UdeM) Jean-Luc,Guerin (ENVT), Sjaak DeWit (UU), Gary Flory (Virgina DEQ), Francesco Bonfante (IZSVe), Gwenaelle Dauphin (CEVA)*
10.25–10.30	**Progressive Management Pathway-Terrestrial Animal Biosecurity (PMP-TAB)**	*Melissa Mclaws (FAO)*
10.30–11.00	Coffee Break	
11.00–11.40	**Breakout rooms (online and in-person separate)** Group A: Endemic countries: *What needs to be done to move towards lower burden or elimination?* Group B: Countries with historically-free status: *Why has biosecurity broken down– what should be done about it?*	
11.40–12.00	**Plenary discussion**	

12.00–13.45	Lunch Break	
	Session 5: Human-animal-environment interface and pandemic preparedness	*Chair: Cornelia Adlhoch (ECDC)*
13.45–14.00	**Keynote: The global zoonotic risk from AI viruses – the latest evidence**	*Magdi Samaan (WHO)*
14.00–14.15	**Keynote: Surveillance options in mammals**	*Ian Brown (APHA)*
14.15–15.00	**Group work**	
	Online group discussions: How can we improve surveillance for pandemic preparedness? **Group A: Considerations when designing surveillance efforts** **Group B: Barriers to surveillance**	*Richard Webby (SJCRH), Nicola Lewis (Crick)*
	In-person scenario breakout rooms: "Influenza pandemic emergence: what did we miss?"	*Erik Karlsson (FAO), Ron Fouchier (Erasmus), Magdi Samaan (WHO), Zelalem Tadesse (FAO)*
15.00–15.15	**Feedback and Summary presentation by Chair**	*Cornelia Adlhoch (ECDC)*
15.15–15.30	Coffee Break	
	Session 6: Ecology of AI in Wild birds and the wildlife livestock interface	*Chair: Thijs Kuiken (Erasmus)*
15.30–15.40	**Surveillance in wild birds for different objectives and regional bottlenecks**	*Thijs Kuiken (Erasmus)*
15.40–15.45	**Wild-domestic bird interface modelling**	*Claudia Pittiglio (FAO)*
15.45–16.30	**Panel discussion** *Surveillance for different objectives and associated challenges*	*Dave Stallknecht (UGA), Julianna Lenoch (USDA), Michelle Wille (US), Laura Roberts (UP), Jonas Waldenström (LNU), Marcela Uhart (UCD), Ruth Cromie (CMS), Alexander Shestopalov (NSU), Zheng Huang (NNU)*
16.30–16.40	**Impacts on the population ecology of wild birds**	*Ruth Cromie (CMS)*
16.40–17.00	**Panel discussion** *Perspectives on the impacts on wild birds*	*Dave Stallknecht (UGA), Julianna Lenoch (USDA), Michelle Wille (US), Laura Roberts (UP), Jonas Waldenström (LNU), Marcela Uhart (UCD), Ruth Cromie (CMS), Alexander Shestopalov (NSU), Zheng Huang (NNU)*
	End of Day 2	

DAY 3	04 May 2023	
Time	**Topics**	**Speakers**
	Session 7: Recommendations for AI prevention and control	*Chair: Lidewij Wiersma (FAO), Gounalan Pavade (OFFLU)*
09.00–10.00	**Breakout rooms: identify key elements and approaches for AI prevention and control to include in the updated HPAI Global Strategy**	
10.00–10.20	**Presentation from rapporteurs of each breakout room**	
10.20–10.50	Coffee Break	
10.50–11.50	**Round-table discussions**	
	Session 8: Conclusions and closing remarks	*Chair: Madhur Dhingra (FAO)*
11.50–12.00	**Conclusions**	*Madhur Dhingra (FAO)*
12.00–12.30	**Closing Remarks**	*Rosanne Marchesich (FAO), Keith Sumption (FAO)*
	End of Day 3	

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Availability: August 2023

Ar – Arabic
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Highly pathogenic avian influenza (HPAI) is a severe and highly contagious disease that has severe impacts on animal and human health, livelihoods, and the economy. At the time of the consultation the recent panzootic had affected more than 70 countries and territories, resulting in over 11 000 disease events in both wild and domestic bird populations. The disease has also spilled over to several mammalian species, including humans, and may result in severe ecological and biodiversity consequences.

Considering the alarming spread of HPAI and the evolution of avian influenza in the wild birds, The Food and Agricultural Organization (FAO) and Network of Expertise on Animal Influenza (OFFLU) brought together the global scientific community to review the latest science and evidence on the disease, to support development/implementation of disease prevention and control strategies and policies and contribute to global efforts towards reducing pandemic risk. The report summarizes the meeting discussions, and key recommendations to reduce the transmission of HPAI along the poultry value chains, and the spillover risk to humans and wildlife. The meeting report will contribute to revising the FAO-WOAH global control strategy for HPAI and developing evidence-based policies and research agendas to tackle the disease. Sharing the meeting report with technical experts and policy makers will help support the development of a research and development agenda to tackle HPAI globally.

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