MONTHLY SCIENTIFIC REVIEW ON **AVIAN INFLUENZA A(H5N1)**

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Situation at a glance

- From 1 January 2003 to 20 January 2025, 964 cases of human infection with avian influenza A(H5N1) viruses and 466 deaths (CFR of 48%) were reported from 24 countries to the WHO. The last case is a 2-year-old boy from Prey Veng Province, Cambodia, who developed symptoms on February 17, 2025. He was hospitalized on February 20 and passed away on February 25, 2025. The child had exposure to chickens in the backyard of his home. (WHO)
- Additionally, 70 human cases of A(H5N1) were recently reported (41 from dairy herds, 24 from poultry farms, 2 from other animal exposure, and 3 with exposure unknown) in 10 states of the USA. The number of H5N1 human cases reported by the CDC in the United States has remained stable since February 2025. (CDC)
- Following exposure to infected dairy cattle, marking the first documentation of zoonotic transmissions of the A(H5N1) virus from a mammal.

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Scientific articles

This section presents relevant articles published on peer-reviewed scientific journals or pre-print platforms.

This week, explore new insights into H5N1 vaccines, transmission, surveillance, and public health risks.

Pathogen characterization

Receptor binding, structure, and tissue tropism of cattle-infecting H5N1 avian influenza virus hemagglutinin. Song H, Hao T, Han P, Wang H, Zhang X, Li X, Wang Y, Chen J, Li Y, Jin X, Duan X, Zhang W, Bi Y, Jin R, Sun L, Wang N, Gao GF.

Published in Cell on February 2025.

In this study, the authors sought to elucidate the receptor-binding specificity, tissue tropism, and structural determinants of hemagglutinin (HA) from a human-infecting bovine H5N1 virus. They found that the HA protein from a cattle-infecting H5N1 virus has acquired slight binding to human-like α2-6-linked receptors while still exhibiting a strong preference for avian-like α2-3-linked sialic acid receptors. Immunohistochemical staining revealed HA binding to bovine pulmonary and mammary tissues, aligning with clinical observations. HA also binds effectively to human conjunctival, tracheal, and mammary tissues, indicating a risk for human transmission, notably in cases of conjunctivitis. High-resolution cryo-electron microscopy structures of this H5 HA in complex with either α2-3 or α2-6 receptors elucidate the molecular mechanisms underlying its receptor-binding properties. These findings provide critical insights into the tropism and transmission potential of this emerging H5N1 virus, especially on cattle mammary gland inflammation and human conjunctivitis.

Human naïve B cells recognize prepandemic influenza virus hemagglutinins. Feldman J, Ramos ASF, Vu M, Maurer DP, Rosado VC, Lingwood D, Bajic G, Schmidt AG

Published in Nat Immunol on January 2025.

In this study, the authors profiled naïve B cell reactivity against a prototypical HPAI H5 hemagglutinin (HA), the major target of antibody responses. They found that the frequency of H5-specific human naïve B cells targeting the HA "head" domain was increased relative to cross-reactive B cells to a circulating seasonal H1N1 strain. They classified the isolated monoclonal antibodies (mAbs) by the HA epitopes engaged and found that selected mAbs neutralized H5N1 at germline. They determined a cryo–electron microscopic structure of one mAb in complex with H5 HA to define its epitope. This study defines the naïve human B cell repertoire recognizing a potentially zoonotic HPAI.

Molecular determinants of cross-strain influenza A virus recognition by αβ T cell receptors. Quiñones-Parra SM, Gras S, Nguyen THO, Farenc C, Szeto C, Rowntree LC, Chaurasia P, Sant S, Boon ACM, Jayasinghe D, Rimmelzwaan GF, Petersen J, Doherty PC, Uldrich AP, Littler DR, Rossjohn J, Kedzierska K.

Published in Sci Immunol on February 2025.

In this study, the authors identified functional broadly cross-reactive T cells universally recognizing NP418 variants by screening 12 naturally occurring influenza-derived HLA-B*35:01–restricted nucleoprotein (NP) 418–426 epitopes (B*35:01-NP418) that emerged since 1918 within influenza A viruses, including 2024 A/H5N1 viruses. Binding studies demonstrated that TCR cross-reactivity was concomitant with diminished antigen sensitivity. Primary human B*35:01/NP418+CD8+ T cell lines displayed reduced cross-reactivity in the absence of CD8 coreceptor binding, validating the low avidity of cross-reactive B*35:01-NP418+CD8+ T cell responses. Six TCR–HLA-B*35:01/NP418 crystal structures showed how cross-reactive TCRs recognized multiple B*35:01/NP418 epitope variants. Specific TCR interactions were formed with invariant and conserved peptide-HLA features, thus remaining distal from highly varied positions of the NP418 epitope. This study defines molecular mechanisms associated with extensive TCR cross-reactivity toward naturally occurring viral variants highly relevant to universal protective immunity against influenza.

Reverse genetics-derived cattle H5N1 virus from Clade 2.3.4.4b shows enhanced systemic infectivity and pathogenicity than an older Clade 1 H5N1 virus in BALB/c mice. Xiao N, Oong XY, Chen Y, Li C, Chung HC, Wang P, Ye Z, Lam AH, Cai J, Song W, Lee AC, Chu H, Kok KH, Chan JF, Yuan S, Chen H, Yuen KY, Zhang AJ

Published in Emerg Microbes Infect on March 2025.

In this study, the authors examined the viral tissue tropism, histopathological damages, and host immune responses upon intranasal inoculation with a reverse-genetic virus constructed based on A/dairy cattle/Texas/24-008749-003/2024 (Cattle-H5N1) and comparing with an older reference Clade 1 virus, A/Vietnam/1194/2004 virus (VNM1194-H5N1), using both non-lactating and lactating BALB/c mice. They observed significant differences in replication kinetics and histopathology between the two viruses in various organs of the infected mice and the ability of the Cattle-H5N1 virus to disseminate to multiple extrapulmonary organs and induce dysregulated inflammation.

Epidemiology

Prediction models show differences in highly pathogenic avian influenza outbreaks in Japan and South Korea compared to Europe. Kjær LJ, Kirkeby CT, Boklund AE, Hjulsager CK, Fox AD, Ward MP.

Published in Sci Rep on February 2025.

In this study, the authors used data on H5 HPAI virus (HPAIV) occurrence from the World Organization for Animal Health and the Food and Agriculture Organization, and employed a spatial time-series modelling framework to predict occurrences in Japan and South Korea, 2020–2024. This framework decomposes time-series data into endemic and epidemic components and has previously been used to model HPAIV in Europe. They identified 1,310 HPAIV detections from 2020 to 2024, the majority being H5N1 (55.3%) and H5N8 (35.0%). These data consisted of 827 and 483 detections in wild and domestic birds, respectively. The model included seasonality and covariates in both endemic and epidemic components and revealed consistent yearly seasonal patterns. The model predicted 81% of detections as epidemic, primarily due to within-region transmission (53%), whereas only 19% were endemic. This model effectively predicts weekly H5 HPAIV detections, aiding decision-makers in identifying high-risk periods.

Steps to prevent and respond to an H5N1 epidemic in the USA. Dhillon RS, Karan A, Garry RF, Srikrishna D.

Published in Nat Med on February 2025.

The article addresses the risk of an H5N1 avian influenza outbreak in the United States, where over 900 dairy herds in 16 states have been infected. Although no efficient human-to-human transmission has been detected, the spread in cattle increases the risk of dangerous mutations. The circulating clades, particularly 2.3.4.4b, are concerning, although some strains (such as B3.13 in cattle) appear to be less virulent. The risk of reassortment with seasonal influenza viruses is high, especially during the winter period. Preventive measures are necessary, including the protection of agricultural workers, increased genomic surveillance, farm disinfection, and enhanced testing of milk and wastewater. Finally, improved communication and the restoration of public trust are essential to prevent a health crisis. The article emphasizes the importance of rapid action to avoid a major public health crisis.

Surveillance

H5N1 avian influenza: technical solutions, political challenges. The Lancet.

Published in Nat Commun on January 2025.

The article analyzes the H5N1 avian influenza outbreak in the United States, one year after its detection in dairy cattle. Although human-to-human transmission has not yet been confirmed, the emergence of genotype D1.1, responsible for the first human death in Louisiana, raises concerns. The infection has spread to other states such as Nevada and Arizona, highlighting the risk of viral evolution. In response to this threat, the World Organisation for Animal Health (OIE) and the FAO recommend enhanced surveillance, poultry vaccination, and strengthened biosecurity measures. In the United States, a One Health plan has been adopted, but its implementation is hindered by budget cuts and political obstacles. The reluctance to report infections, due to economic losses and trade restrictions, further complicates the crisis management. The article emphasizes the need for international coordination and concrete actions to prevent a new pandemic.

Vaccination

Evaluation of humoral immune response and milk antibody transfer in calves and lactating cows vaccinated with inactivated H5 avian influenza vaccine. Abousenna MS, Shafik NG, Abotaleb MM.

Published in Sci Rep on February 2025.

This study evaluated the efficacy of various doses of an inactivated H5 avian influenza (AI) vaccine in cattle and assessed antibody transfer in milk against a recent bovine isolate of Highly Pathogenic Avian Influenza (HPAI) A (H5N1, clade 2.3.4.4b). Calves were inoculated with different vaccine doses, while lactating cows received the vaccine four weeks later. The humoral immune response was measured using the Hemagglutination Inhibition (HI) test and ELISA. Results showed a dose-dependent immune response, with higher doses producing stronger and more sustained antibody levels. One groupe maintained a stable HI titer of 6 log2, while the rest of the groups peaked at 8, 9, and 9 log2, respectively, by the fourth week post-vaccination. Milk antibody transfer was observed, with strong positive responses in milk samples by the second week post-vaccination. The ID Screen ELISA demonstrated higher sensitivity for detecting antibodies in milk compared to serum. These findings highlight the potential for using inactivated H5 AI vaccines in cattle to enhance immune protection and facilitate antibody transfer through milk.

Single Dose of Attenuated Vaccinia Viruses Expressing H5 Hemagglutinin Affords Rapid and Long-Term Protection Against Lethal Infection with Highly Pathogenic Avian Influenza A H5N1 Virus in Mice and Monkeys. Yasui F, Munekata K, Fujiyuki T, Kuraishi T, Yamaji K, Honda T, Gomi S, Yoneda M, Sanada T, Ishii K, Sakoda Y, Kida H, Hattori S, Kai C, Kohara M.

Published in Vaccines (Basel) on January 2025.

As part of the development of vaccines against H5N1 influenza, three recombinant influenza vaccines targeting H5 subtype viruses were tested using two distinct strains of highly attenuated vaccinia virus (VACV) vectors. These vaccines included two LC16m8-based vectors: rLC16m8-mcl2.2 HA (clade 2.2) and rLC16m8-mcl2.3.4 HA (clade 2.3.4), as well as a DIs-based vector, rDIs-mcl2.2 HA (clade 2.2). A single dose of rLC16m8-mcl2.2 HA provided rapid protection within one week and long-lasting immunity for up to 20 months in mice against highly pathogenic avian influenza (HPAI) H5N1 virus. Similar protection was observed in cynomolgus macaques exposed to a heterologous clade of the HPAI H5N1 virus. Furthermore, the rDIs-mcl2.2 HA vaccine demonstrated comparable protective efficacy. These vaccines effectively protected animals previously immunized with VACV against lethal HPAI H5N1 infection. These findings provide strong evidence for the efficacy of both vaccines against HPAI H5N1 infection, with rDIs-mcl2.2 HA emerging as a promising vaccine candidate against H5 HA subtype viruses.

Treatment

Pre-exposure antibody prophylaxis protects macaques from severe influenza. Kanekiyo M, Gillespie RA, Cooper K, Canedo VG, Castanha PMS, Pegu A, Yang ES, Treaster L, Yun G, Wallace M, Kettenburg G, Williams C, Lundy J, Barrick S, O'Malley K, Midgett M, Martí MM, Chavva H, Corry J, Treat BR, Lipinski A, Batsche LO, Creanga A, Ritter I, Walker R, Olsen E, Laughlin A, Perez DR, Mascola JR, Boritz EA, Loo YM, Blair W, Esser M, Graham BS, Reed DS, Barratt-Boyes SM.

Published in Science on January 2025.

As part of the development of preventive treatments against H5N1 influenza, the authors investigated the protective efficacy of the broadly neutralizing antibody (bnAb) MEDI8852 in cynomolgus macaques. Their results indicate that MEDI8852 provides effective protection against severe disease caused by H5N1 infection. The extent of protection was dose-dependent but did not require Fc-mediated effector functions at the tested dose. Macaques that received MEDI8852 at a dose of 10 milligrams per kilogram or higher exhibited minimal respiratory impairment following infection, whereas control animals developed severe disease and did not survive. Based on these findings, protection against a potential influenza A pandemic appears to be achievable.

Influenza H5Nx Viruses are susceptible to MEK1/2 Inhibition by zapnometinib. Schreiber A, Oberberg N, Ambrosy B, Rodner F, Kumar S, Caliskan DM, Brunotte L, Beer M, Ludwig S

Published in Emerg Microbes Infect on February 2025.

The authors investigated the MEK1/2 inhibitor zapnometinib (ZMN) as a potential antiviral agent against highly pathogenic avian influenza viruses (HPAIVs). In cell cultures, ZMN significantly reduced the replication of HPAIVs, including H5N1 clade 2.3.4.4b. It blocks the MEK/ERK/RSK1 pathway, trapping viral ribonucleoprotein (vRNP) complexes in the nucleus, thereby preventing viral propagation. Furthermore, ZMN exhibited synergistic effects when combined with direct-acting antivirals such as oseltamivir or baloxavir, enhancing its potential as a promising strategy for the future development of antiviral treatments.

Public health

Selected microwave irradiation effectively inactivates airborne avian influenza A(H5N1) virus. Bia P, Losardo M, Manna A, Brusaferro S, Privitera GP, Vincentelli AS.

Published in Sci Rep on January 2025.

In this study, the authors sought to investigate the efficacy of microwave inactivation against aerosolized A (H5N1) virus by identifying the optimal frequency band for a 10-min exposure and evaluating the impact of varying exposure times on virus inactivation. A(H5N1) was aerosolized and exposed to various microwave frequencies ranging from 8 to 16 GHz for a duration of 10 min. Viral titers were quantified using TCID50, and inactivation was assessed by comparing irradiated samples to controls. The 11–13 GHz band yielded the highest inactivation, with an average 89% mean reduction in A(H5N1) titer, particularly within the 11–12 GHz range, which exhibited peak efficacy. Based on the overall results, the optimal frequency band (8–12 GHz) was further tested with exposure durations of 1, 3, and 5 min. Inactivation was time-dependent, with a 5-minute exposure resulting in a 94% mean reduction, compared to 58% and 48% for 3- and 1-minute exposures, respectively. This study showed that optimized microwave emitters in high-risk environments like poultry farms and veterinary clinics could offer a novel, non-chemical approach to mitigating avian influenza spread and outbreaks.

Pasteurisation temperatures effectively inactivate influenza A viruses in milk. Schafers J, Warren CJ, Yang J, Zhang J, Cole SJ, Cooper J, Drewek K, Kolli BR, McGinn N, Qureshi M, Reid SM, Peacock TP, Brown I, James J, Banyard AC, Iqbal M, Digard P, Hutchinson E.

Published in Nat Commun on January 2025.

In this study, the authors assessed heat inactivation in milk for a panel of different influenza viruses including, human and avian influenza A viruses (IAVs), an influenza D virus that naturally infects cattle, and recombinant IAVs carrying contemporary avian or bovine H5N1 glycoproteins. At pasteurization temperatures of 63 °C and 72 °C, they find that viral infectivity is rapidly lost and becomes undetectable before the times recommended for pasteurisation (30 minutes and 15 seconds, respectively). They also show that an H5N1 HPAIV in milk is effectively inactivated by a comparable treatment, even though its genetic material remains detectable. The authors conclude that pasteurisation conditions should effectively inactivate H5N1 HPAIV in cows' milk, but that unpasteurised milk could carry infectious influenza viruses.

Relevant news

This section presents official reports from health agencies, manufacturers and press releases with reliable sources.

Are We on the Cusp of a Major Bird Flu Outbreak?

Published in Harvard Medical School, on March 7 2025.

La grippe aviaire, ou influenza aviaire H5N1, circule en Amérique du Nord depuis 2022, infectant les oiseaux, le bétail, la faune sauvage, les animaux de compagnie et les humains. Malgré 70 cas humains documentés, aucun cas de transmission interhumaine n'a été identifié. Cependant, certains scientifiques commencent à craindre que ce ne soit qu'une question de temps.

Prepare now for a potential H5N1 pandemic

Published in Science, on March 6 2025.

The H5N1 virus has crossed species and adapted to mammalian hosts, including dairy cattle, causing widespread exposure and sporadic human illness. Although most cases have been mild, H5N1 can cause severe disease. Given H5N1's potential to spread, urgent action is needed to address pandemic preparedness gaps.

Avian Influenza (H5N1) Vaccines: What's the Status?

Published in American Society for Microbiology, on March 4 2025.

Researchers are developing completely new vaccine options as well. Different types of vaccines (e.g., mRNA, whole inactivated virus, live-attenuated virus, among others) stimulate the immune system in different ways, and rely on different manufacturing tools and processes. Investigations into the use of mRNA vaccines against H5N1 have shown promising results.

CDC shares clinical and sequencing details from 3 recent human H5N1 cases

Published in CIDRAP, on February 26 2025.

The Centers for Disease Control and Prevention (CDC) today shared new sequencing findings on samples from two people with H5N1 avian flu infections, one a patient from Wyoming who was hospitalized after contact with backyard poultry and the other a dairy worker from Nevada. It also fleshed out clinical findings for the two patients, plus another from Ohio.

'Exceptionally rare' mutation on H5N1 virus in Canada tied to antiviral drug resistance

Published in CIDRAP, on February 21 2025.

In a research letter published this week in *Emerging Microbes & Infections*, researchers at the Canada Food Inspection Agency (CFIA) describe their discovery of a mutated H5N1 avian flu strain resistant to the antiviral drug oseltamivir (Tamiflu) on eight chicken farms in British Columbia in October 2024.

U.S. conditionally approves vaccine to protect poultry from avian flu

Published in Science, on February 14 2025.

With egg prices in the United States soaring because of the spread of H5N1 influenza virus among poultry, the U.S. Department of Agriculture (USDA) yesterday conditionally approved a vaccine to protect the birds. President Donald Trump's administration may therefore soon face a fraught decision on whether to join the ranks of other nations—including China, France, Egypt, and Mexico—that vaccinate poultry against H5N1.

A brief history of human infections with H5Ny avian influenza viruses

Published in Cell Host & Microbe, on February 12 2025.

The H5 subtype of avian influenza viruses (AIVs) presents a continued threat to human health, intensifying with the H5N1 outbreak in cattle herds and onward transmission to humans. In this commentary, authors offer a brief history of and explore recent advances in H5Ny AIVs and their impact on public health.

Guidelines and practical information

This section lists official manuals of recommendations for clinical practice or public health policy published by leading health organizations.

January 2024	Interim Guidance for Employers to Reduce Exposure to Avian Influenza A Viruses for People Working with Animals
August 2024	Practical interim guidance to reduce the risk of infection in people exposed to avian influenza viruses
June 2024	Highly Pathogenic Avian Influenza A(H5N1) Virus in Animals: Interim Recommendations for Prevention, Monitoring, and Public Health Investigations (CDC)
June 2024	Prevention and Antiviral Treatment of Avian Influenza A Viruses in People (CDC)
May 2024	Avis du COVARS du 24 mai 2024 - Point sur la situation liée au virus influenza H5N1 (MESRI)
December 2023	Considerations for emergency vaccination of wild birds against high pathogenicity avian influenza in specific situations (WOAH)
June 2023	Enhanced surveillance of severe avian influenza virus infections in hospital settings in the EU/EEA (ECDC)
January 2022	Guidelines for the clinical management of severe illness from influenza virus infections (WHO)
December 2021	Avis relatif à la prévention de la transmission à l'homme des virus influenza porcins et aviaires (HCSP)

Fact sheets

Transmission

Influenza A viruses are segmented, negative-sense single-stranded RNA viruses, members of the *Orthomyxoviridae* family. The antigenic diversity of these viruses arises from two surface glycoproteins: **hemagglutinin (HA)** and **neuraminidase (NA).** Combinations of these proteins create numerous influenza subtypes, with currently 18 HA and 11 NA subtypes recognized in the environment. Although avian influenza viruses spread mainly among waterfowl, particularly Anseriformes and Charadriiformes, as well as in other susceptible bird species such as Galliformes. Unlike most other avian influenza viruses, A(H5N1) 2.3.4.4b has infected more than 200 mammal species and they can occasionally infect humans but no sustained human-to-human transmission has been identified.

Diagnosis

Appropriate samples for influenza tests should be rapidly taken and processed from patients with a relevant exposure history within ten days preceding symptom onset. A(H5N1) viruses have been detected in raw milk from infected dairy cows in some locations.

Symptoms

The incubation period for A(H5N1) infection is typically two to five days after the last known exposure. A(H5N1) influenza virus infection can cause a range of diseases in humans, from mild to severe, and in some cases, it can even be fatal. Symptoms are primarily respiratory, including fever, malaise, cough, sore throat, and muscle aches. Other early symptoms may include conjunctivitis and other non-respiratory symptoms. The infection can quickly progress to severe respiratory illness and neurological changes. A(H5N1) virus has also been detected in asymptomatic individuals.

Treatment

Influenza patients should be managed properly to prevent severe illness and death. Patients with laboratory-confirmed should be treated with antiviral medicines like oseltamivir as soon as possible.

Vaccination

Vaccine development leading to the licensure of three H5N1 vaccines - clade 1 and 2.1 - by the FDA and EMA under the trade name Audenz® / Afllunox ®, Preprandix® / Pumarix®, and Foclivia® / Adjupanrix®.

More information

Technological landscape

This section outlines the current pipeline of drug development, clinical trials and technologies aimed at preventing and treating the disease.

VACCINE	**IDCDC-RG71A (Seqirus®)** (A/Astrakhan/3212/2020)	A(H5N8) antigenic prototype 2.3.4.4b Split-inactivated virion, adjuvanted	Restricted use	Developed by CDC, U.S and referenced on WHO GISRS pandemic candidate vaccine pipeline. Successfully passed relevant safety and potency HI testing. Approved by EMA for emergency use in EU/EEA countries since 9 October 2023. Pre-clinical studies have demonstrated that antisera produced against this vaccine is cross-reactive against the currently circulation H5N1 2.3.4.4b from a Texas dairy farm worker. Two phase I/II clinical studies are currently under evaluation in adults, expected to be completed end of 2024 (NCT05874713 and NCT05975840).
	A/Fujian-Sanyuan/21099/2017-like	A(H5N6) antigenic prototype 2.3.4.4b	Restricted use	Developed by CCDC, China and referenced on WHO GISRS pandemic candidate vaccine pipeline. Successfully passed relevant safety and potency HI testing.
	IDCDC-RG78A (A/American wigeon/South Carolina/22-000345-001/2021-like)	A(H5N1) antigenic prototype 2.3.4.4b	Restricted use	Developed by CDC, U.S and referenced on WHO GISRS pandemic candidate vaccine pipeline. Successfully passed relevant safety and potency HI testing.
	NIID-002 (A/Ezo red fox/Hokkaido/1/2022)	A(H5N1) antigenic prototype 2.3.4.4b	Restricted use	Developed by NIID, Japan and referenced on WHO GISRS pandemic candidate vaccine pipeline. Successfully passed relevant safety and potency haemagglutination inhibition testing.
	A/chicken/Ghana/AVL-76321VIR7050-39/2021-like	A(H5N1) antigenic prototype 2.3.4.4b	In development	In development by CDC, U.S. Currently passing relevant safety and potency testing.
	A/chicken/Ghana/20/2015-like	A(H5N1) antigenic prototype 2.3.2.1f	In development	In development by CDC, U.S. Currently passing relevant safety and potency testing.
	Preprandix® / Pumarix® (A/Indonesia/05/2005)	A(H5N1) clade 2.1 Split-inactivated virion, adjuvanted	Restricted use	Contain reactive AS03 adjuvant. Approved by EMA for emergency use in EA/EEA countries since March 2011. LIcensed by the FDA in 2013 and is currently in the U.S. National stockpile for pre-pandemic preparedness. Usable in persons six months of age and older. Generates cross-reactive binding antibodies cross-neutralization titers against H5 clade 2.3.4.4b A/Astrakhan/3212/2020 strain (Khurana et al., 2024).
	Foclivia® / Adjupanrix® (A/VietNam/1194/2004)	A(H5N1) clade 1 Split-inactivated virion, adjuvanted	Restricted use	Developed by Sanofi Pasteur (unadjuvanted), Seqirus (adjuvanted with MF59) or GSK (adjuvanted with AS03) and approved by FDA since September 2016. Vaccines are stored in the U.S. National stockpile for pre-pandemic preparedness. Foclivia® (adjuvanted with MF59) and Adjupanrix® (adjuvanted with AS03) formulation are approved for emergency use in EA/EEA countries in October 2009. Generates cross-reactive binding antibodies cross-neutralization titers against H5 clade 2.3.4.4b A/Astrakhan/3212/2020 strain (Khurana et al., 2024).
	Audenz® / Afllunox ® (A/turkey/Turkey/1/2005)	A(H5N1) 2.2.1 inactivated, monovalent vaccine, adjuvanted	Restricted use	Approved for emergency use in EA/EEA countries in November 2010. Approved by FDA since January 2020 for use in persons six months of age and older at increased risk of exposure to the influenza A virus H5N1 subtype contained in the vaccine. The license has been renewed in the U.S. on 24 April 2024.
	Panvax®	A(H5N1) Inactivated vaccine, adjuvanted	Restricted use	Developed by CSL Limited and approved by Australia since 2008. The vaccine, given in two doses, was found to be safe and well tolerated among adults aged 18 to 64 and adults older than 64.
	Influenza Virus Vaccine, H5N1 (A/Vietnam/1203/2004)	A(H5N1) clade 1 Inactivated, monovalent vaccine	Restricted use	Developped by Sanofi Pasteur and approved by FDA for emergency use in U.S since 2007. This vaccine is stored in the U.S. National stockpile for pre-pandemic preparedness. Indicated for active immunization of persons 18 through 64 years of age at increased risk of exposure to the influenza A virus H5N1 subtype contained in the vaccine.