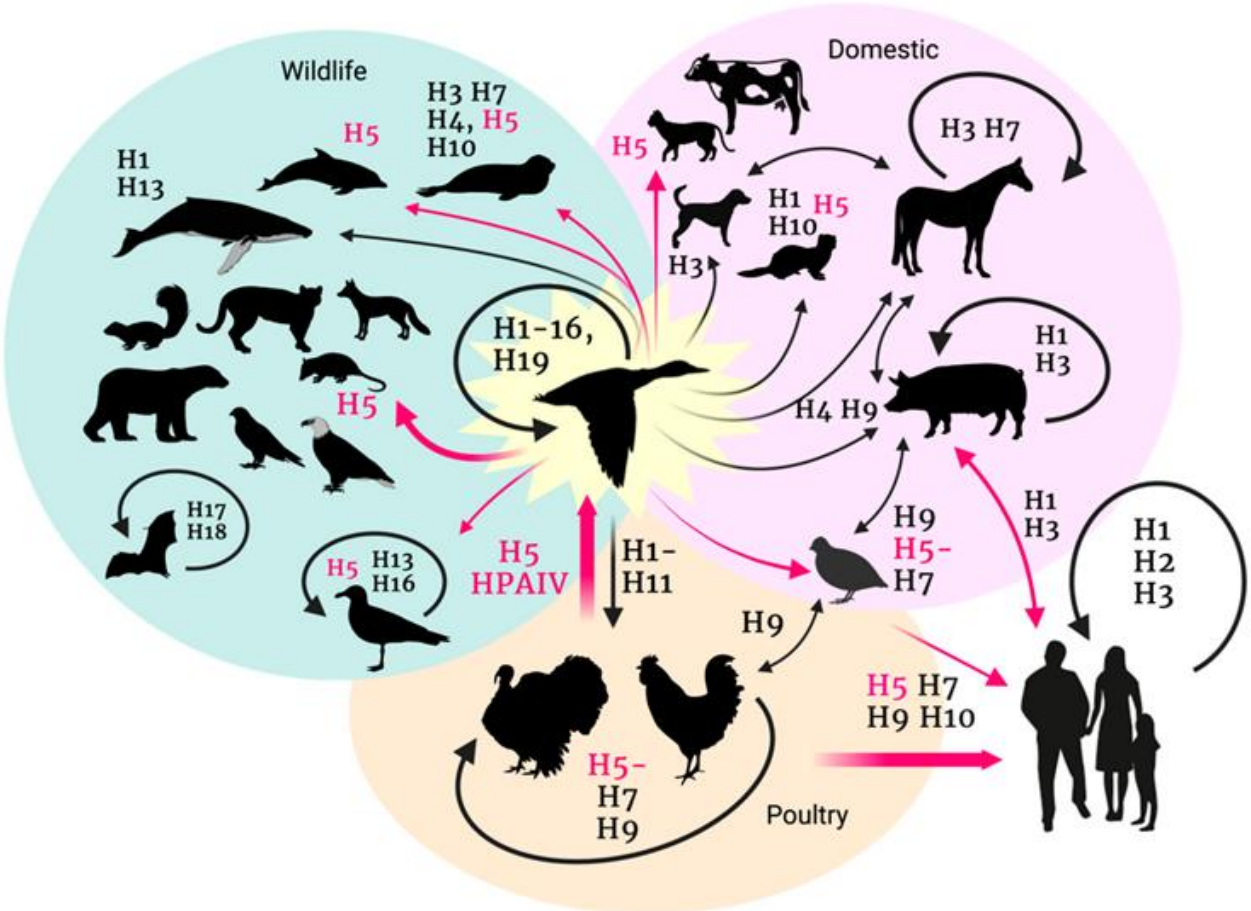
2025

Appropriate Level of Protection (ALOP) *for*

High Pathogenicity Avian Influenza (HPAI)



Department of Veterinary Services Malaysia
2026

TABLE OF CONTENTS

TABLES

FIGURES

SUMMARY

Malaysia, as a Member of the World Trade Organization (WTO) and the World Organization for Animal Health (WOAH), establishes its Appropriate Level of Protection (ALOP) for Highly Pathogenicity Avian Influenza (HPAI) to safeguard animal health, public health, food security, and national economic stability while facilitating safe international trade. Guided by the WTO SPS Agreement and scientific risk assessment, Malaysia adopts a highly precautionary approach to prevent the introduction and spread of HPAI.

Malaysia has remained officially free from HPAI without vaccination since December 2018, following five historical outbreaks that caused significant economic losses but no human infections. Maintaining this disease-free status is critical for protecting poultry production, preventing zoonotic transmission, sustaining consumer confidence, and preserving market access in international trade. The country implements a strict stamping-out policy within a 1 km radius of infected premises and prohibits vaccination to ensure early detection, avoid silent virus circulation, and maintain surveillance sensitivity.

Given the evolving global epidemiological situation, including continued multi-continental HPAI circulation, spillover into mammals, and emerging scientific evidence on virus adaptation, Malaysia applies a conservative risk management framework. The country maintains zero tolerance for imports of poultry, poultry products, and genetic materials from non-HPAI-free countries, zones, or compartments, or from populations vaccinated against HPAI. Veterinary certification must confirm the absence of outbreaks, compliance with stamping-out policy, and adherence to WOAH standards. Malaysia reserves the right to suspend imports based on new scientific evidence.

The scientific basis underpinning Malaysia's ALOP highlights the highly contagious nature of HPAI, its zoonotic potential, capacity for mutation and reassortment, expanding host range including mammals, and ability for silent transmission. These characteristics justify stringent biosecurity, surveillance, and rapid response measures to ensure risks remain below the nationally acceptable threshold.

In addition, Malaysia recognizes the growing importance of a One Health approach in addressing the complex and evolving risks posed by HPAI. The virus is no longer confined to poultry but has demonstrated the ability to infect a wide range of mammalian species, increasing the potential for zoonotic transmission and public health implications. Strengthened integration of animal, human, and environmental surveillance systems is therefore essential to support early detection, improve preparedness, and enhance national resilience against emerging infectious disease threats.

Furthermore, Malaysia's poultry sector plays a vital role in national food security and economic development, making the prevention of HPAI introduction a strategic priority. Strong biosecurity, continuous surveillance, movement control, and science-based import risk management remain the cornerstone of Malaysia's policy. While international standards recognize vaccination as a possible control tool under certain conditions, Malaysia maintains a non-vaccination policy to preserve surveillance clarity, minimize epidemiological uncertainty, and sustain international confidence in the country's HPAI-free status.

Overall, Malaysia's ALOP reflects a precautionary, science-based, and risk-driven policy aimed at maintaining HPAI-free status, protecting national health and economic interests, and ensuring transparent and consistent sanitary measures aligned with international obligations.

Department of Veterinary Services, Malaysia

1st Edition 2026

CHAPTER 1.0: INTRODUCTION

As a Member of the World Trade Organization (WTO) and the World Organization for Animal Health (WOAH), Malaysia is committed to safeguarding public health, animal health, and food security, while facilitating international trade based on scientific principles. In accordance with Article 5 (Assessment of Risk and Determination of the Appropriate Level of Sanitary or Phytosanitary Protection) of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), Malaysia has the sovereign right to determine its Appropriate Level of Protection (ALOP).

This document sets out Malaysia's ALOP for High Pathogenicity Avian Influenza (HPAI) in relation to the importation of susceptible animals and animal products. It provides the policy framework to guide risk assessment, risk management, and the application of sanitary measures, ensuring that the risk of HPAI introduction remains at or below the level considered acceptable by Malaysia.

1.1 Objective of this document

The Appropriate Level of Protection (ALOP) document is developed to:

i. Provide a clear justification for risk management decisions and policy formulation in Malaysia.
ii. Establish a national benchmark for consistent implementation of sanitary measures.
iii. Guide the determination of appropriate levels of biosecurity, surveillance, and response measures to ensure that risks remain below the nationally accepted threshold.
iv. Enhance transparency and consistency in policy development and decision-making processes.
v. Serve as a risk-based foundation for international trade, including strengthening risk communication with trading partners.
vi. Ensure alignment with the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), while safeguarding Malaysia's national animal health status and integrity.

1.2 Background

High Pathogenicity Avian Influenza is a highly contagious viral disease affecting poultry and wild birds, caused mainly by H5 and H7 subtypes. These viruses cause high mortality, significant economic disruption, and pose zoonotic risks [5,88].

Avian Influenza (AI), commonly known as Bird Flu, is caused by the Influenza A virus and is classified into two forms: High Pathogenicity Avian Influenza (HPAI) and Low Pathogenic Avian Influenza (LPAI). HPAI viruses can infect a wide range of poultry species and are associated with high mortality rates, which can reach up to 100% in affected flocks. In addition, the virus has zoonotic potential and can infect mammals, including humans, potentially causing severe disease and death.

Malaysia has experienced five (5) episodes of HPAI, resulting in significant economic losses amounting to millions of Malaysian Ringgit. The details of these outbreaks are as follows:

i. The first episode occurred in Kelantan on 17 August 2004, involving 12 outbreaks. A total of 18,537 poultry were culled and completely disposed of.

ii. The second episode occurred on 19 February 2006, simultaneously affecting three states: The Federal Territory of Kuala Lumpur, Perak, and Penang. A total of five outbreaks were recorded, with the highest number of poultries culled and disposed of in Malaysia's HPAI history, amounting to 58,457 birds. This episode lasted for 124 days.

iii. The third episode occurred on June 5, 2007, in Selangor, involving a single outbreak. The outbreak was successfully controlled within 95 days, with 4,266 poultry culled and disposed of.

iv. The fourth episode took place in Kelantan, starting in Kampung Pulau Tebu, Kota Bharu, on 6 March 2017, involving ornamental chickens. A total of 56,961 poultry and 17,531 eggs from 1,243 premises were culled and disposed of. The outbreak was successfully controlled within 24 days. The Government paid approximately RM413,000 in compensation to affected farmers and poultry owners for this episode alone.

v. The fifth episode occurred in Sabah on 4 August 2018. A total of 34,674 poultry were culled, and 4,903 eggs from 313 premises were disposed of. Malaysia regained its HPAI-free status on 15 December 2018, as recognized by the World Organization for Animal Health (WOAH).

Although these five HPAI episodes resulted in significant infection and mortality in poultry, no human cases were reported in Malaysia.

Malaysia adopts a stamping-out policy within a 1 km radius of infected premises as part of its strategy to prevent, control, and eradicate HPAI. All poultry and eggs within the affected area are destroyed and disposed of, and are strictly prohibited from entering the food chain due to the risk of disease transmission to humans throughout the processing and marketing stages. In addition, vaccination against HPAI is strictly prohibited in Malaysia to maintain the country's HPAI-free status without vaccination.

1.3 Malaysia's Status

Since 2018, Malaysia has been officially free from HPAI without the need for vaccination. The country implements a stamping-out policy during outbreaks to quickly eliminate the disease. Recent developments, such as outbreaks in vaccinated poultry and new evidence of HPAI infecting mammalian hosts (including livestock), have raised concerns about virus adaptation, silent transmission, and potential public health threats. Therefore, strong emphasis is placed on prevention, early detection, and rapid response to maintain Malaysia's disease-free status.

Maintaining HPAI-free status is critical to safeguard animal health, public health, and the national economy. Freedom from the disease prevents high mortality and economic losses in poultry production, while also protecting food security and the livelihoods of farmers. It reduces the risk of zoonotic transmission to humans and sustains consumer confidence in the safety of poultry products. From a trade perspective, HPAI-free status is a key requirement for maintaining and expanding market access, as many importing countries impose strict restrictions once outbreaks are detected. Demonstrating freedom also reflects strong veterinary governance, effective surveillance, and compliance with WOAH and WTO-SPS standards, thereby enhancing the country's credibility in international trade and animal health forums.

1.4 Recent Developments to extend to: Globally and regional distribution

Globally: HPAI activity remains multi-continental, with WOAH reporting hundreds of new poultry and wildlife events since late June 2025; mammals continue to be affected sporadically. Surveillance signals remain elevated across the Americas, Europe, and parts of Asia.

USA: Unprecedented spillover into mammals, especially dairy cattle, with associated detections in raw milk and a small number of human cases; regulators continue strong advisories against consuming unpasteurized milk. Poultry/wild bird detections persist, but human risk to the general public is still assessed as low. Implication: trading partners scrutinize dairy-poultry interfaces; robust milk chain controls and worker PPE policies are essential.

EU countries: The EU has formal rules enabling vaccination with trade under Delegated Regulation (EU) 2023/361 (movement conditions + post-vaccination surveillance). France's large-scale duck vaccination (from Oct 2023) has reduced outbreak pressure, though France briefly lost and then re-gained HPAI-free status over Dec 2024–Apr 2024/2025; the US/Canada have since eased some import curbs on French poultry/ducks. The Netherlands moved from field trials to a national pilot (2025) for laying hens. Implication: vaccination can now be integrated into control while maintaining market access if surveillance and certification meet EU/WOAH expectations.

Asia: Between October 2024 and the present, Japan has culled approximately 9.3 million birds across dozens of farm outbreaks, with continued high pressure during migratory seasons. In the Republic of Korea, recurrent winter poultry outbreaks, including a 2023 cat-shelter cluster linked to contaminated raw duck pet food, highlight feed-borne risks for mammals, necessitating stricter controls on rendered and raw animal-origin feed. Sporadic human A(H5) reports persist across China, Vietnam, and the wider region, maintaining a non-zero public-health risk, underscoring the importance of vigilant farm-to-health surveillance.

1.5 Malaysia's Stance

i. Stamping-out policy

Malaysia maintains a strict stamping-out policy within a 1 km radius of infected premises as a fundamental measure to prevent, control, and eradicate HPAI. All poultry and eggs

within the designated control area are humanely destroyed and safely disposed of, and are strictly prohibited from entering the food chain, in view of the potential risk of disease transmission along the processing and marketing continuum.

ii. HPAI-free status without vaccination

Malaysia does not permit vaccination against HPAI. This policy is maintained to preserve the country's HPAI-free status without vaccination, ensure early detection of infection, and uphold confidence in Malaysia's animal health status in accordance with international standards. Malaysia maintains a non-vaccination policy against HPAI based on the following considerations:

iii. Masking of clinical signs

Vaccination may suppress the clinical manifestations of disease without fully preventing infection. This masking effect complicates the detection of infected animals, as they may appear clinically healthy while still harboring the pathogen, thereby increasing the risk of undetected disease presence and spread.

iv. Silent circulation of the virus

Under certain circumstances, vaccinated animals may continue to replicate and shed the virus without exhibiting clinical signs. Such silent circulation presents a significant challenge to disease control, as infection may persist undetected within populations and facilitate transboundary spread.

V. Potential for viral mutation and reassortment

Continued viral circulation in vaccinated populations may exert selective pressure that promotes genetic changes. This increases the likelihood of viral mutation and reassortment, potentially resulting in the emergence of new variants with reduced vaccine sensitivity and greater epidemiological significance.

v. Reduced the sensitivity of surveillance systems

Vaccination may interfere with diagnostic and serological interpretation, limiting the ability to differentiate between vaccinated and naturally infected animals. This may reduce

the effectiveness of surveillance systems, complicate epidemiological assessment, and weaken early detection capacity critical for maintaining national animal health security.

Malaysia applies a very conservative level of protection to prevent the introduction of HPAI. Zero tolerance for the introduction of live poultry and birds, poultry meat, or hatching eggs from:

i. Countries, zones, or compartments that are not free from HPAI; or
ii. Countries, zones, or compartments where HPAI outbreaks occurred and not practicing stamping out policy (including the cleaning and disinfection); or
iii. Poultry and bird populations vaccinated against HPAI

Restriction on importation of live animals, including animal-derived genetic products, from countries/ zones or compartments with documented cases of HPAI in specific species.

Veterinary Health Certification must explicitly confirm:

i. No HPAI outbreaks in the exporting zone/ country/ compartments in the past 90 days, with stamping out policy (including the cleaning and disinfection) of the last affected premises where susceptible animals were kept.; and
ii. Absence of HPAI vaccination in the source population; and
iii. Compliance with WOAH Terrestrial Code chapters on avian influenza and safe commodities.

However, Malaysia reserves the right to suspend imports if new scientific evidence emerges regarding HPAI risks.

1.6 **Recognition of disease-free status**

Malaysia recognizes a country, part of a country, or state or compartment of animal origin as free from HPAI following the completion of a 90-day stamping-out policy, including the cleaning and disinfection of the last affected premises where susceptible animals were kept.

CHAPTER 2.0: SCIENTIFIC BASIS FOR ALOP DETERMINATION

2.1 HPAI structural characteristics

i. Influenza viruses are characterized by segmented, negative-strand RNA genomes requiring an RNA-dependent RNA polymerase of viral origin for replication[13]. It is enveloped and is pleomorphic with a size ranging from 80-120 nm[72].
ii. Influenza viruses comprise a family of four distinct viruses: influenza A, B, C and D viruses[50].
iii. Influenza A viruses (IAV) are the only orthomyxoviruses known to naturally affect birds [87].
iv. Structurally, the IAV is enveloped by a lipid bilayer derived from the host cell membrane. There are two types of glycoproteins embedded in the capsule: hemagglutinin (HA) and neuraminidase (NA). HA is responsible for virus attachment to the host cell, and is the major target of the humoral immune response, while NA plays a crucial role in viral replication and spread by facilitating the release of new virus particles from infected cells [52,70,93,95].
v. Below the viral envelope are the matrix proteins, which play a crucial role in maintaining the structural integrity of the virus. It interacts with the viral genome, envelope proteins, and other viral components.
vi. Encapsulated inside the virus are eight gene segments which encode at least ten proteins: polymerase basic 1 (PB1), PB2, polymerase acid (PA), hemagglutinin (HA), nucleoprotein (NP), neuraminidase (NA), matrix 1 (M1), M2, nonstructural 1 (NS1) and 2 (NS2, also nuclear export protein - NEP)(Figure 1)[3,58,85].

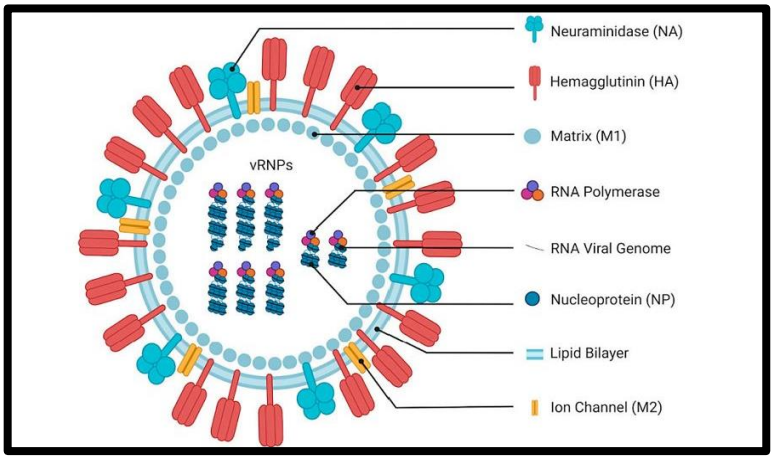


Figure 1. IAV virion structure[3].

2.2 AI subtypes

i. IAV are classified into subtypes based on the antigenic variations of their surface glycoproteins, hemagglutinin (HA or H), and neuraminidase (NA or N) (World Health Organization Expert Committee, 1980). Based on this, distinct 18 HA (H1-H18) and 11 NA (N1-N11) subtypes were identified[1,78,82].

ii. IAV that infect birds are referred to as avian influenza virus (AIV). AIVs are further divided into two groups, high pathogenicity avian influenza (HPAI) and low pathogenicity avian influenza (LPAI).

iii. HPAI viruses cause high levels of morbidity and mortality in chickens and other terrestrial poultry[5]. To date, naturally occurring HPAI viruses that produce acute clinical disease in poultry and aquatic wild birds (e.g chickens, turkeys, ducks, geese, shorebirds etc) of economic importance have been associated only with the H5 and H7 subtypes[14,69], although these two subtypes can also occur as LPAI.

iv. Some avian influenza virus strains have also caused sporadic zoonotic infections principally of H5, H7 and H9 subtypes and these three subtypes have been highlighted as potential pandemic risks should additional mutations occur that support sustained human-to-human transmission[20].

v. In a host infected with 2 closely related influenza viruses, the strains can reassort, exchanging gene segments to produce new strains, some of which might have increased virulence. The exchange of genes between pairs of influenza virus subtypes increased virulence in animal models, including reassortment between subtypes H9N2 and H1N1, between H5N1 and H1N1, and between H3N2 and H5N1[28,85,87].

2.3 Host range

i. A large reservoir of IAV exists in wild aquatic birds, in which the infection is usually asymptomatic.

ii. For AIV, the primary natural host reservoir are wild waterfowl, particularly anatidae (i.e. ducks, geese, swans) in the order *Anseriformes* and scolopacidae (shorebirds/waders) and laridae (gulls, terns) in the order *Charadriiformes*[85,87].

iii. Increasing host range has been observed for IAVs, including mammals such as foxes, seals, and dairy cattle. This is not surprising as the viruses are capable of evolving and crossing into new species due to the possible occurrence of genomic reassortment between viral segments. AIVs have transmitted from ducks to chickens or pigs and from birds to seals. Two antigenically distinct subtypes of influenza virus have also

been detected in bats, but bat influenza viruses have not been observed to cross into other species. Occasionally, influenza viruses of animals infect humans (Figure 2)[50].

iv. Once AIV enters human host cells, their replication dynamics differ from those of human-adapted influenza viruses[40].

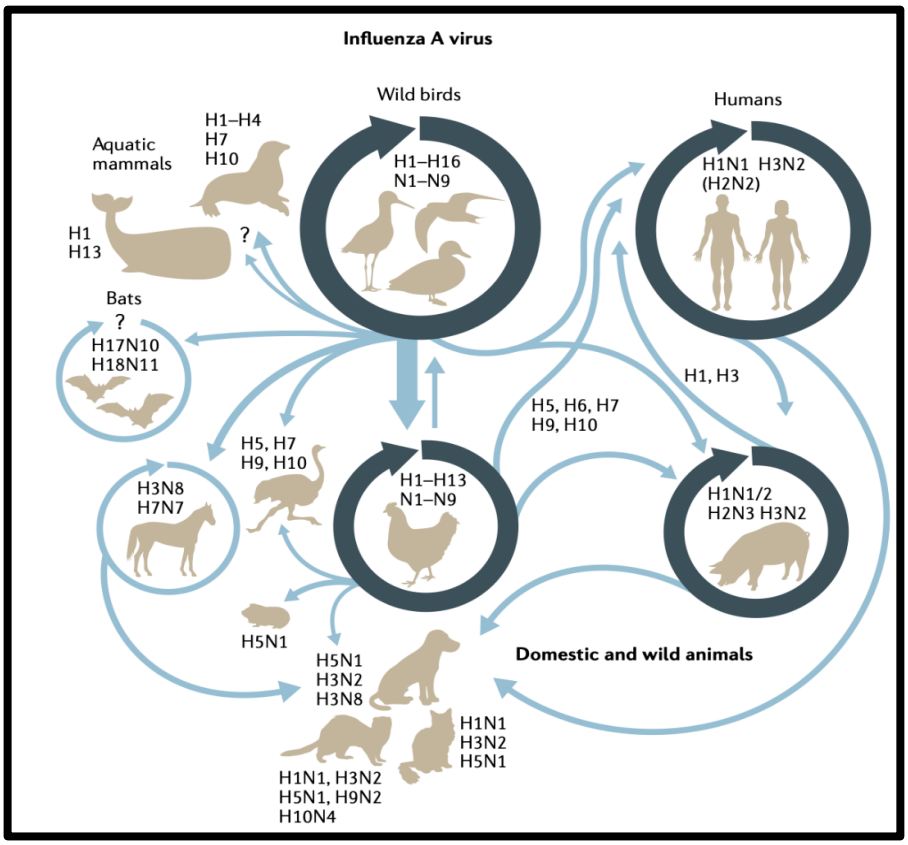


Figure 2: Ecology of influenza viruses. Influenza A viruses (haemagglutinin (HA) subtypes 1–16) circulate in the wild bird reservoir. Subtypes from this reservoir are able to cross into many different species, sometimes via intermediate hosts and sometimes requiring adaptive mutations (light blue arrows). Specific subtypes predominate in certain species (dark blue circles). Human-adapted influenza viruses of the H1, H2 and H3 subtypes have circulated in recent history. H1N1 and H3N2 viruses currently circulate whereas H2N2 viruses do not; the same three subtypes have also circulated in pigs. Avian influenza viruses (AIVs) of H5, H6, H7, H9 and H10 subtypes have infected humans following exposure to infected poultry. Viruses of these subtypes currently do not transmit between humans. HA subtypes H17 and H18 circulate only in bats [50]

2.4 Mode of transmission

Avian influenza viruses (AIVs) are shed by infected birds in their saliva, respiratory mucus, and feces, and HPAI can circulate within a flock surpassing one week before overt clinical signs appear, facilitating silent transmission[6]. Susceptible birds acquire infection through direct contact with these secretions or indirectly via fomites and other surfaces

contaminated by them. Most human H5N1 cases have been epidemiologically linked to close exposure to infected poultry especially during on-farm or live-bird-market slaughter where airborne aerosols enable HPAI viruses to spread both among birds and from birds to people[18]. At larger geographic scales, migratory waterfowl disseminate AIV over long distances during seasonal movements, while scavengers and other wildlife vectors amplify local spread between premises[18,27].

2.5 Genetic Lineage of HPAI Virus Strains

HPAI phenotype in poultry arises predominantly in **H5** and **H7** subtypes.

i. The genetic lineage of HPAI is diverse, with major lineages such as:
   a. Eurasian H5N1 Goose/Guangdong (Gs/GD) Lineage: the historically significant A/goose/Guangdong/1/1996 (gs/Gd)-lineage that spread globally in the 2000s. A notable subclade is the clade 2.3.4.4b, which has caused extensive outbreaks in many bird species and mammals since 2020[86].
   b. Eurasian H7N9 Virus Lineage: This lineage has been reported in several countries, primarily in Asia, and causes severe symptoms in poultry[23].
   c. North American H7N3 Virus Lineage: A distinct North American lineage, including the H7N3 subtype, has been detected and circulates in the region.

ii. Figure 3 is the global timeline of HPAI H5N1 Evolution (1959–2023)[18]. The timeline showcases significant events and outbreaks associated with the virus, along with the corresponding countries and clades involved.

iii. Malaysia first reported the HPAI H5N1 outbreak in chickens in 2004 in Kelantan state of the Gs/Gd-lineage[31]. In the same year, LPAI H5N2 viruses were isolated from ducks in the Perak state and grouped with the Eurasian H5 lineage[96] .

iv. Malaysia has also reported HPAI H5N1 occurrence of the lineage 2.3.2.1c in 2017 and 2018[48,84].

v. The H7 AIV has not been detected in Malaysia so far.

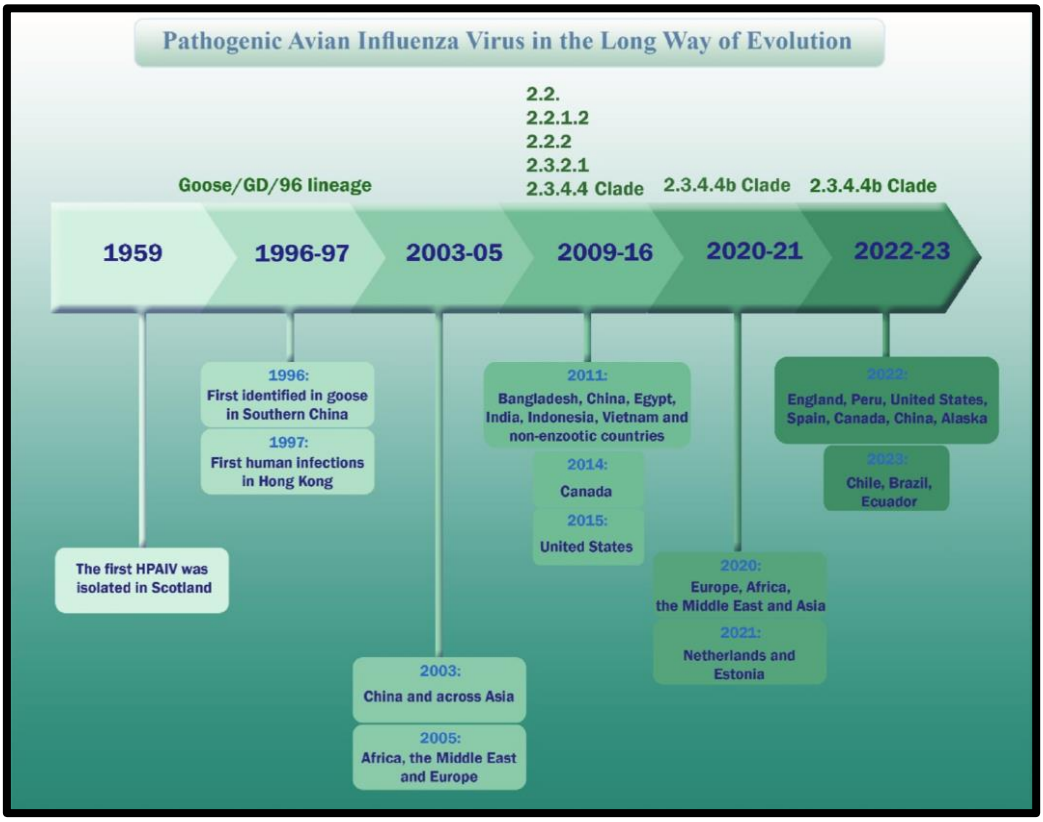


Figure 3: Timeline showcases significant events and outbreaks associated with HPAI, along with the corresponding countries and clades involved[18].

2.6 Susceptibility to chemical and physical agents

i. pH Tolerance

IAV is most stable at slightly acidic pH levels ranging from 5.0 to 5.3 for seasonal human strains, and 5.6 to 6.5 for highly pathogenic H5N1 and H7N9[62,74]. It is sensitive to extreme pH conditions, as highly acidic or alkaline environments can denature the virus. Acidic (pH 1, 3) and basic (pH 11, 13) conditions were virucidal after 6 hours of contact, while the virus remained infectious at pH 5 for up to 18 hours, and at pH 7 and 9 for more than 24 hours[68].

ii. Temperature Tolerance

HPAI is stable at low temperatures. Through freezing, the infectivity of the virus can be preserved over extended periods, posing storage and transport risks. Survival at ambient and

higher temperatures also varies depending on the matrices harboring the virus. The variation in temperature tolerance of different HPAI on different matrices is summarized in Table 1.

Matrix	*Survival at Low Temperature*	*Survival at ambient/high temperature*	*References*
Chicken muscle	Infectivity retained >22 weeks at 4°C	Inactivated with 1 sec exposure at 70°C Infectious up to 6 days at 20-22°C	[76,94]
Feather tissues	Infectivity retained 34 weeks at 4°C	Infectivity retained up to 30 days at 20°C	[94]
Liver	Infectivity retained 20 days at 4°C	Infectivity retained up to 3 days at 20°C	[94]
Allantoic fluid	Infectivity retained 14 weeks at 4°C	Stops after 24 hrs at room temp or 30 min at 56°C	[68]
Yolk	Detectable more than 17 days at 4°C		[39]
Albumen	Detectable up to 17 days at 4°C		[39]
Egg shells	Infectivity retained <3-4 hours at 4°C and higher		[39]
Milk	Infectivity retained 8 weeks at 4°C	Infectivity stop after pasteurization at 15 sec – 30 min at 60–72°C	[55,67]
Dry & wet faeces	Propagate up to 8 weeks at 4°C	No virus propagation after 24h at 37°C Loses infectivity at 24 hrs at 25°C ; 15 min at 40°C	[19,46]

			[41,56]
Polypropylene & Stainless steel	Infectivity retained >40 days at 4°C	Infectivity retained >24 hours at 22±2°C	
Plastic surfaces	-	Survives ~26 hrs at 25°C	[9]
Skin surfaces	-	Survives ~4.5 hrs at 25°C	[9]
Wastewater	Most stable in water <17 °C	Half-life ~12 hrs at 25°C	[15,41]

Table 1: Summary of AIV temperature tolerance

iii. Sensitivity to Disinfectants

The virus is susceptible to disinfectants such as bleach (sodium hypochlorite), hydrogen peroxide and quaternary ammonium compounds. Effective disinfection, however, relies on using the correct concentration and ensuring adequate contact time[73,78].

iv. Resistance to Ultraviolet (UV) Light

The virus exhibits moderate resistance to ultraviolet (UV) radiation; although UV can damage viral RNA, it is generally less effective for inactivation compared to heat or chemical disinfectants (Moderately resistant to UV radiation [19,57,68].

2.7 Pathogenicity and Infectivity

Avian influenza viruses are categorized into two groups, based on their pathogenicity (ability to cause disease) as determined by the intravenous pathogenicity index (IVPI) test: HPAI and LPAI[87]. The designation of low or high pathogenicity avian influenza refers to the potential for these viruses to kill, with chicken and turkey being the indicator species; HPAI causes severe organ failure and high mortality in birds, and LPAI often causes mild or subclinical respiratory symptoms.

Infectivity relates to the virus's ability to attach to and infect host cells, a process influenced by its hemagglutinin (HA) protein and its binding to specific sialic acid receptors, which differ in birds and humans[97]. HPAI strains possess HA proteins that can bind to receptors throughout the body, allowing systemic infection and disease, while LPAI strains are generally restricted to the respiratory and digestive tracts[50].

Drivers of pathogenicity and infectivity:

i. Reassortment

The exchange of viral segments between one or more influenza virus subtypes can contribute to a shift in virulence and adaptation to new hosts[28]. This key mechanism enables influenza viruses to adapt and evolve, potentially causing outbreaks or pandemics. Three of the human influenza pandemics since the beginning of the last century were caused by reassorting viruses bearing genes of avian, human or swine influenza virus origin. The infections of humans with either swine influenza H1N1 or H3N2 were reported in 1919 due to exposure to infected pigs[51].

ii. Viral Fitness

The internal genes of a virus, particularly in influenza viruses, can significantly influence its transmission fitness. These genes, which include those coding for proteins involved in replication, assembly, and immune evasion, can affect how efficiently a virus spreads from one host to another[38,50]. The reassortment potential of internal genes from two major H9N2 lineages G1-like and BJ94-like in the generation of novel H7N9 viruses was evaluated[38]. The findings indicate that H7N9 viruses containing internal genes derived from BJ94-like H9N2 viruses exhibit a fitness advantage over those with G1-like internal genes, particularly in their ability to transmit efficiently among chickens[38]. Furthermore, during chicken transmission, novel reassorting viruses emerged that were capable of infecting and replicating efficiently in human cells[38]. These results highlight the elevated zoonotic risk posed by reassorting H7N9 viruses containing BJ94-like H9N2 internal genes.

iii. Viral Load:

High viral loads can indeed contribute to severe illness and adverse outcomes in viral infections. A higher viral load, meaning a greater concentration of the virus in the body, can increase the likelihood of efficient virus transmission to others. Moreover, high viral loads often correlate with more intense inflammatory responses, which can cause significant lung damage, organ dysfunction, and, unfortunately, even death[18].

iv. Sialic acid receptor:

The Influenza viruses, including the common human influenza A and B viruses, rely on sialic acid receptors on host cells to initiate infection. These viruses use their hemagglutinin (HA) protein to bind to these sialic acid receptors, which are often found on the surface of respiratory tract cells. Sialic acid is a type of sugar molecule found on the surface of many animal cells including those in the respiratory tract of humans and other animals[97].

V. Polybasic cleavage site:

Monobasic cleavage site limited to trypsin-like protease; and Polybasic cleavage site allows the virus to be readily cleaved by host proteases includes ubiquitous furin-like proteases found throughout the host, resulting in systemic infection, insignificantly increasing its pathogenicity, and making it more likely to cause severe disease.

2.8 Clinical signs

Wild birds, especially migratory waterfowl, serve as the natural reservoir for these viruses and pose a significant risk of introducing various avian influenza subtypes to poultry, particularly those raised in free-range or outdoor systems [45].

In wild birds, avian influenza infections are typically asymptomatic. In poultry, however, the disease can range from mild or no clinical signs to severe illness with mortality rates reaching up to 100%[77]. Viruses that cause mild or no illness in chickens are classified as low pathogenicity avian influenza viruses (LPAIV), whereas those that result in high mortality are classified as high pathogenicity avian influenza viruses (HPAIV)[89].

The clinical signs, disease severity, and mortality rates of avian influenza (AI) differ based on the specific virus strain and the host species.

Since 2003, H5N1 has infected various mammal species, raising concerns due to its potential to adapt to mammals[63]. Such adaptation could pose a significant risk not only to a range of wild mammals but also to human health.

The clinical signs identified in the different animal groups are outlined in the table below:

Species / Category	**Disease Type**	**Clinical Signs**
Poultry (Birds)	LPAI	• Often no signs or mild disease • Mild respiratory signs (nasal discharge, sneezing) • Decreased feed consumption • Ruffled feathers • Decreased egg production • Few signs in wild birds • Some LPAI may mutate into HPAI

	HPAI – Per acute	• Sudden death, sometimes without gross lesions • Dehydration • Fibrinous exudate in air sacs, oviduct, peritoneum, and pericardial sacs
	HPAI – Mild to Moderate	• Conjunctivitis, tracheitis, air sacculitis • Congested musculature • Ovarian regression in layers • Head edema, congestion, hemorrhage, cyanosis of combs/wattles/sinuses • Vesicles/ulcers on the comb • Petechial & ecchymotic hemorrhages (fat, serosa, mucosa, heart, gizzard, proventriculus, intestine) • Edematous feet with hemorrhage, red shanks
Dairy Cattle	HPAI (H5N1)	• Reduced appetite • Sudden drop in milk yield • Abnormal milk (thickened, discolored) • Decreased rumination & motility • Clear nasal discharge • Loose/tacky feces • Lethargy • Dehydration • Fever
Other Mammals	HPAI (H5N1)	• Decreased appetite / anorexia • Poor grooming • Lethargy • Hiding behavior • Disorientation, abnormal gait, ataxia • Neurologic signs (cranial nerve deficits, motor dysfunction all limbs, obtundation) • Eye discharge (watery/purulent) • Increased respirations • Swollen jaw

Table 2: Clinical Signs of Avian Influenza in Different Animal Groups

2.9 Differential diagnosis

Due to the wide range of clinical signs and lesions associated with avian influenza (AI) infections in various species, a definitive diagnosis requires confirmation through virologic and serologic methods. In cases of HPAI, other potential causes of high mortality, such as velogenic Newcastle disease, acute fowl cholera, heat exhaustion, water deprivation, and certain toxins, must be ruled out. For LPAI, differential diagnoses should include other causes of respiratory disease and reduced egg production, such as lentogenic Newcastle disease virus (NDV), avian metapneumovirus, infectious laryngotracheitis (ILT), infectious bronchitis (IB), *Chlamydia*, *Mycoplasma*, and various bacterial infections. Concurrent infections with other viruses or bacteria are also frequently observed[78,80].

2.10 Diagnostic method for confirmation

While the history, clinical signs, and lesions may suggest HPAI or LPAI, they are often indistinguishable from those caused by other avian diseases. Therefore, confirmation of suspected AI cases requires laboratory testing.

i. Nucleic acid testing

Reverse transcriptase polymerase chain reaction (RT-PCR) and real-time RT-PCR (RT-qPCR) methods are routinely used. Influenza A is typically carried out first. Positive Influenza A samples are then subjected to H5 and H7 subtype-specific real-time RT-PCR tests before proceeding with other subtypes[87].

ii. Virus isolation and identification

Avian Influenza viruses can be isolated from embryonated chicken eggs. Chicken embryos, 9–11 days old, are inoculated via the allantoic cavity with approximately 0.2mL of the sample. The presence of the virus from the harvested allantoic fluid is demonstrated by hemagglutinating activity using chicken erythrocytes. It is important to determine whether the hemagglutinating activity detected in the allantoic fluid is due to influenza virus or other hemagglutinating viruses, such as paramyxoviruses, including Newcastle disease virus (NDV). Thus, the isolate is tested in Hemagglutination Inhibition (HI) assays against Newcastle disease and other antiserum. Alternatively, screening is often performed directly with RT-PCR to confirm the presence of a type A influenza virus[87].

Virus isolation and molecular characterization are essential for full confirmation, especially for H5 and H7 subtypes and official reporting.

iii. Serology

Serological tests are commonly used to detect antibodies against avian influenza viruses and support surveillance and diagnosis. The agar gel immunodiffusion (AGID) test targets antibodies against the nucleocapsid or matrix antigens and is useful for general influenza A virus detection. Hemagglutination (HA) and hemagglutination inhibition (HI) tests are employed to detect and quantify subtype-specific antibodies, particularly for hemagglutinin antigens. Enzyme-linked immunosorbent assays (ELISAs) are also widely used, especially those designed to detect antibodies against the nucleoprotein, offering high sensitivity for influenza A infections. For antigen detection, rapid antigen-capture kits and enzyme immunoassays using monoclonal antibodies against the nucleoprotein are available; these methods can detect a broad range of influenza A viruses across different species [26,87].

2.11 Limitations of Vaccination

Malaysia achieved its self-declaration of recovery from HPAI on December 17, 2018[11]. Since then, the country has implemented a policy of strict biosecurity and stamping out, and prohibits the use of vaccination against HPAI. While vaccination can reduce the severity of clinical signs and mortality rates, it still poses several risks and limitations for Malaysia:

i. Evidence of Avian Influenza virus vaccine shedding into the environment, leading to reverse spillover into the wild bird population.

The reverse spillover of avian influenza vaccine strains is an active and documented phenomenon, not merely a theoretical risk. There are multiple instances where genomic surveillance has identified viruses in wild bird populations that are genetically identical or highly similar to live-attenuated vaccine strains used in commercial poultry[64]. These detections, found in wild birds sharing environments with vaccinated flocks, provide tangible evidence that vaccine viruses are being shed, transmitted, and subsequently circulating beyond their intended hosts. Avian Influenza virus vaccine shedding, causing reverse spillover events are already occurring and underscores a significant and underappreciated ecological consequence of widespread vaccination programs[64].

ii. Evidence of fomite transmission.

Influenza viruses, including vaccine strains of other avian viruses, can be shed into the environment through droppings, respiratory secretions, and contaminated surfaces. Experimental and modelling studies show that influenza can survive on surfaces and be transported on small airborne particles or "aerosolized fomites," making indirect transmission via contaminated equipment, clothing, litter, or egg trays a credible route for the

spread of shed vaccine virus[8]. This raises the possibility of fomite transmission through the movement of hatching eggs, particularly when eggs are not properly fumigated before transport.

iii. Vaccines provide variable/short-lived field effectiveness.

Field studies have shown uneven protection and waning immunity at the flock level, meaning vaccination may not reliably prevent outbreaks without very strong coverage and follow-up. The study "Field effectiveness of highly pathogenic avian influenza H5N1 vaccination in commercial layers in Indonesia."[79] evaluated how well vaccination protected layer flocks under real-world farm conditions. While vaccination was associated with a measurable reduction in H5N1 outbreaks, its effectiveness was limited and short-lived. The protective effect declined markedly over time, with flock immunity often waning within a few months of administration. Factors contributing to this limited duration included variable vaccine quality, incomplete antigenic match between circulating viruses and vaccine strains, and inconsistent vaccination practices on farms. This paper concludes that although vaccination can provide temporary protection, it does not ensure long-term immunity at the population level, emphasizing the need for improved vaccine design, better administration practices, and ongoing surveillance to sustain control of HPAI in endemic settings.

iv. Interference from maternal antibodies / immunological complexities may reduce vaccine efficacy.

Maternal antibodies can blunt vaccine take, contributing to apparent "vaccine failure" in the field. Findings from Egypt highlight that maternal antibodies significantly reduce the effectiveness of HPAI vaccination in chicks. Although breeder flocks repeatedly vaccinated with H5N2 vaccines transferred antibodies that provided partial early protection, these antibodies interfered with the immune response to subsequent vaccination. As a result, protection against circulating Egyptian H5N1 field strains was incomplete, allowing virus replication and persistence[30]. This demonstrates that maternal antibody interference undermines vaccine performance, creating gaps in immunity that are inconsistent with Malaysia's ALOP, which prioritises reliable protection, rapid detection, and eradication of HPAI.

Another study[42] also emphasises maternal antibody interference. The authors investigated why H5N1 vaccination campaigns in Egypt failed to control avian influenza despite extensive vaccine use. They demonstrated that maternal antibodies in young chicks significantly interfered with vaccine-induced immunity, reducing both antibody responses and protective

efficacy. Chicks hatched from vaccinated hens carried high levels of maternal antibodies that blunted the immune response to subsequent vaccination, resulting in poor seroconversion and inadequate protection. This interference created large populations of insufficiently protected birds, allowing H5N1 viruses to persist and circulate in vaccinated flocks.

v. Vaccines may prevent clinical disease but do not always prevent viral shedding, allowing silent transmission.

Although AI vaccines can protect individual birds or entire flocks from clinical disease, they only partially reduce virus shedding, meaning vaccinated birds may still spread the virus[60]. This was demonstrated in a transmission experiment involving pairs of chickens, where one bird was inoculated with H5N1 and the other was contact-exposed. Results showed that most vaccinated birds developed hemagglutination inhibition (HI) titres below 4 $\log_2$. While no clinical signs were observed and virus shedding was limited, nearly all vaccinated birds showed a four-fold or greater increase in HI titres after challenge or contact exposure, indicating infection. This suggests that virus transmission likely occurred. The study concluded that a single vaccination, even under field conditions, provided clinical protection but was insufficient to prevent transmission, implying that silent spread may occur within vaccinated commercial flocks[61]. Similarly, findings from Bangladesh indicate that although HPAI H5N1 vaccination reduces clinical disease and reported outbreaks, it carries the risk of silent transmission, as vaccinated flocks can continue to shed virus without overt signs of illness, enabling undetected persistence[34].

vi. Vaccination reduces the sensitivity of traditional surveillance tools, complicating outbreak detection.

Vaccinated birds may harbor and shed the virus at subclinical levels, evading standard detection methods[24]. China, which had implemented mass poultry vaccination, struggled to determine whether reported HPAI H5N1 cases reflected incomplete vaccination coverage or viral escape from vaccine-induced immunity[32]. Most inactivated HPAI vaccines lack DIVA (Differentiating Infected from Vaccinated Animals) capability because they induce antibodies against conserved viral proteins like nucleoprotein (NP), which are present in both infected and vaccinated birds. This prevents serological surveillance from distinguishing between natural infection and vaccination, creating a critical blind spot. Consequently, infected birds in vaccinated flocks may go undetected while shedding the virus, delaying outbreak response and undermining control efforts. As an emphasis, non-DIVA vaccines hinder effective monitoring and reduce confidence in disease-free certification systems [25 75].

vii. Silent transmission from vaccinated animals may lead to endemicity and spillover.

The continuous use of vaccines, particularly inactivated vaccines, without stringent biosecurity and surveillance has permitted low-level circulation of avian influenza (AI) viruses. Consequently, the virus has become endemic in some regions, notably central Mexico[24]. Vaccination against AI can protect birds from clinical disease, but does not always prevent infection or virus shedding, especially when inactivated vaccines are used. This masks the presence of infection, complicating surveillance efforts and potentially allowing the virus to establish endemicity if not carefully monitored[16]. The issue is similarly observed in Bangladesh, whereby silent transmission of HPAI virus in vaccinated flocks in the country facilitated spillover into wild bird populations, thus creating a potential reservoir for viral maintenance and evolution[34].

viii. Risk of vaccine-driven viral evolution and emergence of immune-escape variants.

Long-term vaccine use exerts selective pressure on AI viruses, promoting mutations in circulating strains and reducing vaccine effectiveness. This has led to the emergence of vaccine-resistant variants, as documented in Mexico's H5N2 and H7N3 viruses[24], and is likely a factor behind inconsistent vaccine efficacy in Indonesia [83]. A recent study provides molecular evidence that intensive poultry vaccination against the H5 virus drives adaptive evolution and antigenic drift in the hemagglutinin (HA) gene[49]. Analysis of global H5 HA sequences showed significantly elevated nonsynonymous substitution rates and signs of positive selection at antigenic sites among viruses circulating in vaccinated poultry populations, especially in China. These mutations alter key epitopes on the HA protein, reducing the neutralization efficacy of vaccine-induced antibodies and facilitating immune escape. The findings demonstrate that vaccine-induced immune pressure encourages the emergence of antigenic variants, posing challenges for vaccine effectiveness and necessitating ongoing antigenic monitoring and vaccine updates.

Antigenic drift was also documented in countries using vaccination[75]. Nations like Mongolia, Kazakhstan, France, the Netherlands, Côte d'Ivoire, Sudan, North Korea, Israel, Russia, and Pakistan used AI vaccines in less than 1% of poultry, targeting only preventive or emergency programs. Nevertheless, outbreaks have occurred in vaccinating countries, primarily due to inadequate coverage in target species, but also due to vaccine failures following antigenic drift in field viruses in China, Egypt, Indonesia, Vietnam, and Hong Kong.

A 2017 study reported an H5N1 outbreak in a vaccinated turkey flock in Egypt, where infection and mortality occurred despite the administration of two doses of inactivated H5 vaccine. Genetic analysis of the circulating strain (clade 2.2.1.2a) revealed HA mutations, indicating antigenic drift and a mismatch with the vaccine strain[65].

ix. Operational constraints for HPAI vaccination.

The success of HPAI vaccination is often limited by both how vaccines are used and how widely they are applied. Poor-quality vaccines or mistakes in storage and handling, such as weak antigen content, breaks in the cold chain, wrong administration routes, or incorrect doses, may hide clinical signs but still allow birds to carry and spread the virus. Even with high-quality vaccines given correctly, HPAI spreads so efficiently ($R_0 > 2$) that more than 90% of birds would need to be fully protected to stop transmission[43]. In non-farm systems, achieving this level of coverage is nearly impossible. On top of that, mass vaccination requires huge investments in manpower, cold-chain logistics, vaccination campaigns, and ongoing monitoring, making it an expensive and difficult strategy to maintain[29,66].

x. Heavy surveillance & DIVA requirements.

Where vaccination is used, authorities still need intensive post-vaccination surveillance (often with DIVA strategies) to prove freedom from infection, which is costly and logistically demanding. According to the EFSA Panel on Animal Health and Animal Welfare (Vaccination of poultry against high pathogenicity avian influenza – Part 2. Surveillance and mitigation measures)[54], vaccination against HPAI cannot be implemented as a stand-alone measure. It must be accompanied by intensive surveillance systems capable of detecting circulating viruses in vaccinated populations. A central requirement is the application of DIVA (Differentiating Infected from Vaccinated Animals) strategies, which combine tailored diagnostic tools and targeted monitoring to distinguish between birds that are only vaccinated and those that are infected. Without these measures, vaccination risks masking infection and hindering early outbreak detection. EFSA stresses that only when stringent post-vaccination surveillance and DIVA protocols are in place can vaccinated birds or their products be moved safely in trade, thereby maintaining both disease control and market confidence.

Vaccination against HPAI can reduce disease and mortality, but has important limitations. Protection is often short-lived and inconsistent, while maternal antibodies may reduce vaccine effectiveness in young birds. Vaccinated flocks can silently shed virus without showing illness, leading to endemic circulation and possible spillover to wild birds. Vaccination also

complicates surveillance, especially when DIVA strategies are not applied, making it difficult to distinguish infected from vaccinated birds. Over time, continuous vaccination can drive viral evolution and the emergence of escape variants. Operational challenges such as uneven coverage, cold-chain issues, and administration errors further weaken its reliability. For these reasons, Malaysia prefers stamping-out policies with strict surveillance over vaccination as a long-term control strategy.

CHAPTER 3.0: WOAH Code vs National Policy

WOAH (2023) now recognizes HPAI freedom in vaccinated zones under specific conditions, but Malaysia maintains that such zones present a residual risk. This is supported by the difficulty in detecting subclinical infections and the reduced sensitivity of surveillance systems in vaccinated populations[16].

3.1 Safe Commodities

The WOAH Code specifies that when authorizing importation or transit of commodities such as heat-treated poultry meat products in hermetically sealed containers, extruded dry pet food, rendered protein meals, washed and steam-dried feathers, and down, Veterinary Authorities should not impose conditions related to HPAI, regardless of the exporting country's disease status. These commodities are considered safe, while other poultry-related commodities can also be traded if they comply with the relevant articles. While there are no specific national policies or guidelines on safe commodities for avian influenza, Malaysia ensures safe and compliant trade by applying the relevant WOAH provisions.

The WOAH suggests that vaccination, if conducted according to their guidelines and supported by robust surveillance, should not hinder international trade. However, the practical implementation of these guidelines and the perceived risk by importing countries can still lead to trade barriers.

3.2 Compartmentalization

In terms of compartmentalization, WOAH defines compartments free from HPAI in accordance with Chapter 10.4.4, emphasizing biosecurity and subpopulation management under a disease-free status. The national policy also defines a compartment as an area declared disease-free, involving multiple premises that implement disease management activities such as surveillance, control, eradication, disinfection, and disposal[37]. Both frameworks align in principle, with no substantive differences between the WOAH Code and Malaysia's policy. The WOAH code and national standards are tailored to specific diseases and are designed to match the country's priorities and the expectations of its trade partners.

3.3 Containment Zones

For containment zones, the WOAH Code[91] provides a structured approach whereby, in the event of an outbreak, a containment zone is established around epidemiologically linked outbreaks, with suspension of free status outside the zone until surveillance confirms disease

freedom. This approach considers poultry density, species, management practices, biosecurity, wild bird presence, and proximity to water bodies. Conversely, the national policy relies on stamping out within a fixed 1 km radius, based on past outbreak experiences and WHO recommendations for human health protection. While this effectively limits disease spread, it lacks detailed surveillance frameworks, defined containment zone protocols, trade considerations, and mechanisms for reinstating free status.

3.4 Recovery of Free Status

Regarding recovery of free status, the WOAH Code allows a country or zone to regain freedom 28 days after stamping out and disinfection of the last affected establishment, provided surveillance demonstrates the absence of infection[91]. If stamping out is not implemented, an alternative pathway is available under Article 10.4.3. National policy is closely aligned, requiring active post-outbreak surveillance after 28 days and color-coded indicators; IP Hijau (Green) for recovery, IP *Putih* (white) for freedom based on two consecutive surveillance periods[36]. National regulations do not address recovery pathways without stamping out.

3.5 Vaccination

On vaccination, the WOAH Code acknowledges vaccines as a valuable tool for controlling both HPAI and LPAI[91]. Research has shown that properly administered vaccines can prevent infection, reduce mortality, minimize egg production losses, decrease virus shedding, and reduce onward transmission, with most studies conducted on chickens and turkeys. Vaccination is generally reserved for emergency use under national regulations. In contrast, Malaysia's national policy prohibits vaccination for HPAI in all states. This demonstrates a more restrictive and cautious stance compared to WOAH's science-based endorsement of emergency vaccination as a viable tool in outbreak control.

Malaysia upholds a stringent stance of maintaining complete freedom from disease without vaccination, to minimize ambiguity and ensure clear, effective surveillance, and to prevent trade barriers for export. The rationale for the no-vaccination policy is outlined below:

Malaysia has implemented a policy of stamping out and not vaccinating poultry against HPAI. Vaccination, while it can lower clinical signs and mortality rates, may also hinder disease surveillance and make it challenging to demonstrate Malaysia's HPAI-free status for international trade purposes.

Commercial vaccines for HPAI are available in the market globally, including monovalent, bivalent, and recombinant options. However, there are concerns that widespread vaccination could potentially drive the evolution of new HPAI strains based on the mechanism of transmission. This is supported by scientific evidence as detailed in Section 2.2 i. and v.

i. The exchange of viral segments between one or more influenza virus subtypes can contribute to a shift in virulence and adaptation to new hosts. This key mechanism enables influenza viruses to adapt and evolve, potentially causing outbreaks or pandemics. Three of the human influenza pandemics since the beginning of the last century were caused by reassorting viruses bearing genes of avian, human or swine influenza virus origin. The infections of humans with either swine influenza H1N1 or H3N2 were reported in 1919 due to exposure to infected pigs[51].

ii. The AI virus has the ability to mutate. Under certain conditions, genetic variations can develop, influenced by exposure to other clades or genetic factors. This potential for change highlights the importance of ongoing monitoring and adaptation in our vaccination strategies to protect our poultry and public health. Therefore, when vaccination is necessary, although it can lessen the severity of HPAI outbreaks, it may not fully prevent infection or transmission.

iii. Vaccination can also affect international trade. Many countries, particularly those with strong poultry industries, rely on exports and may face trade restrictions if they implement vaccination programs. A country must be able to demonstrate that it is free from HPAI to export poultry products. Vaccination, even if effective in reducing disease, can complicate this demonstration as vaccinated birds may still be infected and potentially shed the virus.

International organizations like the World Organization for Animal Health (WOAH) have guidelines for trade in disease-free animals and products. Vaccination can make it harder to meet these standards. Besides that, vaccination can make it more difficult to detect HPAI outbreaks through traditional surveillance methods, such as testing sentinel birds. Furthermore, vaccination campaigns in large-scale poultry operations can be logistically challenging and costly, requiring extensive infrastructure and trained personnel.

iv. Instead of vaccination, Malaysia implemented strategies as follows:

a. Biosecurity

Effective biosecurity measures, including limiting farm access, enforcing strict hygiene practices, and controlling wild bird populations, are vital for preventing the introduction and spread of HPAI. Malaysia places particular emphasis on the development of compartmentalization as a key strategy for HPAI prevention.

b. Surveillance

Ongoing active and passive surveillance for HPAI, including the testing of both wild birds and poultry, is critical for early detection and effective disease control.

c. Stamping out

In the event of an outbreak, stamping out infected and all high-risk birds within a 1-kilometer radius of infected premises is mandatory to control the spread of the disease. Malaysia has proven its ability to control and eradicate the disease through the experience of 5 episodes of HPAI outbreaks in Malaysia.

d. Movement control

During an outbreak, the movement of poultry and poultry products into, out of, and within a 10-kilometre radius of the affected area is strictly prohibited except under certain conditions set by the state director of veterinary services.

The comparison between the WOAH Code and Malaysia's national policy on HPAI highlights both similarities and differences. The two frameworks align well on compartmentalization principles and the 28-day waiting period for recovering free status, although the national policy utilizes local adaptations like color-coded indicators. However, there are notable gaps, especially in recognizing safe commodities, establishing structured containment zones, and offering alternative recovery pathways when stamping out is not used. Additionally, while WOAH supports vaccination as an emergency tool backed by scientific evidence, the national policy remains restrictive, permitting vaccination only with central authority approval. These gaps could impact international recognition, trade continuity, and flexibility in disease control strategies. Updating policies to specifically reference WOAH standards would enhance alignment, improve preparedness, and strengthen Malaysia's capacity to manage HPAI risks effectively.

CHAPTER 4.0 Zoonotic and One Health Risks

4.1 Zoonotic Potential of Influenza A Viruses (IAVs)

IAVs possess a significant zoonotic potential as they can infect a wide range of bird and mammal species, including humans. This adaptability arises from their ability to alter their genetic makeup over time, either through mutations or by exchanging genes when a host is co-infected with multiple viral strains. These genetic changes drive high diversity, enabling the virus to adapt rapidly and making it more challenging to control[53].

4.2 Global Trends in HPAI Outbreaks and Zoonotic Spillover

The global pattern of HPAI outbreaks in animals and humans has clearly demonstrated a strong zoonotic component and expanding spread. Since 2022, over 131 million poultry have been lost due to HPAI H5N1 in 67 countries, and there have been high occurrences of spill-over cases between wild birds, mammals, and humans, highlighting the virus's significant zoonotic threat[12,22].

4.3 Human Cases and Community-Level Risk in Malaysia

Between January 2003 and May 2018, a total of 860 human cases of HPAI H5N1 infection were reported globally, resulting in 454 deaths[53,90]. Recent scientific evidence from Sabah, Malaysian Borneo, demonstrates that the risk of H5 avian influenza spillover is not confined to poultry workers alone. Individuals residing within a 10 km radius of migratory shorebird habitats have shown clear serological evidence of prior exposure to H5 viruses, despite the absence of reported clinical cases. This finding highlights a previously under-recognized risk group within the general population living near wildlife interfaces[44].

4.4 Strengthening Surveillance Through One Health

Given these findings, Malaysia must strengthen its cross-sectoral disease surveillance and response systems through a comprehensive One Health approach. The integration of human, animal, and environmental health surveillance is critical for the early detection and effective management of zoonotic threats such as HPAI. This approach directly aligns with Malaysia's commitment to maintaining an Appropriate Level of Protection (ALOP) while strengthening national biosecurity, pandemic preparedness, and public health resilience. Moreover, by addressing the complex interconnections

between animal, human, and environmental health, Malaysia enhances its overall capacity to anticipate, prevent, and respond to future infectious disease outbreaks.

4.5 Climate Change and HPAI Transmission Dynamics

Climate change is actively affecting the spread of HPAI by altering wild bird migration routes (Figure 3), changing habitats, weakening poultry health, and helping the virus survive longer in the environment. Warmer weather can also allow the virus to spread to new areas. In Southeast Asia, climate change is causing wild birds to stay longer during migration, increasing the chances of contact with domestic poultry and raising the risk of zoonotic spillover[2]. These changes highlight the need to regularly update monitoring and control measures.

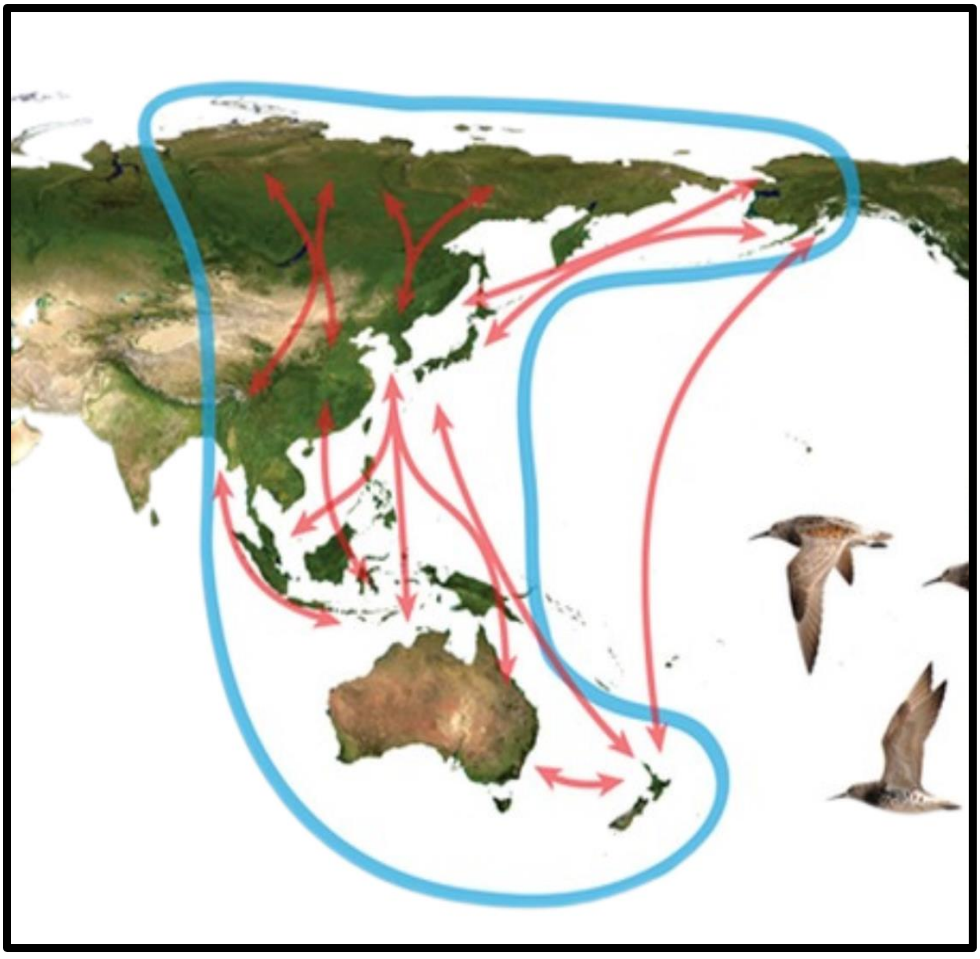


Figure 4: East Asian-Australasian Flyway[21]

4.6 Economic Impact of HPAI outbreaks in Asia

Since 2003, HPAI has caused substantial economic disruption in Southeast Asia's poultry sector. In Thailand, the 2004 H5N1 outbreak resulted in estimated losses of approximately USD 631 million, stemming from poultry mortality, culling operations, and trade restrictions[81]. Regionally, the Food and Agriculture Organization (FAO) projected that the economic costs associated with HPAI across Asia had surpassed USD 10 billion by late 2005, considering both direct and indirect impacts on production, trade, and rural livelihoods[7].

4.7 Malaysia's Poultry Sector and National Vulnerability

As of 2024, Malaysia's poultry industry contributes significantly to the economy and food security, with RM1.38 billion in exports and RM20.30 billion in ex-farm value, supported by 335.55 million birds. This scale of production heightens vulnerability to HPAI, reinforcing the need for a strong ALOP.

4.8 Global Poultry Losses Due to HPAI (2022–2025)

Globally, since 2022, the United States has experienced the largest poultry losses globally due to HPAI, with over 166 million birds culled, including 30 million layers in early 2025 alone. In Japan, outbreaks have occurred in repeated seasonal waves, resulting in the culling of 8.1 million birds during the 2024–2025 season and an additional 1.44 million thereafter. Brazil reported its first commercial poultry outbreak in May 2025, leading to the culling of approximately 158,000 birds. In Canada, particularly British Columbia, 70 of 87 infected flocks were reported in 2024, marking it as a regional hotspot. Europe has faced extensive losses, with 11 million birds culled in February 2025 alone, and 50 million during the peak year of 2022. The Philippines reported over 2.2 million birds affected since 2022 due to widespread outbreaks. Meanwhile, Australia has dealt with multiple outbreaks involving diverse HPAI strains, resulting in recurrent farm depopulations (Reuters June 19, 2025; Phys Org February 27, 2025; nippon.com Feb 3, 2025; reddit.com Jan 5, 2025, March 8, 2025, July 23, 2024; The Poultry Site, 2 April 2025; bbc.co.uk, 12 February 2025).

4.9 Importance of the One Health Approach

HPAI is a multi-species, cross-border threat. It cannot be controlled by treating it as just an animal disease or a human disease. Therefore, only a coordinated One Health

approach can effectively manage its risks and prevent future pandemics. A One Health approach ensures that surveillance, prevention, and response are integrated, making them more effective and sustainable. The One Health approach can also strengthen early warning systems by tracking wildlife, livestock, and environmental indicators, allowing for the detection of viral spillover events at their origin. This enables prompt action to control the virus before it spreads to humans[10].

4.10 Expanding Host Range of HPAI

HPAI is no longer just a bird disease. It has demonstrated the ability to infect a diverse range of mammalian species, including pets, livestock, wildlife, and even humans, making it a complex, multi-species threat. The broad host range increases the chances of viral mutation and adaptation, which could eventually facilitate human-to-human transmission. CDC Technical Reports[17] confirm infections in a wide range of mammals, including farmed mink, cattle, wild carnivores, and marine mammals. The detection of HPAI in mammals, notably dairy cattle in the USA, underscores the unpredictable nature of the virus and its potential cross-species transmission risk.

4.11 Occupational Risk

Out of 150 bovine veterinarians working directly with cattle, three showed antibodies indicating recent H5N1 infection. Two vets had been unknowingly infected, despite no obvious exposure to infected cattle. None reported respiratory or flu-like symptoms, nor did they use eye or respiratory protection during their work. The survey highlights that veterinarians are indeed at occupational risk, even when using minimal PPE, and some infections may be asymptomatic[47].

4.12 Trade and Biosecurity Implications

As a net exporter of poultry, Malaysia must maintain its reputation as an HPAI-free zone to avoid trade bans. Failure to control zoonotic risks could trigger import restrictions under the Agreement on the Application of Sanitary and Phytosanitary Measures, making zoonotic threats not only a public health issue but also a critical trade concern[92].

CHAPTER 5.0: Trade Risk Amplifiers

Trade in live animals and animal products can serve as a significant risk pathway for the introduction of influenza A viruses (IAV), particularly avian influenza viruses (AIV). Import risk analysis, comprising hazard identification, risk assessment, risk management, and risk communication essential to evaluate and manage this risk. Decisions may lead to import prohibition, conditional import with mitigation, or acceptance based on existing systems, but must be underpinned by transparent and science-based evidence. Ultimately, any trade decision must align with the established ALOP.

5.1 *Explanatory Notes*

The trade risk amplifiers are factors or conditions that increase the likelihood, severity, or complexity of trade-related risks, especially in the context of live animals and animal products. These amplifiers do not directly cause trade bans or barriers, but they intensify the consequences or perceptions of risk, leading to stricter controls, disruptions, or delays in trade.

5.2 Limitations of pre-export certification

i. The FAO Food Export Control and Certification (2021) discusses the limitations of pre-export certification in ensuring food safety and preventing disease spread. The FAO emphasizes that certification alone may not be sufficient due to the risk of asymptomatic carriers and improper processing, which can allow pathogens to persist in exported poultry products.

ii. Over-reliance on pre-export certification alone amplifies trade risks due to undetected faults, silent failures, and dynamic real-world conditions that static certifications may miss. Certifications can contain flaws (e.g., sampling errors, fraud) or fail to account for post-shipment degradation, leading to rejected shipments, recalls, or operational failures. These risks escalate when certifications lack redundancy, real-time validation, or context-specific testing. Mitigation requires layered inspections (e.g., IoT monitoring, third-party audits), operational profiling, and technologies like blockchain to enhance transparency and reliability beyond pre-export checks.

iii. The study by Ahire & Dreyfus demonstrates that trade risks amplify when pre-export certifications focus solely on design specifications (static quality checks) while neglecting process management (dynamic real-world conditions)[4]. Just as their

research found product quality requires both design and process controls, certifications fail when they don't account for post-approval variables like transport hazards or regulatory mismatches. The "silent failure" phenomenon, where products pass certifications but fail in use, mirrors findings that 47% of quality outcomes depend on post-production process controls. Effective risk mitigation requires integrating certifications with end-to-end quality management, including real-world testing and supply chain monitoring, to bridge the gap between factory compliance and field reliability.

iv. Inconsistencies in applying WOAH-recommended measures

5.3. Presence of asymptomatic carriers in vaccinated populations

i. The report from FAO/WHO/WOAH focuses on the transmission dynamics and risks of influenza A(H5N1) in animals and humans. H5N1 virus has been detected in asymptomatic dairy cattle in the United States, with high viral loads found in raw milk despite the absence of clinical signs. These asymptomatic infections raise concerns about silent transmission, as infected cattle can spread the virus through movements between farms, contaminated fomites such as milking equipment, vehicles, and clothing, as well as environmental exposure via manure and shared handling tools. Although human infections remain rare, the presence of asymptomatic carriers increases zoonotic risk, particularly for occupationally exposed individuals such as farm workers and veterinarians. These findings are part of a broader investigation into the global spread of H5N1 clade 2.3.4.4b across wild birds, poultry, mammals, and more recently, dairy cattle in 162 herds across 13 U.S. states as of July 2024. The report notes viral traits of concern, such as altered receptor binding, and concludes that the overall public health risk remains low for the general population but is low to moderate for those in close contact with livestock. Importantly, the observations are limited to unvaccinated cattle, with no data available on vaccine efficacy or asymptomatic transmission in vaccinated populations.

ii. Although vaccination has proven effective in protecting ducks against disease, shedding of the virus still occurs in clinically healthy vaccinated populations. To improve protection of ducks against H5N1 HPAI, vaccination programs must consider the susceptibility of ducks to circulating viruses and the particular pro- duction systems and husbandry practices of the country. Vaccination needs to be implemented as part of a comprehensive control strategy that also includes biosecurity, surveillance, education and elimination of infected poultry[59].

iii. Despite the substantial impact of vaccination on outbreaks, we note that HPAI H5N1 is still enzootic in Bangladesh; vaccinated poultry flocks have high rates of H5N1 prevalence, and spillover to wild birds has increased. Vaccination in Bangladesh thus bears the risk of supporting "silent spread," where the vaccine only protects against disease and not also infection[34].

5.4 Commodities Nature, which poses a risk of HPAI virus survivability

Songserm et al. [71] provides scientific evidence that viruses, such as avian influenza, can survive in improperly processed poultry meat and eggs. This highlights the risk of disease transmission through international trade if processing standards are not rigorously enforced.

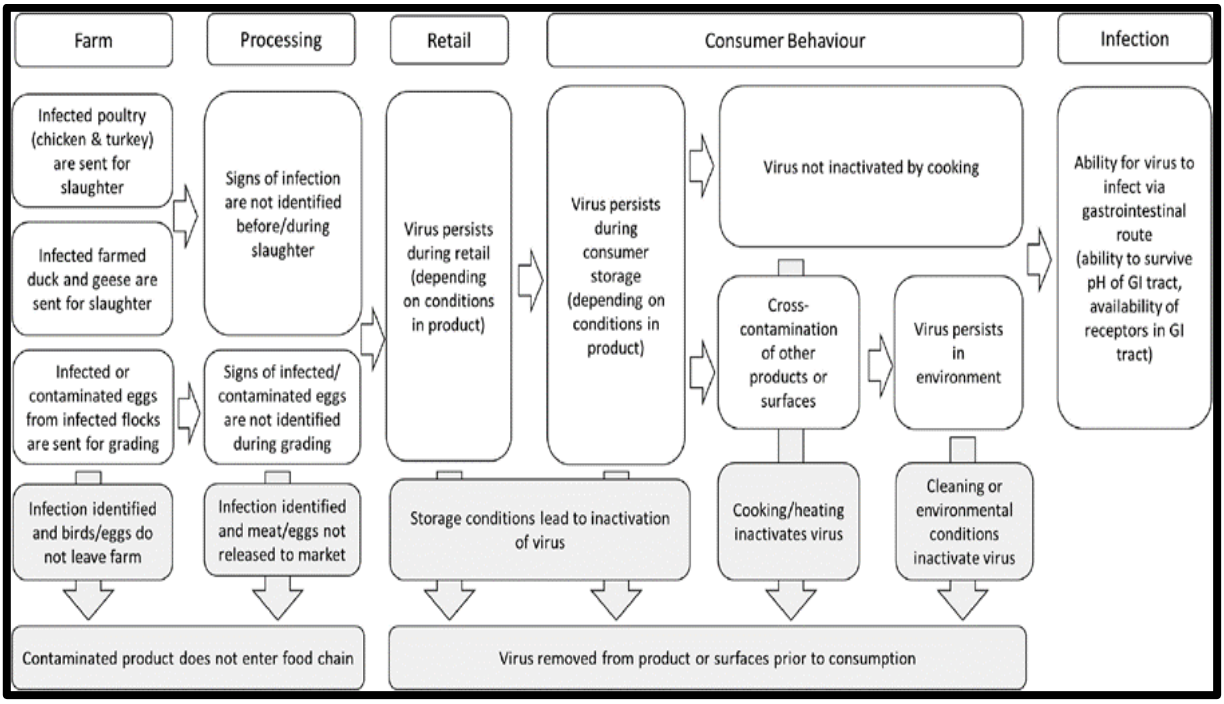


Figure 5: Overall risk pathway for the different poultry products. The stage of the food chain, from the farm through to consumption and including the ability of the AI virus to cause infection, is at the top of the figure. Boxes and arrows filled in grey are opportunities for the virus to be removed from retail or from the product.

5.5 Transport vehicles and cleaning failures

Inadequate cleaning and disinfection of transport equipment heightens the risk of disease transmission through trade. During France's H5N8 outbreaks (2017) and again in 2020–2021, studies revealed that even after cleaning and disinfection (C&D), a significant proportion of transport trucks and crates remained contaminated with the virus—29% before cleaning, and still 18% after cleaning in one study[33].

This suggests that substandard decontamination practices can allow transport vectors (trucks and crates) to carry and further disseminate HPAI during culling and depopulation operations.

In the context of trade, inadequate control of vehicle access and the use of shared transport vehicles significantly act as risk amplifiers for HPAI. In Bangladesh, allowing poultry transport vehicles unrestricted entry into poultry sheds dramatically increased AIV infection probability (from 8% to 38%)[35].

By recognizing these trade risk amplifiers, Malaysia ensures that its import risk management framework, surveillance systems, and biosecurity standards are designed to mitigate heightened vulnerabilities. Addressing amplifiers directly contributes to achieving Malaysia's ALOP by reducing the likelihood of HPAI introduction and protecting both the poultry industry and public health.

The table below describes trade risk amplifiers and mitigations under Malaysia's ALOP:

No.	Trade risk amplifiers	Impact on HPAI risk	Mitigation
1.	Limitation of pre-export certification	- Weak or fraudulent certification undermines sanitary measures - Greater cumulative probability of introduction even when consignments are certified - Reduces traceability, weakens disease control and containment capacity - Elevated risk of transboundary spread from neighboring or outbreak affected countries - Amplifies within- country transmission once virus is introduced	1. Verification of exporting country's veterinary authority performance; audit and inspection missions; mutual recognition agreements with conditions 2. Applying risk-based import conditions; limiting imports from high-risk zones; strengthening inspection and sampling protocols 3. Enhancing border control measures; promoting

			formalized trade channels; implementing traceability and movement control systems 4. Applying zoning and compartmentalization recognition; dynamic import suspensions; intensified border surveillance 5. Strengthening biosecurity at markets; regulating live bird market operations; education and compliance monitoring
2.	Presence of asymptomatic carriers in vaccinated populations	- Silent spread - Increased transmission potential - Immune escape and viral evolution - False sense of security	1. Enhance surveillance 2. Biosecurity reinforcement 3. DIVA Strategy (Differentiating Infected from Vaccinated Animals)
3.	Commodities Nature which poses risk of HPAI virus survivability	High likelihood of carrying viable HPAI virus	Restricting high-risk commodity imports; requiring heat treatment / processing; enforcing commodity-specific Veterinary Health Certificate (VHCs)
4.	Transport Vehicles & Cleaning Failures	Contaminated vehicles, equipment, or facilities act as mechanical vectors	Mandatory cleaning and disinfection protocols; licensing of transporters; enforcement checks at farms, borders, and markets

Table 3: Trade risk amplifiers and mitigations under Malaysia's ALOP

5.6 **Compliance of Malaysia's ALOP with the WTO SPS Agreement**

Under the WTO SPS Agreement, members may introduce or maintain sanitary or phytosanitary measures which result in a higher level of sanitary or phytosanitary protection than would be achieved by measures based on the relevant international standards, guidelines, or recommendations. This agreement also outlines the requirements for science-based sanitary and phytosanitary measures, minimal trade effects, and the use of precautionary principles under uncertainty. The agreement underpins the regulatory framework that countries must follow, but also illustrates how differing interpretations and implementations can amplify trade risks, especially during outbreaks or when scientific uncertainty exists.

The determination of ALOP is aligned with Article 3 and Article 5 of the WTO SPS Agreement. Malaysia's ALOP is not static. A systematic review mechanism ensures that policies and measures remain current, evidence-based, and adaptable to changing epidemiology, scientific advancements, and WOAH guidance. This mechanism guarantees continuous improvement in HPAI risk management.

5.7 **Potential Mitigation to be Applied on the Importation of Live Animals and Animal Products**

In determining ALOP for the importation of live animals and animal products, Malaysia adopts a risk-based approach to minimize the likelihood of introduction and spread of transboundary animal diseases, particularly Highly Pathogenic Avian Influenza (HPAI) and other diseases of veterinary importance.

The mitigation measures applied are proportionate to the commodity risk profile, disease status of the exporting country or zone/compartment, and the intended use of the imported commodities. These measures are implemented in accordance with the principles of the World Organization for Animal Health Terrestrial Animal Health Code (TAHC), relevant national veterinary requirements, and international sanitary standards.

Depending on the commodity category, mitigation measures may include recognition of compartmentalization or regionalization, laboratory testing prior to exportation, heat treatment, Hold-Test-Release (HTR) procedures, and compliance with specific WOAH requirements. The following table summarizes the potential mitigation measures that may be applied for different categories of imported live animals and animal products.

Importation Goods Categories	Mitigation
Live Animals	
1. DOC	
2. DOD	Farm biosecurity measures
3. HE	Recognition of Compartmentalization
4. Live pigs (when relevant)	Recognition of Regionalization
5. Live ruminants (when relevant)	HPAI laboratory testing prior to exportation
6. Other animals	
Animal products:	
Raw meat	Recognition of Compartmentalization Recognition of Regionalization Hold-Test-Release (HTR)
Egg and egg products	Recognition of Compartmentalization Recognition of Regionalization Hold-Test-Release (HTR)
Dairy products	Heat treatment
Semen	HPAI laboratory testing prior to exportation Compliance to WOAH TAHC 4.6 and 4.7
Animal based Fertilizer	Heat treatment
Poultry product intended for use in animal feeding	Heat treatment
Feathers and down	Heat treatment
Specimens, skins and trophies of bird's others than poultry	Heat treatment

Table 4: Potential Mitigation to be Applied to the Importation of Live Animals and Animal Products

CONCLUSION

Malaysia's determination of its Appropriate Level of Protection (ALOP) for HPAI reflects a precautionary, science-based, and risk-driven national policy aimed at preventing the introduction and spread of the disease while safeguarding animal health, public health, food security, and economic stability. Guided by international obligations under the World Trade Organization SPS Agreement and standards of the World Organization for Animal Health, Malaysia adopts a stringent approach to ensure that the risk of HPAI remains below the nationally acceptable threshold.

The country's continued HPAI-free status without vaccination underscores the effectiveness of its stamping-out policy, strong biosecurity, active surveillance, and strict import risk management measures. Given the evolving global epidemiological landscape, including increased virus adaptability, cross-species transmission, and zoonotic potential, Malaysia maintains a conservative and preventive framework to minimize uncertainty and protect national interests. The prohibition of vaccination and the application of strict certification and disease-free requirements remain essential to preserve surveillance sensitivity, ensure early detection, and sustain confidence in Malaysia's sanitary system.

Recognizing the interconnected risks at the animal-human-environment interface, Malaysia also emphasizes strengthening the One Health approach, enhancing surveillance integration, and maintaining preparedness for emerging disease threats. The poultry sector's critical role in national food security and economic development further reinforces the importance of preventing HPAI introduction and maintaining disease freedom.

Malaysia's ALOP is dynamic and subject to continuous review in response to evolving scientific evidence, global disease trends, and international standards. Through consistent implementation of transparent, science-based, and risk-proportionate measures, Malaysia remains committed to protecting national health, supporting safe trade, and sustaining long-term resilience against Highly Pathogenic Avian Influenza.

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1st Edition 2026

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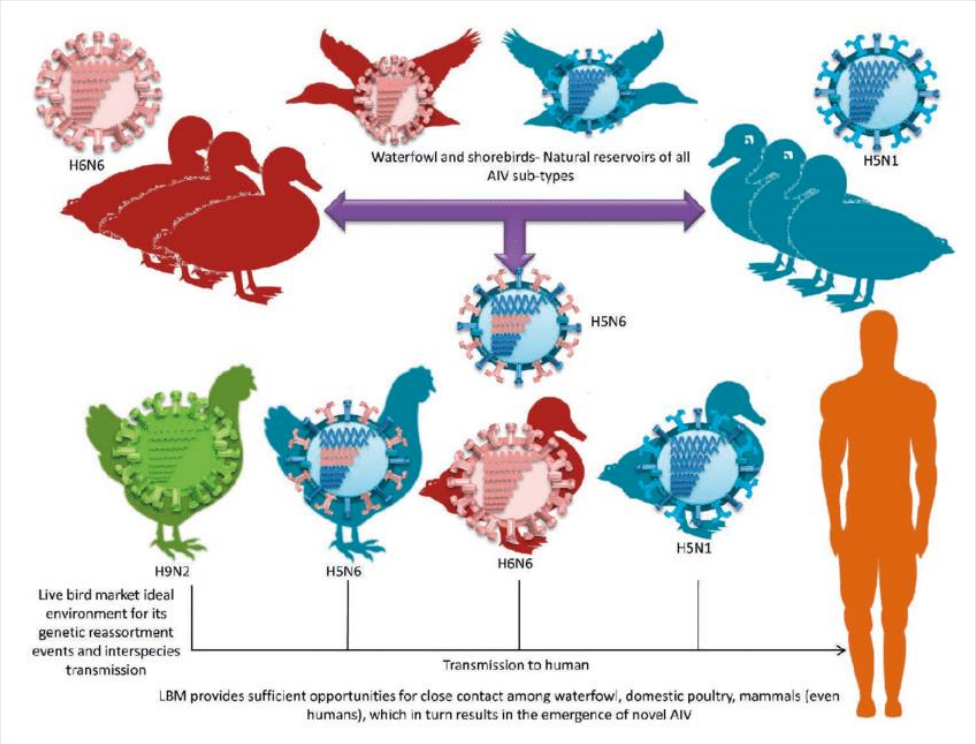
19. DR. NURUL HUSNA BINTI ZULKIFLI
20. DR. NURUL SYAZWANI BINTI RADZUAN
21. DR. YONG QIAN HUI
22. DR. FAHMI RIDZA B. MOHAMAD NUR
23. DR. NUR AIN SHAFIQAH BINTI MOHD SAID
24. PN. FAZLIN ADREENA BINTI KHIDIR
25. EN. MOHD AZRULNIZAM BIN JAAFAR
26. PN. SYAMSIAH AINI BINTI SHOHAIMI
27. PN. NURAIN IZZATI BINTI SAID @ SAIDI
28. EN. MUHAMMAD ZAHIRUDDIN BIN MOHAMAD HUSSIN
29. PN. THENAMUTHA A/P MUNIANDY
30. PN. ROZILA BINTI MOHD ZIN
31. PN. YUSNASHIRA BINTI MOHD YUSOFF
32. EN. EMRIE BIN TAHAR



Prepared by;

Department of Veterinary Services, Malaysia

1st Edition 2026